Advances in Intelligent Systems and Computing 1215

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Advances in Physical, Social & Occupational Ergonomics

Proceedings of the AHFE 2020 Virtual Conferences on Physical Ergonomics and Human Factors, Social & Occupational Ergonomics and Cross-Cultural Decision Making, July 16–20, 2020, USA

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Advances in Human Factors and Ergonomics 2020

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Proceedings of the AHFE 2020 Virtual Conferences on Physical Ergonomics and Human Factors, Social & Occupational Ergonomics and Cross-Cultural Decision Making, July 16–20, 2020, USA

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Preface

The discipline of human factors and ergonomics (HF/E) is concerned with the design of products, process, services, and work systems to assure their productive, safe, and satisfying use by people. Physical ergonomics involves the design of working environments to fit human physical abilities. By understanding the constraints and capabilities of the human body and mind, we can design products, services, and environments that are effective, reliable, safe, and comfortable for everyday use. A thorough understanding of the physical characteristics of a wide range of people is essential in the development of consumer products and systems. Human performance data serve as valuable information to designers and help ensure that the final products will fit the targeted population of end users. Mastering physical ergonomics and safety engineering concepts is fundamental to the creation of products and systems that people can use, avoidance of stresses, and minimization of the risk for accidents. This book focuses on the advances in the physical HF/E, which are a critical aspect in the design of any human-centered technological system.

An exploration of how ergonomics can contribute to the solution of important societal and engineering challenges, advances in social and organizational factors discusses the optimization of sociotechnical systems, including their organizational structures, policies, and processes. It includes coverage of communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, organizational culture, virtual organizations, telework, and quality management.

The book also highlights issues with special populations, detailing how to design and adapt products and work situations for these groups. In addition to exploring the challenges faced in optimizing sociotechnical systems, the book underlines themes that play a role in all the challenges and how they are linked to each other. It concludes with an exploration of emotional ergonomics and the important positive effects of making people happy and healthy. With chapter authors from around the globe, the book supplies a broad look at current challenges and possible solutions. This book contains a total of ten sections that covers the following topics.

The ideas and practical solutions described in the book are the outcomes of dedicated research by academics and practitioners aiming to advance theory and practice in this dynamic and all-encompassing discipline. A total of ten sections presented in this book:

Physical Ergonomics

Section 1 Posture Assessment
Section 2 Work-Related Musculoskeletal Disorders
Section 3 Workplace Design and Ergonomics
Section 4 Ergonomics in Product Design
Section 5 Risk Assessment and Injury Prevention
Section 6 Workload Assessment

Social & Occupational Ergonomics

Section 7 Occupational Ergonomics Analysis and Methods
Section 8 Social, Legal and Epistemology
Section 9 Social and Occupational Ergonomics

Cross-Cultural Research

Section 10 Cross-Cultural Decision Making

Each section contains research papers that have been reviewed by members of the International Editorial Board. Our sincere thanks and appreciation to the Board members as listed below:

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We hope that this book, which presents the international state of the art in the physical domain of human factors, will serve as a valuable source of theoretical and applied knowledge enabling the human-centered design of a variety of products, services, and systems for global markets.

July 2020

Waldemar Karwowski
Ravindra S. Goonetilleke
Shuping Xiong
Richard H. M. Goossens
Atsuo Murata

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Social & Occupational Ergonomics Analysis and Methods

Social, Legal and Epistemology

Posture Assessment

Comparison of Joint Angle Measurements from Three Types of Motion Capture Systems for Ergonomic Postural Assessment

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Abstract. Observational ergonomic postural assessment methods have been used to evaluate the risks of musculoskeletal disorders. Recently, researchers have actively proposed semiautomatic approaches using motion capture data. This study compared joint angle measurements from optical, inertial, and depth-based motion capture systems, especially for cases with occlusions. Participants performed 6 static postures with different degrees of occlusion while capturing motion data by three motion capture systems. Results showed that the joint angle difference between the three systems was acceptably low in general, but the difference between Kinect and the other two systems was larger, especially in cases with occlusions. The findings indicate that the Kinect-based system is less stable than optical and inertial-based motion capture systems, but it can be used for ergonomic postural assessments in the environment without severe occlusions.

Keywords: Postural assessment · RULA · REBA · Motion capture · Kinect v2

1 Introduction

Musculoskeletal disorders (MSDs) are considered as one of the most common work-related health problems, being the main cause of absence from work in the US [1, 2]. It is critical to minimize MSDs as it damages a person's health and increases medical costs [3]. MSDs occur due to the accumulated musculoskeletal load caused by repetitive improper working postures, thus a worker's posture and movement are important information to determine the risk of musculoskeletal injury [4].

In order to minimize MSDs, observational postural assessment methods which experts evaluate based on the direct observation on-site or video of the workers performing their tasks, have been widely used by industrial practitioners due to the advantages of being simple to use and suitable for a variety of work situations and a

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large number of subjects at relatively low costs. Among those, Rapid Upper Limb Assessment (RULA) [5] and Rapid Entire Body Assessment (REBA) [6] are two popular postural assessment tools.

However, the main drawback of these methods is that not only it requires a field expert conducting a time-consuming manual analysis, but also observation and evaluation processes are highly dependent on the input information and the evaluator's subjective judgment, which results in high intra- and inter-rater variability [7, 8]. For instance, a fair intra-class correlation coefficient (ICC < 0.5) was reported on the RULA score from four trained raters [9], and the need for serial assessments by the same rater was suggested to increase the reliability of RULA [10].

To overcome the problems of the observational method, researchers have proposed semiautomatic approaches using motion capture (MoCap) data as input. Optical marker-based and wearable inertial sensor-based [11–13] MoCap systems are generally equipped with high precision but suffer from high equipment cost, need for a skilled technician, and obtrusiveness of body-attached sensors [14, 15], thus considered to be inapplicable in some real work conditions. Accordingly, a low-cost, marker-less, and calibration-free MoCap system utilizing a depth camera such as Kinect has gained attention by researchers. Kinect's validity as a MoCap system is slightly less than more pricy devices but sufficiently reliable for some ergonomic assessments [16–19]. Proposed Kinect-based methods [20–22] calculate necessary joint angles to conduct postural assessments from Kinect-generated center positions of the major body joints.

Some recent studies have attempted to validate joint angles and RULA scores from the Kinect with ones from the optical MoCap system and expert raters [21–24]. However, limited studies have simultaneously compared optical, inertial, and depth-based MoCap systems, especially for cases with occlusions [25, 26] where the tracking capability of Kinect could significantly deteriorate. Therefore, this study aims to compare joint angles necessary for RULA and REBA derived from three different types of MoCap systems (optical, inertial, and depth-based).

2 Methods

2.1 Participants and Experimental Settings

Ten Korean young males (age: 22.0 ± 2.5, height: 171.6 ± 4.6 cm, weight: 64.5 ± 3.9 kg) participated in the experiment, and all of them were healthy enough to perform required postures. Participants with BMI $\leq$ 25 were recruited because tight suits for the MoCap systems could not comfortably accommodate people with the endomorph body type. All participants gave consent for the experiment protocol approved by the University Institutional Review Board.

Three different MoCap systems were used. First, Vicon optical MoCap system with eight Vicon MX40+ infrared cameras and 53 body reflective markers was used. Data was recorded with the Vicon Blade 2 software with a frequency of 120 Hz. Second, Xsens MVN Link wearable inertial sensor-based system with 17 inertial sensors was used, and the data was recorded with the Xsens MVN Analyze 2018.2 software with a frequency of 240 Hz. Third, a depth camera-based MoCap system, Microsoft Kinect v2 was mounted on a tripod and positioned at 1.3 m height from the ground and 2.5 m distance from the participant, facing exactly the front (0°) of the participant. The body joint data was recorded by a self-developed data acquisition software based on Kinect for Windows SDK 2.0 with a frequency of 30 Hz.

2.2 Experimental Procedure

After being informed of the experimental procedure, participants were asked to wear the Xsens MoCap suit, and 17 inertial sensors were attached by experimenters. After finishing the calibration process of Xsens to initialize the setup, participants put on a Vicon suit on the top of the Xsens suit, and 53 reflective markers were properly attached at anatomical landmarks by experimenters. No serious interference between two suits that hindered accurate placement of the Xsens sensors and the Vicon markers was found. After calibration for the Vicon system was conducted, subjects were asked to stand at the capturing spot where the Kinect sensor was properly positioned.

During the main experiment session, participants were asked to perform 6 experimental tasks (Fig. 1). Each task was repeated three times. Four tasks ((1)–(3), (5)) used in this study were adapted from postures introduced in previous studies [19, 22, 27]. Task (4) and (6) were added to consider different degrees of clutters or self-occlusions. The human motion data of participants while performing experimental tasks was captured and recorded by three MoCap systems simultaneously (Fig. 2).

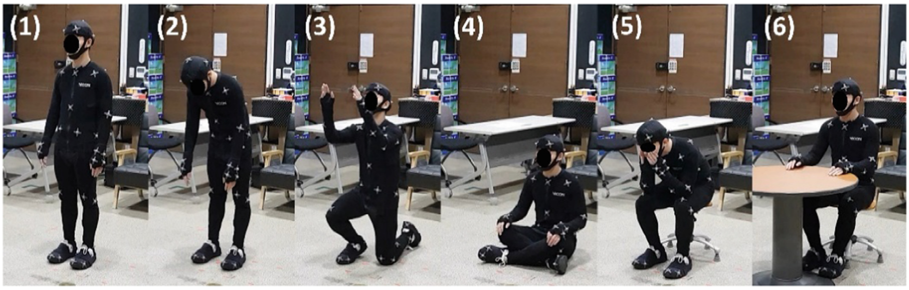

Fig. 1. The tested static postures: (1) upright standing, (2) trunk flexion, (3) kneeling above the head, (4) sitting on the ground with legs crossed, (5) elbows on knees, and (6) sitting at the desk

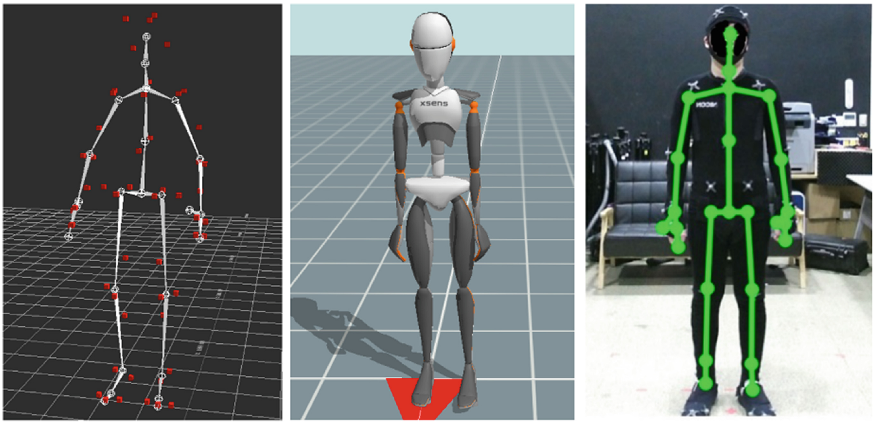

Fig. 2. Human motion data captured from three MoCap systems: Vicon (*left*), Xsens (*middle*), and Kinect (*right*)

2.3 Calculation of Joint Angles

For RULA and REBA analyses, 22 joint angles (neck flexion/side-bending/twisting, trunk flexion/side-bending/twisting, left/right shoulder flexion/abduction/raise, left/right elbow flexion, left/right wrist flexion/deviation/twisting, and left/right knee flexion) are required. Among them, 5 joint angles (neck twisting and left/right wrist deviation/twisting) were excluded from the analysis due to the inability of Kinect for getting accurate measures [22]. The target joint angles to be investigated in this study are for ergonomic postural assessment, hence all joint angles were set to 0 when standing upright as in the case of RULA and REBA. The mean of three trials of the upright standing task of each subject was used to offset the measurements.

While joint angles of Xsens were exported from the MVN Analyze 2019.1 software, joint angles of Vicon and Kinect were calculated from the joint position output. Vectors that are parallel or perpendicular to the coronal, sagittal, and transverse body planes were derived based on left/right shoulder and left/right hip joints, and then used to project other body segment vectors in order to calculate target joint angles. Note that the wrist flexion angle from Kinect was approximately assessed without projection by calculating the angle between the lower arm and hand segments. Interested readers can refer to the study of Manghisi et al. [22] for details.

2.4 Data Processing and Analysis

After data from different systems were equally resampled and synchronized, five consequent non-outlier data frames were extracted and the average values were used for the analysis. It is worthy to note that joints identified by Kinect do not come from a clear anatomical basis, thus counterparts from Vicon were landmarks with the nearest distance during the upright standing posture [19]. The mean absolute difference between joint angles from Vicon, Xsens, and Kinect was computed and compared, and then analysis of variance (ANOVA) and Tukey post hoc grouping tests were conducted with the significance level of 0.05. All data processing and calculation of statistics were performed using Matlab R2019a, SPSS 25, and Minitab 17.

3 Results and Discussion

Table 1 shows the mean absolute difference of joint angles between three types of MoCap systems. The overall mean absolute joint angle difference across all tasks and joints was the lowest between Vicon and Xsens with a value of 7.5°, followed by 9.4° between Vicon and Kinect, and 10.1° between Xsens and Kinect. The degree of overall difference was not negligible for joint kinematics which may require more accurate joint angle inputs but was considered to be acceptably low for ergonomic postural assessments where joint angle inputs are classified into two to five categories of the score.

Table 1. Mean absolute difference (SD) of joint angles between three types of MoCap systems in all tasks and joint angles (*Tukey post-hoc grouping results are indicated by superscript letters*)

Joint angle	MoCap*	Mean absolute difference (°)					
		Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
Neck flexion	V-X	0.4(0.4)^{a}	4.3(2.5)^{a}	15.7(8.0)^{b}	5.4(4.2)^{b}	10.5(6.7)^{a}	7.0(3.8)^{a}
	X-K	0.5(0.5)^{a}	12.2(14.2)^{b}	8.5(3.8)^{a}	3.3(2.4)^{a}	20.3(13.5)^{b}	9.4(11.3)^{ab}
	V-K	0.6(0.5)^{a}	14.3(13.5)^{b}	7.9(7.4)^{a}	8.1(4.8)^{c}	17.5(9.9)^{b}	14.0(9.7)^{b}
Neck side-bending	V-X	0.3(0.3)^{a}	2.3(1.8)^{a}	1.4(1.2)^{a}	2.0(1.4)^{b}	1.7(1.4)^{a}	1.4(0.8)^{a}
	X-K	0.5(0.4)^{b}	4.3(3.9)^{b}	2.2(1.4)^{b}	1.8(1.1)^{b}	7.2(11.6)^{b}	3.6(5.6)^{a}
	V-K	0.3(0.4)^{a}	3.1(4.4)^{ab}	1.2(1.2)^{a}	1.3(1.2)^{a}	7.1(11.9)^{b}	3.2(5.4)^{a}
Trunk flexion	V-X	0.5(0.3)^{ab}	6.1(3.3)^{a}	4.6(2.9)^{b}	3.1(2.5)^{a}	5.3(3.1)^{a}	2.9(1.9)^{a}
	X-K	0.5(0.3)^{b}	14.0(8.8)^{c}	3.8(2.3)^{b}	3.9(3.0)^{a}	15.5(6.1)^{b}	10.9(10.0)^{b}
	V-K	0.3(0.2)^{a}	9.8(5.8)^{b}	2.5(1.9)^{a}	5.1(2.4)^{b}	10.6(4.8)^{b}	11.3(8.8)^{b}
Trunk side-bending	V-X	0.3(0.2)^{b}	1.7(1.2)^{b}	1.6(1.3)^{b}	2.7(1.4)^{b}	3.8(1.9)^{b}	1.3(1.0)^{a}
	X-K	0.2(0.2)^{b}	1.8(1.3)^{b}	1.9(1.5)^{b}	2.7(1.3)^{b}	4.0(2.0)^{b}	4.3(5.5)^{b}
	V-K	0.1(0.1)^{a}	0.3(0.5)^{a}	0.5(0.6)^{a}	0.4(0.4)^{a}	0.2(0.3)^{a}	3.3(5.5)^{ab}
Trunk twisting	V-X	0.8(0.6)^{b}	6.2(2.3)^{c}	5.0(2.5)^{a}	4.5(2.8)^{ab}	7.3(3.3)^{b}	5.0(2.4)^{a}
	X-K	0.8(0.6)^{b}	4.3(3.1)^{b}	3.6(3.7)^{a}	3.3(2.4)^{a}	4.4(4.9)^{a}	4.4(4.3)^{a}
	V-K	0.3(0.2)^{a}	3.0(2.5)^{a}	5.2(3.9)^{a}	4.9(2.5)^{b}	5.0(3.5)^{a}	5.2(3.9)^{a}
Left shoulder flexion	V-X	1.1(0.9)^{b}	9.6(6.0)^{ab}	14.0(6.8)^{a}	12.5(5.4)^{b}	7.4(5.8)^{b}	12.7(4.2)^{ab}
	X-K	1.1(0.8)^{b}	9.9(5.9)^{b}	13.2(9.1)^{a}	12.0(5.6)^{b}	5.1(4.0)^{a}	15.9(9.0)^{b}
	V-K	0.1(0.2)^{a}	7.1(7.8)^{a}	12.6(8.7)^{a}	3.0(2.1)^{a}	7.6(7.1)^{b}	10.2(9.0)^{a}
Right shoulder flexion	V-X	1.2(1.3)^{b}	10.6(7.0)^{b}	15.2(10.1)^{a}	12.5(7.9)^{b}	9.1(6.5)^{a}	13.1(4.9)^{a}
	X-K	1.0(1.0)^{b}	10.0(5.9)^{ab}	15.2 (8.1)^{a}	12.8(7.9)^{b}	10.4(11.9)^{a}	16.3(10.0)^{a}
	V-K	0.4(0.4)^{a}	8.5(7.9)^{a}	14.5(6.8)^{a}	2.0(1.6)^{a}	10.0(13.6)^{a}	11.9(12.9)^{a}
Left shoulder abduction	V-X	1.0(0.7)^{b}	11.7(3.8)^{c}	6.4(4.4)^{a}	5.7(3.7)^{a}	9.4(5.0)^{b}	8.5(3.7)^{a}
	X-K	0.8(0.7)^{ab}	4.2(2.9)^{a}	17.9(9.3)^{b}	5.5(4.2)^{a}	4.5(3.3)^{a}	8.3(8.6)^{a}
	V-K	0.7(0.6)^{a}	7.5(3.1)^{b}	16.6(9.0)^{b}	7.5(5.0)^{a}	9.1(3.0)^{b}	15.5(8.4)^{b}
Right shoulder abduction	V-X	1.0(0.9)^{a}	10.5(5.6)^{b}	5.9(4.6)^{a}	6.5(4.5)^{ab}	10.2(4.8)^{b}	9.6(5.1)^{a}
	X-K	1.1(0.9)^{a}	7.4(5.7)^{a}	13.2(8.1)^{b}	5.7(5.1)^{a}	6.9(7.1)^{a}	7.5(6.1)^{a}
	V-K	1.1(1.2)^{a}	7.6(4.5)^{a}	13.7(7.8)^{b}	7.6(4.3)^{b}	11.0(7.9)^{b}	6.9(7.6)^{a}
Left shoulder raise	V-X	0.4(0.5)^{a}	5.8(5.0)^{a}	9.6(5.1)^{a}	2.5(1.8)^{a}	4.7(3.3)^{a}	4.0(2.7)^{a}

(*continued*)

Table 1. (*continued*)

Joint angle	MoCap*	Mean absolute difference (°)					
		Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
	X-K	0.4(0.4)[a]	11.9(5.4)[b]	10.2(5.5)[a]	5.6(3.4)[b]	10.2(7.5)[c]	12.1(8.1)[b]
	V-K	0.4(0.5)[a]	6.4(4.3)[a]	15.9(8.8)[b]	5.1(3.9)[b]	6.9(7.4)[b]	9.3(8.1)[b]
Right shoulder raise	V-X	0.4(0.3)[a]	4.0(2.7)[a]	10.2(6.0)[a]	4.4(3.4)[b]	3.5(1.8)[a]	2.4(1.9)[a]
	X-K	0.4(0.3)[a]	10.0(6.2)[b]	12.1(10.4)[a]	2.4(1.6)[a]	6.2(5.3)[b]	7.9(10.3)[b]
	V-K	0.4(0.3)[a]	7.8(5.0)[b]	19.7(12.8)[b]	3.9(3.8)[b]	6.8(6.1)[b]	8.8(10.2)[b]
Left elbow flexion	V-X	1.4(1.5)[a]	4.5(2.7)[ab]	27.7(14.3)[c]	14.1(7.5)[b]	31.2(13.5)[b]	9.0(5.0)[a]
	X-K	0.9(0.8)[a]	3.9(2.7)[a]	21.1(16.5)[b]	12.8(7.3)[b]	29.2(28.3)[ab]	14.2(9.9)[b]
	V-K	1.0(0.9)[a]	5.2(2.4)[b]	10.6(7.0)[a]	5.7(5.7)[a]	17.5(21.1)[a]	11.3(6.0)[ab]
Right elbow flexion	V-X	0.9(1.0)[a]	6.0(3.6)[a]	26.2(10.6)[c]	13.4(7.9)[c]	25.8(12.0)[a]	11.0(4.4)[a]
	X-K	0.6(0.5)[a]	5.9(7.3)[a]	19.2(12.6)[b]	9.9(6.9)[b]	26.9(32.2)[a]	18.1(12.9)[b]
	V-K	0.9(0.6)[a]	7.5(5.3)[a]	11.2(11.3)[a]	4.7(4.9)[a]	22.5(23.1)[a]	12.5(8.3)[a]
Left wrist flexion	V-X	0.5(0.4)[a]	3.5(2.4)[a]	9.6(11.2)[a]	6.4(4.9)[a]	18.0(14.3)[a]	9.8(14.6)[a]
	X-K	1.6(1.2)[b]	9.7(16.6)[b]	15.9(18.9)[ab]	11.6(9.5)[b]	22.5(13.7)[ab]	12.2(14.8)[a]
	V-K	1.6(1.3)[b]	9.4(16.1)[b]	20.6(18.2)[b]	8.6(6.9)[ab]	28.5(23.4)[b]	11.6(12.8)[a]
Right wrist flexion	V-X	0.7(0.8)[a]	3.2(3.8)[a]	17.3(17.5)[a]	8.9(6.9)[a]	21.8(15.6)[a]	12.9(15.4)[a]
	X-K	1.3(1.1)[b]	10.1(8.9)[b]	28.1(33.5)[a]	17.1(13.0)[b]	23.1(16.6)[a]	13.1(13.9)[a]
	V-K	1.8(1.4)[b]	9.9(8.9)[b]	31.9(36.5)[a]	13.4(12.6)[ab]	29.1(25.2)[a]	10.5(9.4)[a]
Left knee flexion	V-X	0.2(0.1)[a]	1.8(1.0)[a]	13.0(7.2)[a]	9.4(5.8)[a]	8.2(2.7)[b]	12.7(3.4)[a]
	X-K	0.5(0.3)[b]	12.9(9.0)[b]	102.9(28.7)[c]	16.3(12.4)[b]	5.5(4.3)[a]	19.3(14.2)[a]
	V-K	0.4(0.3)[b]	12.8(8.5)[b]	89.9(27.8)[b]	9.3(9.8)[a]	11.5(5.6)[c]	26.9(15.3)[b]
Right knee flexion	V-X	0.2(0.2)[a]	1.7(1.5)[a]	20.5(5.4)[b]	12.9(8.7)[a]	12.8(2.5)[b]	16.6(3.0)[a]
	X-K	0.4(0.3)[b]	10.9(7.0)[b]	23.5(8.7)[c]	29.5(24.3)[b]	4.6(3.5)[a]	25.7(20.2)[a]
	V-K	0.3(0.3)[ab]	12.1(6.8)[b]	4.9(4.5)[a]	25.7(22.1)[ab]	13.1(5.8)[b]	36.6(15.8)[b]

*V: Vicon; X: Xsens; K: Kinect

The range of difference between Vicon and Kinect was generally consistent with previous studies [18, 21], however, the result of this study includes some cases with occlusions which eventually lead to fairly or extremely large joint angle differences (e.g. left knee flexion at task 3).

The difference between Vicon and Xsens tended to be lower or similar compared to the difference between Kinect and the other two systems in most cases, but some obvious exceptions were found in elbow flexion. At more complicated postures with larger degrees of elbow flexion, a large difference (20°–30°) between Xsens and the other two systems was found, and further analysis revealed that Xsens has a tendency to overestimate elbow flexion angles than the other two systems.

There were multiple indications of the low accuracy problem of Kinect when occlusions occurred. The left knee flexion angle at task 3 showed a case of complete occlusion of a body segment, where the left lower leg of the participants was completely hidden from the sensor when knelt down. Kinect assumed the leg was straight not knelt hence generated very large difference. On the other hand, the right knee flexion angle at task 4 and 6 demonstrated cases of partial occlusion of a body segment, where the left leg blocked the right leg at task 4 and the desk blocked the lower body at task 6. The joint angle difference calculated from the occluded body segment was not as high as the case of task 3 but showed a considerable increase in comparison with other tasks. Finally, task 5 presented a case of partial occlusion of multiple body segments. The lower arms and hands partially blocked the face, the torso, and the upper arms, thereby contributed to the increase in the difference of neck flexion/side-bending, trunk flexion, and elbow flexion angles compared to the other tasks. Therefore, caution is needed when using Kinect for ergonomic postural assessments in the occluded environment.

Among all joint angles, the difference was the largest for knee flexion angles with a mean value of 16.8°, although the difference in knee flexion was highly influenced by the abnormal measurements from Kinect due to the occlusions. The mean difference of the wrist flexion angles to the exclusion of task 3 and 6 that have large knee flexion difference turned out to be the largest with the value of 10.9°, while the difference of knee flexion angles was reduced to 8.9°. The difference in wrist flexion angles was mainly caused by the insecure tracking capability of Kinect for capturing hand joints, indicating the risk of using wrist angle measurements from Kinect for ergonomic postural assessment.

This study has a limitation. The joint center locations from Vicon could be more accurate if the Plug-in Gait biomechanical model of Vicon Nexus was used instead of the labeling skeleton template of Vicon Blade. While Vicon Blade is certainly capable of capturing marker positions accurately, Vicon Nexus has been claimed to be more suitable for biomechanics and movement analysis even though the exact difference is unclear.

4 Conclusion

In this paper, we have compared the joint angle measurements from three types of MoCap systems (optical, inertial, and depth-based). The results showed that the overall difference between systems could be acceptable for ergonomic postural assessments, even though the Kinect tends to be less reliable than the other two systems. Considerable caution is required in case of using the Kinect, however, as the accuracy could decline significantly when body parts are occluded or calculating wrist angles. Different levels of occlusion resulted in different levels of accuracy reduction.

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Quantitative Assessment of Trunk Flexion in Nurses Using Wearable Inertial Sensor: A Pilot Study

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Abstract. Nurses are at increased risk to develop musculoskeletal disorders (in particular low back pain) due to prolonged exposure to awkward postures, but there is a lack of quantitative objective measurements useful to characterize such postures. In the present study, we employed a single wearable inertial measurement unit (IMU) placed in the low back to monitor trunk flexion of eleven professional nurses working at maternity and cardiology wards during two hours of a regular shift. Trunk movement was analyzed using an exposure variation analysis approach which classifies flexion in three classes (i.e. 30–60°, 60–90° and >90°). The results show that tested nurses spent 3.5% of the monitored time with their trunk flexed between 30 and 60° and 0.2% between 60 and 90°. The IMU-based approach appears suitable to perform long-term monitoring of trunk postures in workers at risk for musculoskeletal disorders, overcoming the limitation of the observational methods and questionnaires.

Keywords: Trunk posture · Inertial sensors · Nurses · Work related musculoskeletal disorders

1 Introduction

Nursing activities, which are characterized by a variety of tasks including patient's handling and transfers, supplies carriage, therapy administration etc. put nurses at high risk of work-related musculoskeletal disorders [1, 2], even considering that they are likely to spend a significant amount of time in awkward postures. Such condition is known to be among the most significant factors associated with the development of musculoskeletal disorders [3, 4]. In particular, epidemiological studies estimated that 50 to 60% of nurses report at least on occurrence of low-back pain (LBP) in the last six months [5]. Thus, a detailed and accurate estimation of the exposure to such critical postures is essential to improve the risk management process related to low back injuries [3, 6]. To date, the assessment of the working conditions is mostly performed by means of self-report measurements and observational methods. The former are easy to use and inexpensive, but biased by the subjective perception of physical work

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demand [7]. On the other hand, observational methods suffer from two kinds of issues related to the intrinsic nature of the nursing job: firstly, nurses perform non-cyclical tasks at several different workstations, which makes harder to use videotape techniques. Moreover, the nurse-patient interaction poses critical privacy issues that may arise when a direct observation by a third party is performed. For these reasons, there is the need to have available reliable non-obtrusive tools able to collect data about intensity, frequency and duration of any potentially harmful postures [8]. Recent studies demonstrated that wearable inertial measurement units (IMU) are suitable to quantitatively characterize the position and movement of several body districts during actual occupational tasks [9–11]. Thus, this pilot study aims to apply this approach to assess the postural exposure (especially in terms of trunk flexion) of a cohort of nurses during actual work shifts, using a single miniaturized unit placed in the low back.

2 Materials and Methods

2.1 Participants

Eleven professional nurses (9F, 2M), with (mean ± SD) age = 44.8 ± 6.7 years, height = 153.1 ± 21.6 cm body mass = 71.0 ± 31.9 kg and seniority of service 14.5 ± 10.4 years, currently enrolled at the maternity and cardiology wards of the Policlinico Universitario "D. Casula" (Hospital of the University of Cagliari, Italy) participated to the study on a voluntary basis. At the time of the experimental trials, they were all free from any sign of acute or chronic musculoskeletal condition.

2.2 Experimental Protocol

Workers' trunk posture was assessed using a lightweight miniaturized inertial sensor (G-Sensor, BTS Bioengineering S.p.A., Italy) which includes tri-axial accelerometer, gyroscope and magnetometer. The device was placed on the low back approximately at their first lumbar vertebrae (L1) [12] using a dedicated semi-elastic belt. Participants were also requested to wear two activity trackers validated for clinical use (Actigraph GT3X, ActiGraph Corp., USA) on both wrists to obtain an overall indication about amount and intensity of the physical activity (PA) carried out during the shift. The GT3X device, which is based on a three-axial accelerometer, allows to assess number of steps, percentage of PA spent at different intensities and vector magnitude count (VMC), that is an aggregate measure of movement based on the accelerations recorded on the three axes by the device. All sensors were worn continuously for two hours of regular actual shifts during which nurses performed their common routine tasks.

2.3 Data Processing

Raw accelerations and angular velocities recorded onboard by the low-back IMU at 100 Hz frequency, were processed by means of a custom routine developed in Matlab (R2019a, MathWorks, USA) to estimate and classify trunk flexion angles as follows [14]:

- Class 1: flexion angle = 30°–60°
- Class 2: flexion angle = 60°–90°
- Class 3: flexion angle > 90°

Subsequently, using an approach based on Exposure Variation Analysis (EVA) [13] duration of exposure to each posture class was calculated, using time periods of 0–2 s, 2–4 s, and > 4 s. At last, we calculated the time spent in each of the combinations of posture class and time period classes in terms of either frequency or percentage of the total working time.

Data acquired from wrist-worn trackers was processed using the dedicated software Actlife (v6.13.4 ActiGraph Corp., USA), to obtain number of steps and PA intensity classification performed on the basis of the cut-points for the acceleration proposed by Hildebrand et al. [14] for wrist-worn devices in healthy adults. Data were processed both considering the entire period of acquisition and separately for the first and second hour to evaluate repeatability. For each outcome measure noted above, descriptive statistics and the coefficient of variation (CV = mean/SD) were calculated. The latter was used to provide an index of inter-subject variability among PA parameters and trunk-flexion patterns. Paired *t*-tests were used to test for differences between the first and the second hours of acquisition. The level of significance was set at $p < 0.05$, and all statistical analyses were performed using SPSS software (v.20, IBM, Armonk, NY, USA).

3 Results

3.1 General Considerations

Data provided by the wrist-worn activity trackers (reported in Table 1), show a substantial similarity across all the tested operators in terms of number of made per hour and percentage of PA spent at different intensities. In particular, during the acquisition period the participants carried out approximately 1340 steps/h and spent 76.3% of time in moderate to vigorous PA (MVPA), with relatively small inter-subject differences (defined by CV) of 12.2. Such value is in agreement with previous studies which reported that nurses are characterized by an energy expenditure that include up to 90% of MVPA during a regular working day [15].

Table 1. Physical Activity parameters assessed from wrist-worn accelerometers. Values refer to 1 working hour.

Parameter	Mean ± SD	CV
VMC	269576 ± 84467	31.3
Steps	1340 ± 447	33.4
% of Light Intensity PA	23.6 ± 9.3	39.4
% of Moderate Intensity PA	69.2 ± 10.3	14.9
% of Moderate-to-vigorous PA (MVPA)	76.3 ± 9.3	12.2

3.2 Trunk Flexion

Processing of trunk accelerations collected by the IMU placed on the low-back, revealed that participants spent approximately 4% of time in flexed posture and the EVA analysis show that, during this period, the patterns of flexion were quite various in terms of both amplitude and duration. In particular, we found that for the 60% of the time the trunk was flexed with angles between 30 and 60° (i.e. Class 2), while 35% of time refer to Class 3 flexion and a negligible percentage was calculated for Class 4 flexion angles.

In terms of duration, most flexion events (approximately 60%) last 1 s or less, 30% of them are in the range 2–4 s and 10% were kept for more than 4 s (Fig. 1).

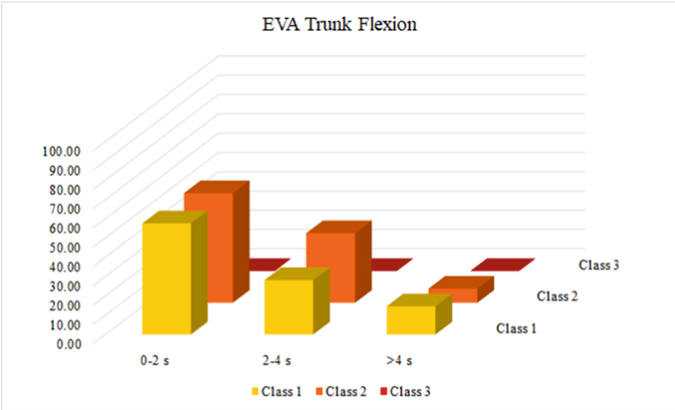

Fig. 1. Frequency of trunk flexion classified for amplitude and duration. Vertical axis reports the percentage of the total acquisition time spent in flexed posture.

The analysis of the two hours of monitoring performed separately did not find any significant differences in terms of patterns of flexion considering either only the first or the second hour of monitoring (see Table 2).

At last, it is noteworthy that the analysis of variability suggests that although the working task was found similar in terms of physical profile for all the tested workers (as indicated by the low CV values associated with the PA parameters) some relevant differences exist in terms of trunk movement strategies. In fact, the CV values calculated for the different ranges of trunk flexion are more than double with respect to those associated with PA parameters.

Table 2. Percentage of time spent in different classes of trunk flexion.

Classes	Mean ± SD	Mean ± SD	Mean ± SD	CV
	All Monitoring	1st Hour	2nd Hour	All Monitoring
30–60°	3.5 ± 2.7	2.9 ± 1.7	4.1 ± 4.0	77.7
60–90°	0.2 ± 0.1	0.1 ± 0.1	0.2 ± 0.2	51.8
>90°	negligible			

4 Discussion and Conclusion

Since low-back disorders (LBD) are among the most common musculoskeletal disorders that affect nurses, the interventions aimed to prevent them, or at least reduce their negative impact, are of crucial importance. In this regard, it appears essential to have available specific tools capable to accurately assess the exposure to the most relevant factors, which are known to influence the risk of LBD onset. Such tools should certainly allow assessing intensity, duration and frequency of relevant movements, but there are other important aspects to consider, such as the intrinsic approach of each individual to the working task according to his/her anthropometry, physical fitness and experience. This can originate a certain degree of variability even when the task is well defined and repetitive.

In this context, our study summarizes the attempt to characterize trunk flexion exposure in nurses during an actual shift, using a simplified non-obtrusive setup composed by a single IMU placed on low back and processing the experimental data according to the EVA approach. Our results show that, on average, nurses spent 3.5% of working time with their trunk flexed between 31° and 60° and only 0.2% of time with trunk flexed between 61° and 90°. According to what previously reported in similar studies, such figures depict a relatively low risk for their tasks. In fact, Hoogendorn et al. [16] and Coenen et al. [17] indicated that workers are at an increased risk of onset of LBD is they spend either more than 10% of their daily shift with a trunk flexion exceeding 30°, or more than 5% of the time with trunk flexion exceeding 60°. Thus, considered as a group, the nurses here tested appear to be at low risk of LBD based on their trunk flexion exposures. Such results are somehow contrasting with previous studies that indicate high levels of flexion in nurses but it should be considered that there is a great variability in the postures according to the ward in which nurses operate. A recent study by Nourollahi et al. [3] show that the percentage of time spent with trunk flexed with angles $\geq 45°$ changes dramatically passing from Intensive Care Unit (for which is approximately 60%) to maternity (approximately 10%). The latter ward, which is also one of the cases investigated in the present study, probably represents the less challenging condition in terms of trunk flexion demand.

An interesting aspect of our study is represented by the separate analysis of the first and second hour of working. As no significant differences were found (and this indicates that the intra-subject repeatability is quite good), this suggest that probably a single hour of monitoring might be sufficient to capture the most relevant information about the overall level of exposure. The search for the minimal optimal period of monitoring is a topic that requires further investigations on larger cohorts, as a reduction of this period would allow an easier and faster monitoring of large groups of workers.

Of course, some limitations of the study should be acknowledged. In particular, the choice to use a single IMU to estimate the trunk flexion, although very convenient in terms of minimal disturbance to the operator's work, implies that the spine is modelled as a rigid segment, but of course, this is a rough approximation. In fact, for instance, the thoracic part of the spine might assume a non-neutral posture even when this does not occur for the lumbar part. Such differences cannot be captured by the setup here employed. In addition, in the present study, we investigated only trunk flexion (being this movement strongly associated with LBD onset) but, in principle, the IMU would allow also the analysis of other movements like lateral bending and axial rotation.

In conclusion, the present pilot study demonstrated that a simple measurement setup based on a single miniaturized IMU, may effectively support the assessment of quantitative details associated with the exposure to non-neutral postures in nurses activities, taking into account the amplitude, duration and frequency of trunk flexion movements. In particular, given the non-repetitive nature of nurse's job, this approach is suitable to highlight the existence of different movement strategies, overcoming the limitations associated with time-consuming observational methods. Future studies should also consider possible asymmetric component of movements (such as combined flexion-rotation or flexion-lateral bending) and the effect of ward type and individual's anthropometry, which are also known to represent a co-factor in the onset of musculoskeletal disorders.

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Comparing the Ergonomics of Gestural Interfaces While Running on a Treadmill

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Abstract. Interactions with treadmills are based on pressing buttons or through a touchscreen. However, these interactions require the user to touch the frontal dashboard of the treadmill while running. Indeed, for each interaction that the runner does, the user needs to break her/his running form to reach the interface. Those actions cost also some additional energy to the runner with a possible impact on performance. Current technologies allow finding a better solution for the runner like gesture-based interaction. This paper presents a comparison of different interaction modalities, including gestures, on a treadmill. The goal of this study is to analyze the ergonomics of gestural interfaces while running on a treadmill. In fact, specific tailored gestures are perceived as more natural and easier to perform while doing an activity and can improve significantly the user experience.

Keywords: Gestural interface · Interaction while running · Treadmills

1 Introduction and Background

Digital technologies in fitness equipment are becoming more and more common. Indeed, they are used for tracking performance, displaying information, interacting with gym equipment and many other uses [1]. These new technologies are influencing how the athlete interacts with her/his context while being at the gym and doing sports [2]. In particular, some research studies explored how alternative interaction modalities can improve the user experience, for instance Run&Tap [3] show a new way to interact with a system while running by touching different points on the body. However, that solution is more oriented for running outside. Therefore, interaction modes while running on a treadmill are still unexplored and also offer new interesting opportunities. We analysed three different interfaces: one gesture-based wearable, the Myo bracelet, one gesture-based environmental, the Leap Motion, as well as a tactile interface as control condition. The Myo was selected because it is wearable and needs little movement to perform a gesture reducing the impact on the runner form. The Leap was selected because although it requires the user to interact in a specific area, the zone in

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which movement is captured is fairly large and no considerable effort is required to reach a specific spot. Indeed, this larger interacting area can allow a significant margin of error when doing the gesture in contrast to a tactile interface that requires a lot of precision and aiming to interact with during the activity. The gestures were specifically designed for each interface. Each system has five functions: speed up, speed down, inclination up, inclination down and start/stop. The gestures were designed considering two main factors [4]: the relation to locomotion, running in this case, and the inhibition on interaction that can cause those gestures.

The running form is important when it comes to performance [5]. To create a movement on a treadmill, it is necessary to take an interest to what composes the running economy. The latter is basically the oxygen cost of running at a certain speed. A lot of factors impact the running economy, but we will focus only on the running form. However, for now, we cannot establish the perfect running form. As a matter of fact, only some mechanical key points are known to help a runner having a better running economy [6]. Most of them are from the hips to the toes. It feels intuitive that the runner uses her/his legs to run, so it is difficult to create an interaction with them and the treadmill. The arms are used to balance the body weight during the run. They are, therefore, also used during the activity. On the other hand, it is easier to use them for interaction since they are free. The runner's body is also slightly bent forward. Normally the runner has an interface in the form of a touch screen or buttons in front of her/him. He normally uses her/his steering arm to interact with it.

2 Interfaces

The Myo bracelet can recognize the movements of the user's forearm (the one where the Myo is placed). It analyzes the electrical activity of the muscles, and thus can recognize certain movements (Table 1). The problem with this prototype is the accuracy that the user must have during interactions.

Table 1. The commands used with the Myo and the explanation of the gestures

Command	Explanation
Increase the speed	With your Myo-tracked hand, make a right-hand movement with the wrist
Decrease the speed	With your Myo-tracked hand, make a left-hand movement with the wrist
Increase the inclination	With your Myo-tracked hand, make an opening movement
Decrease the inclination	With your Myo-tracked hand, make a closing movement
Soft start/stop	With your Myo-tracked hand, double tap with your fingers

The Leap motion is a small device equipped with 3 infrared cameras that can model the joint skeleton of one or more hands standing above the sensors (Table 2). The problem with this prototype is that the user must have her/his hands exactly on the Leap motion for it to detect the hands. This creates a restrained area of interaction in the air. This area must be understood by the user, if he/she does not want parasitic movements to be detected.

Table 2. The commands used with the Leap motion and the explanation of the gestures

Command	Explanation
Increase the speed	With one hand above the leap, make a swipe to the right
Decrease the speed	With one hand above the leap, make a swipe to the left
Increase the inclination	With one hand above the leap, make an upward elevation
Decrease the inclination	With one hand above the leap, make a downward elevation
Soft start/stop	With one hand above the leap, make a circle with one of the fingers

Finally, our experiment comprised a tactile interface. The goal is to create a simple interface that looks like a Technogym treadmill dashboard. The interface that we developed was made on JavaFX (Fig. 1). The interface is simple to prevent an excessive workload when interacting with it. The use of colors makes it easy to recognize the buttons during the interaction.

3 User Experiment

For every question in the experiment, we used a 5-point Likert scale [7] ranging from "Strongly disagree" (1) to "Strongly agree" (5). We conducted the study with 12 participants (11 men) with an average age of 24.25 years. We note that our set of participants is well balanced between the ones that run regularly (score 2.9) and those who do not. Notably, the former group also do not often run on treadmills (score 1.6) and usually do not use gestures to interact with systems (score 1.75). Participants were first informed of the experiment content and were asked to start it by answering the introductory questionnaire. We then explained the first interface and how to interact with it. The participant got on the mat, and found her/his running speed, and then she/he tried the interface (Fig. 1) with a few movements. Once she/he had a comfortable speed and is ready, we started the timed test. When the test was completed, she/he had to complete the questionnaire on the interface based on the Software Usability Scale (SUS) [8]. The SUS is a fast and reliable test to determine the usability of a service/system. It consists of 10 questions that also use the Likert scale like all other questions. At the end of each test, the rider must complete a questionnaire per interface which includes:

– Do you need a lot of precision and concentration to do the movements?
– Do the interactions impact on the way of running?
– Are the movements easy and natural to do during the race?

This process is repeated for each type of interface. In a running session, for each type of interface, the runner must do the movement "Start/Stop" 10 times, 10 times "Increase/Decrease" the speed and 10 times "Increase/Decrease" the gradient. Each interaction is timed. This provides an average of time per interface per interaction. In addition, we also note any error (movement not recognize or false movement). In order to compute the average error rate per movement. Interactions are dictated to the user verbally by the examiner.

Fig. 1. On the left the tactile interface on a tablet and on the right the Leap Motion, everything is on the treadmill that will be used by the runner.

4 Results and Discussion

Table 3 shows average timing of the action along with the average error rate per action, for each interface and each movement.

Table 3. The results of each interfaces with the average time for each action and the average error per action.

Device	Action	Average time in second	Average error per action
Tactile	Increase speed	0.74 s (SD = 0.11 s)	18.3%
	Decrease the speed	0.75 s (SD = 0.088 s)	10%
	Increase the angle	0.755 s (SD = 0.137 s)	15.8%
	Decrease the angle	0.747 s (SD = 0.139 s)	16.7%
	Start/Stop	0.61 s (SD = 1.161 s)	1.7%
Leap	Increase speed	0.552 s (SD = 0.114 s)	17.5%
	Decrease the speed	0.563 s (SD = 0.117 s)	33.3%
	Increase the angle	0. 566 s (SD = 0.126 s)	11.7%
	Decrease the angle	0.588 s (SD = 0.09 s)	35%
	Start/Stop (6 people)	1.928 s (SD = 1.194 s)	120%
Myo	Increase speed	0.507 s (SD = 0.095 s)	5%
	Decrease the speed	0.5 s (SD = 0.112 s)	10%
	Increase the angle	–	–
	Decrease the angle	–	–
	Start/Stop	–	–

First, it is important to report the difficulties encountered during the tests. Indeed, during the study, we decided to stop testing the “Start/Stop” for the leap. Only half of the participants were timed for their actions (i.e. 6). Indeed, doing a circle with the arm in a specific area while running is not obvious and was not well detected. After too many failures and frustrations of the users, the “Start/Stop” movement was removed from the study for practical reasons. It can also be noted that the actions “Decrease speed” and “Decrease angle” for the Leap have a higher error rate than “Increase speed” and “Increase angle”. The reason for this is simple: to reduce the angle/speed, the user must first do the opposite movement to have the hand positioned in the right place. This can be recognized as an increase before performing the decrease gesture (Fig. 2).

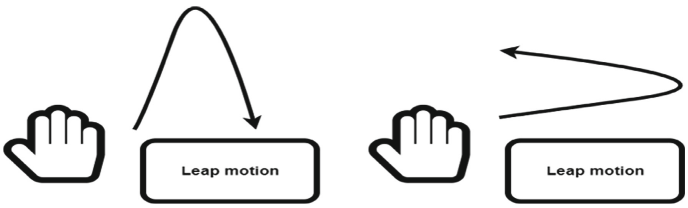

Fig. 2. On the left, the motion of the hand going up (increase the angle) and down (decrease the angle). On the right the motion of the hand going right (increase the speed) and left (decrease the speed).

The movements “Increase angle”, “Decrease angle” and “Start/Stop” were not recognized by the Myo during the run. Indeed, running makes the fingers shake and the hand move so that the “Double tap” of “Start/Stop” is automatically activated, and occurs too often. However, the gesture is not well recognized if it is done voluntarily. “Decrease angle” was also not appropriate, as the movement was to close the fist, and this was the default hand-posture of some of the participants. We had to take these movements out of the study because they were impossible for the participants to do while running and would have slowed down the study and provided unnecessary information. What we can observe on the Myo concerns only the movement with the wrist for the speed up and down that did work properly. We can see that the timing is almost the same, but the error of the left-movement for decreasing the speed (direction of the body) has 2 times the error rate of the right-movement. Our interpretation is that a movement of the wrist towards the inside of the body or the opposite hand with the wrist is more common when running than the movement outside that feels a bit abnormal. So, the runner would not do accidentally the movement outside of her/his wrist but could accidentally do the movement inside.

Ideally, the study should be repeated using other movements specifically designed for running. These movements should be based on runners’ feedback and opinions. This would allow implementing gestural interfaces that would be natural and intuitive for the runner while avoiding compromising the running form.

At the end of the study it was unanimous for the users that a touch screen-based interface for interacting with a treadmill is not a practical solution (score 4.42). The users preferred the Myo based interface despite the error during the study. As a participant said: “One can interact with the machine without decreasing the running speed.” And “You do not have to target a particular area or pay attention to its movements.” Or “One can interact with the machine without decreasing the speed because it is more responsive and less restrictive.” We can say that the main argument for the Myo was that this interface does not disturb the running and it is quick to react to the user intention. However, the preference for the Myo was not unanimous. Some of the users were not pleased with it because “It is annoying to carry an object on your body during the race.” They preferred the Leap because for them it was “It is more natural and easier to use because there is no need to be too precise”. So, for some of them wearing a device was perturbing and not a comfortable choice when it comes to a physical exercise.

For the users, both interfaces still interfere with the running motion (score 1.92 for the Leap and score 1.83 for the Myo). However, the movements felt easier and more natural to do while running with the Leap (score 2.58) compared to the Myo (score 2.33). Despite the user-friendliness of the Leap, the users think that it still requires more accuracy and focus to interact with the Leap (score 2.42) than with the Myo (1.83). We think it is partly due to the constraint of the zone where the interaction with the Leap needs to take place compared to the freedom of the Myo where they can perform an interaction anywhere. A small difference that we note is that the Myo bracelet was slightly more responsive (0.06 s less than the Leap). We can say that the error rates of the interfaces are more or less the same (around 1–1.2) except for the “Start/Stop” of the tactile interface. Indeed, the error rate is only (0.017) which is explained by the accessibility of the button. It is in the middle of the interface and is larger than the others.

5 Conclusion

We presented our study where we compared three different interaction modalities to command a treadmill while running, which are: touchscreen, gestural interface in the air based on the Leap device, and a wearable gestural interface based on the Myo armband. The results show that users prefer gestural interfaces, in particular the wearable one, to touchscreens. However, choosing the adequate gestures for an interface is more complex than it seems, and the default gestures implemented in the Leap and in the Myo are not adequate for interacting while running. The movements need to be natural for the runner for not compromising the running form and they also need to be well calibrated for an easy recognition by the system. Not only accuracy is key to the adoption of gestural interfaces for runners but also avoiding false positives should be a priority, since running implies moving the arms and this can interfere with the gestural interface if not properly designed.

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On the Analysis of the Relationship Between Alkaline Water Usage and Muscle Fatigue Recovery

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Abstract. The lactate concentration significantly increases during exercise destabilizing the cellular acid-base balance. In this study, we examined the relationship between alkaline water usage and muscle fatigue recovery measured as the change in lactate concentration. Thirty healthy subjects were asked to pedal on a cycle ergometer for 25 min at a constant pace. At the end of the physical exercise, each subject was asked to drink, in one hour, either one liter of water with a pH equal to 6.9 (control) or one liter of alkaline water with a pH value ranging between 8.5 and 9.3 (experimental). The two conditions were separated by an interval of 24 h. The concentration of the lactate was measured just after the physical exercise and after the water consumption. In control condition, there was not significant change in lactate concentration ($p = 0.097$), whereas, in the experimental condition, the lactate concentration measured after the alkaline water consumption was significantly lower than the concentration measured just after the physical exercise ($p < 0.000001$). The observed results have proven the beneficial effects of the alkaline water on the reduction of the lactate concentration thus accelerating the muscle fatigue recovery process.

Keywords: Alkaline water usage · Lactate dehydrogenase · Muscle fatigue recovery

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1 Introduction

In the human body, the production of energy in the form of adenosine triphosphate (ATP) is mainly driven by aerobic processes thus needing oxygen. When the level of cellular oxygen is too low, the cells produce energy through anaerobic mechanism with a lower efficiency than the aerobic one [1]. Lactic acid is a by-product of energy production in the anaerobic state, as example during an intense muscular activity [2]. The lactic acid is generated by the interconversion of pyruvate into lactate that is mediated by the lactate dehydrogenase (LDH). Hence, the concentration of lactic acid within the blood can be seen as a direct evaluation of the oxygen availability [3]. Since the lactic acid is a weak acid, it dissociates in water resulting in ion lactate and H^+. Such accumulation of H^+ is the main cause of the cell acidity increase (Figs. 1 and 2).

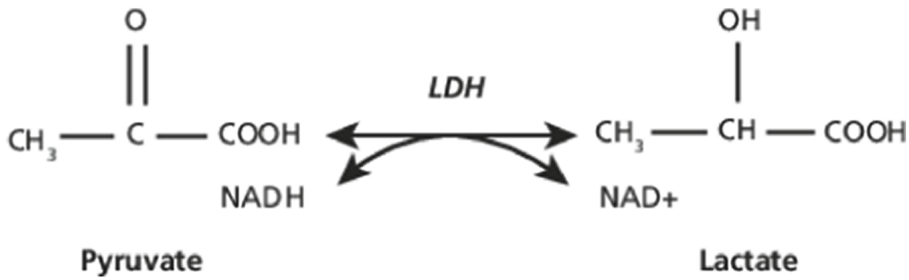

Fig. 1. Lactate dehydrogenase (LDH) conversion of pyruvate and lactate.

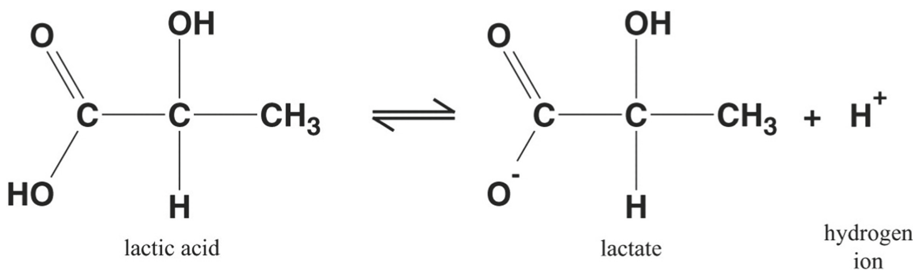

Fig. 2. Lactic acid deprotonation.

In medical practice, the acid-base balance is often underestimated even though it is well known that lifestyle changes, especially in food, produce substantial benefits. An incorrect diet can indeed lead to an acid-base imbalance with consequent negative symptoms, such as cramps, muscle fatigue and accumulation of lactic acid. Basic therapy can be used to treat numerous pathologies and several studies have already focused attention on the benefits deriving from the consumption of alkaline water. However, the relationship between alkaline water usage and muscle fatigue recovery is not yet fully understood.

The main goal of this study regards the analysis of the relationship between the usage of alkaline water and muscle fatigue through the quantitative evaluation of hematochemical parameters, in detail we have analyzed the change in concentration of the lactate within the blood after the consumption of two different water: normal water with a pH equal to 6.9 and alkaline water featuring a pH ranging in [8.5–9.3].

2 Materials and Methods

2.1 Subjects

Thirty healthy males (age: 30.2 $\pm$ 4.1 years old) volunteered to participate as subjects for this study after being fully informed of the procedures and possible side effects. The exclusion criteria were: 1) being a smoker, 2) practicing either amateur or professional physical activity, and 3) suffering from neuromuscular diseases.

2.2 Experimental Protocol

All subjects underwent two experimental conditions presented randomly and unknown both to them and to the clinical staff. Exercise testing was the same in each of the two conditions and consisted in pedaling on a cycle ergometer for 25 min without any resistance at a pace of 15 km/h. At the end of the physical exercise, each subject was asked to drink, in one hour, either one liter of water with a pH equal to 6.9 (control) or one liter of alkaline water with a pH value ranging between 8.5 and 9.3 (experimental). The two conditions were separated by an interval of 24 h.

The alkaline water used in this study has been produced with a domestic reverse osmosis plant equipped with two osmotic membranes characterized by a salt rejection lower than 97.5% and a chlorine tolerance lower than 0.1 ppm. The used domestic plant is also able to remineralize the post-osmotic water by constantly introducing an alkaline concentrate (Patent n. 0000276383; Class I Medical Device BD/RDM 1438157) [4].

The concentration of the LDH within the blood was assessed 1) five minutes before the beginning of the exercise test, 2) two minutes after the end of the exercise test and 3) after the consumption of the defined amount of water (one hour from the end of the physical exercise). The accumulation of LDH was determined by analyzing a peripheral blood sample with the spectrophotometric reader CR 4000 – Callegari [5]. The employed reader has the following technical features: wavelengthequal to 505 nm, sample path length equal to 1.0 cm, volume of the blood sample equalto 5 μl, and reaction time equal to 180”.

3 Results

The difference between the control (water with pH = 6.9) and experimental conditions (water with $8.5 < pH < 9.3$) has been assessed comparing the LDH concentration measured just after the end of the exercise test with the LDH level observed after the water consumption (1 h after the end of the exercise test). The statistical significance has been evaluated with a paired t-test ($p < .05$) and data normality was checked with Kolmogorov-Smirnov test. All statistical analyses have been performed using the IBM SPSS software [6].

Concerning the control condition (see Fig. 3), no significant difference was observed between the LDH concentrations measured after the exercise test ($M = 33.7$ mg/dl, $SD = 16.0$ mg/dl) and after water consumption ($M = 26.9$ mg/dl, $SD = 16.4$ mg/dl); $t(29) = 1.713$, $p = .097$.

Regarding the experimental condition (see Fig. 4), there was a significant difference between the LDH concentrations measured after the exercise test ($M = 32.4$ mg/dl, $SD = 14.7$ mg/dl) and after water consumption ($M = 20.3$ mg/dl, $SD = 13.2$ mg/dl); $t(29) = 7.317$, $p < .000001$.

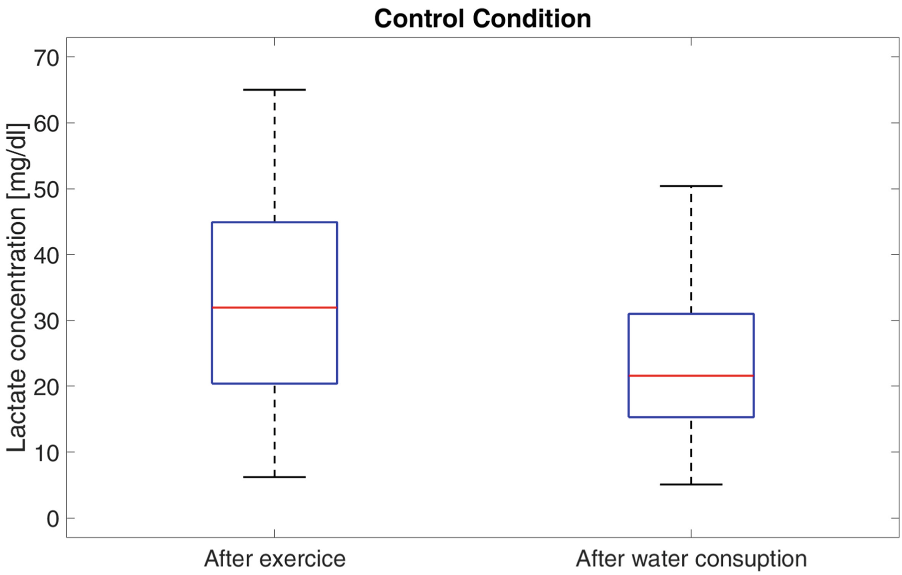

Fig. 3. Comparison of the LDH concentration after the exercise and the water consumption acquired in the control condition.

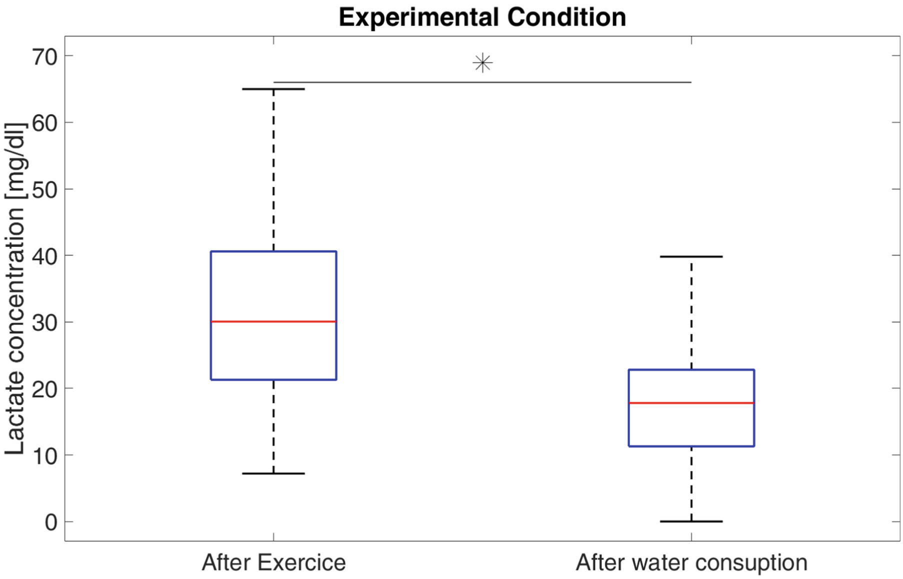

Fig. 4. Comparison of the LDH concentration after the exercise and the water consumption acquired in the experimental condition (* indicates $p < 0.001$).

4 Discussions and Conclusions

In the presented work we have investigated the effect of alkaline water on the muscle fatigue recovery. Thirty healthy subjects were involved in the study and underwent two different conditions: control and experimental. During both conditions, subjects were asked to pedal on a cycle ergometer for 25 min at a constant pace. At the end of the physical exercise, each subject was asked to drink, in one hour, either one liter of water with a pH equal to 6.9 (control) or one liter of alkaline water with a pH value ranging between 8.5 and 9.3 (experimental). The two experimental conditions were separated by an interval of 24 h. The observed results have shown a substantial difference between the effect of the normal (control) and the alkaline water (experimental). The consumption of water with a pH equal to 6.9 had no significant effect on the lactate concentration. Infact, the levels of lactate measured both just after the exercise test and after the water consumption, i.e. after one hour from the end of the physical exercise, were comparable ($p = 0.097$). Differently, we observed a significant decrease in the lactate concentration when subjects drank alkaline water ($p < .000001$). These results have proven the significant effect of the alkaline water consumption on the reduction of the lactate concentration. According to such evidence, future studies might prove that the regular consumption of alkaline water has beneficial effects on the muscle fatigue recovery due to its relationship with the lactate concentration. Future studies will also investigate the effect of the alkaline water on the muscle fatigue through an objective analysis of the surface electromyographic signals and movement quality [7–10].

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Posture Assessment and Subjective Scale Agreement in Picking Tasks with Low Masses

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Abstract. This study aims at analyzing the relationship between postural assessment and perceived discomfort for picking tasks with low mass (1 kg), involving a wide range of positions/postures. We analyzed the agreement of the different postural scores (mean value, integral value, root mean square value, weighted average time at each RULA level and the % of time per RULA level) with the subjective assessments. The statistical analysis showed no correlation between subjective and postural scores. A few negative correlations were also noticed, especially for time spent at specific levels of postural discomfort compared to subjective feedback. The results showed that the subjective assessment was not correlated with the postural assessment in such low discriminant tasks. Although postural assessment enabled to discriminate the more difficult postures with regard to the experimental conditions, the subjects were unable to report coherent discomfort feedback.

Keywords: Ergonomics · RULA · Motion capture · CP-50

1 Introduction

Assessing arduousness in work environments can be an effective mean to prevent the musculoskeletal disorders (MSD) that affect the different body parts, causing pain and discomfort, thus affecting, the daily work activities. Evaluating arduousness is a complex problem that entails several factors: biomechanical factors such as posture, repetition, force…, and psychosocial factors like stress, social status… [1]. Several tools have been developed in order to quantify ergonomic risks related to biomechanical factors. These methods can be classified into three groups according to the approach used in measurement [2]: (1) self-report, (2) observational [3, 4], and (3) direct measurement methods.

Self-report methods can be presented under different forms such as rating scales i.e. Borg scale [5] and CP-50 [6], checklists, questionnaires and interviews. The measurements using rating scales are based on the person's physical and mental

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sensitiveness; they vary depending on physical and environmental conditions. Observational methods are also used by ergonomists to evaluate different kinds of risks. NIOSH lifting equation can be used to assess risks mainly based on the load used in manual handling tasks [7]. Occupational Repetitive Actions (OCRA) [8] is mainly used to focus on frequency factors in repetitive tasks. The postural risk can be evaluated by using Rapid Upper Limb Assessment (RULA) method [9] or Rapid Entire Body Assessment (REBA) [10]. The posture score is divided into two groups: upper arms, lower arms and wrist for the first group and neck, trunk and legs for the second one. This score is adjusted with factors related to load handled and repetitive muscular activity to obtain the postural final scores, which varies from 1 for low risks to 7 for high postural risks in the case of RULA [9]. In all observational methods, the joint angles of different body segments and the load manipulated by the worker are scored using a worksheet corresponding to a collected key posture. The results validity for the observational methods depends on the collected input data [11], inter-rater reliability [12, 13]. To partly tackle this problem, observation could be replaced by direct measurements by using motion capture systems, such as optoelectronic systems or Microsoft Kinect [14, 15]. As arduousness at work is a multivariate phenomenon, assessing arduousness requires combining different methods. We could expect that combining various biomechanical, physiological and psychological factors would be correlated with the subjective feedback of the subject. But this correlation between subjective and objective measurements seems to be quite complex. Chihara et al. [16] reported little agreement between CP-50 and RULA for manual material handling tasks, when using 0 to 10 kg loads. In this paper, we propose to investigate this correlation for picking tasks with low mass, but with a high range of postures/positions, and continuous RULA measurement instead of static ones.

2 Materials and Methods

2.1 Protocol

We carried-out an experiment with 14 healthy subjects (five females and nine males); age (27.07 ± 7.6 years), stature (172 ± 11 cm) and body mass (65.64 ± 11.24 kg) respectively. The protocol was approved by a French national ethics committee (South West and Overseas 4 Persons Protection Committee) and registered under the reference n° 2019-A00218-49.

The experimental set-up was composed of a four-levels shelf of 40, 100, 170, 230 cm height and 30 cm left, middle and 30 cm right positions. A table was placed either to the right or left depending on the predominant subject hand. Twelve one-liter bottles, numbered from 1 to 12 were placed on the table in a random order. Before starting the experiment, each subject was asked to sign a consent form and was given a brief introduction on what the experiment was about in case he has questions or concerns.

At the beginning of each trial, the experimenter arranged the 12 bottles according to a random combination displayed in front of him. This random combination guaranteed the uniqueness of the order associated with each of the trials and prevented task-learning effects. Figure 1 represents a subject performing the experimentation. For each trial, the subject was facing the shelf. The bottles were placed on the table on the predominant subject side. The subject grabbed each bottle and placed it in the corresponding place. After placing a bottle, the subject had to evaluate the discomfort of the task according to the CP-50 scale. CP-50 defines five global categories of discomfort defined as follows: very slight discomfort, slight discomfort, discomfort, severe discomfort and very severe discomfort. After choosing a global category, the subject indicated the specific level of discomfort in the category on a 10-points scale. Paper labels were used in this experiment allowing the subject to note the difficulty for each task by placing the labels in front of the bottle. For each bottle, the subjects had to rate discomfort using these labels. The order was to compare the discomfort of picking and placing this bottle at the current placement, to the one in the middle level of the shelf. This latter placement was supposed to be the most comfortable configuration for all subjects, according to the French norm NF X35-109 [17]. More specifically, this norm assumes that the most comfortable position is between 75 cm and 110 cm for handling tasks. The subject returned to the table and took a new bottle for a new placement, and restarted the assessment process, for all the 12 bottles (a trial is defined as a picking and placing a set of 12 bottles). Once all bottles were placed on the shelf, the trial ended followed by a rest period before starting a new trial.

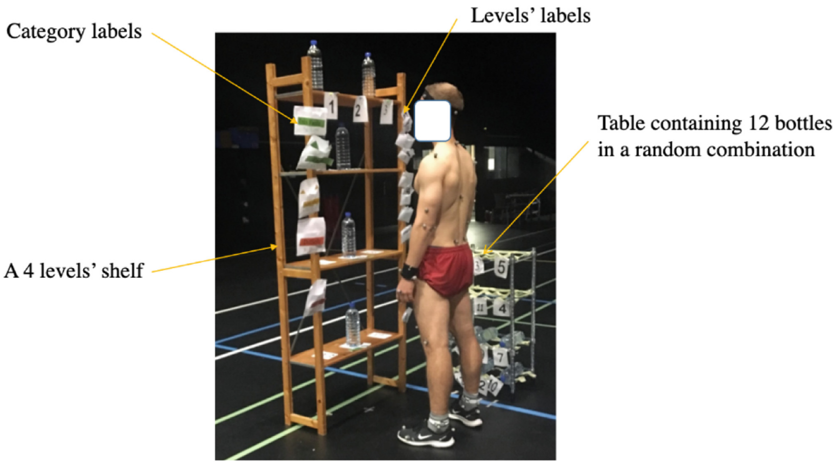

Fig. 1. A subject equipped with the 43 reflective markers following the ISB recommendations [18] facing the shelf, the table on his right and the bottles in a random combination.

An optoelectronic motion capture system Qualisys (composed of 23 12-Mpixels cameras, 200 Hz sampling frequency) was used to track 43 reflective markers placed on standardized anatomical landmarks, following the ISB (International society of Biomechanics) recommendations [18].

2.2 Data Processing

Based on the 3D position of the anatomical landmarks captures with the Qualisys system, joint angles were computed following ISB recommendations [18]. RULA scores were then computed using these joint angles. The RULA method involves adjustments for shoulder abduction\adduction movements, lateral flexion of the trunk. The threshold was set to 20° for the trunk and the wrist as suggested in [15], and 45° for the abduction\adduction of the shoulder. To compare the RULA score with the CP-50 score, both scores were normalized. The RULA score was normalized by the maximum of each score for all the bottles. Similarly, the CP-50 was normalized by the maximum of all placements of a trial. The RULA score was computed continuously all along the task at 200 Hz, whereas CP50 was collected as a unique score for each bottle placement. To obtain a unique postural score derived from RULA for each bottle, we tested different assumptions: the mean value of the continuous RULA score (1), the integral value (2), the Root Mean Square value (3), the weighted average time at each RULA level (4) and the % of time per RULA level (5).

$$\mathrm{Mean} = \frac{\sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{RULA}\ (i)}{N} \tag{1}$$

$$\mathrm{Integral} = \int_{\mathrm{t}=1}^{\mathrm{N}} \mathrm{RULA}\ (\mathrm{t})\mathrm{dt} \tag{2}$$

$$RMS = \sqrt{\frac{\sum_{i=1}^{N} RULA^2(\mathrm{i})}{N}} \tag{3}$$

$$\text{Weighted average time at each RULA level} = \frac{\sum_{\mathrm{i}=1}^{7} \alpha_{\mathrm{i}} * count(RULA = i)}{\sum_{\mathrm{i}=1}^{7} \alpha_{\mathrm{i}}} \tag{4}$$

$$\%\ \text{of time per RULA level:}\ \forall i = 1:7, level_i = 100\frac{count(RULA = i)}{N} \tag{5}$$

With

N: total number of frames.

RULA (i): the value of RULA at frame i.

Count (RULA = i): the number of frames where RULA value equals i.

α_i: weights applied to Count (RULA = i). In this paper we have chosen $\forall i$, $\alpha_i = i$ to give more weight for important RULA scores.

RULA: The time spent in each score level of RULA.

To explore the correlation between scores derived from RULA and subjective ratings of the discomfort of the task, a principal component analysis (PCA) was performed using a pxm matrix where p is the total number of subjects and m = 6 (5 scores derived from RULA and one CP-50 score). The highest PCA coefficients were selected (leading to explain at least 80% of the variance). To evaluate the consistency of the subjects' ratings for the different trials using the CP-50, an intra-class correlation coefficient (ICC) was computed. The difference between subjects' responses were also compared. This method allowed to explore how consistent were the ratings with regard to the experimental conditions.

3 Results and Discussion

Table 1. PCA coefficients for different assumptions and the (%) of total variance for the first three components.

		Coefficient relating to the different assumptions							
Total Variance (%)		Mean	Integral	RMS	Weighted average time	CP-50	%timeRULA = 4	%timeRULA = 6	%timeRULA = 7
First component	29.57	0.03	0.03	0.03	0.003	**0.99**	−0.007	0.03	0.01
Second component	25.67	0.25	0.25	0.26	0.10	−0.05	−0.29	0.73	0.05
Third component	23.81	0.11	0.11	0.08	0.03	0.06	0.82	−0.04	−0.03

Table 1 shows the results of the three first components of the PCA that described 79.05% of the total variance. The first component with 29.57% of the total variance was mainly based on CP-50 (99%). All the postural scores derived from RULA appear in the second and third components with 25% for the mean RULA score value, 26% for the root mean square RULA score value. The percentage of time spent at specific RULA levels (%time RULA = 1, 2, 3 and 5) were not significant in these three first components and therefore not reported here. We noticed a few negative correlations especially with the %time spent at RULA score equal to 4. The PCA results reveal that no correlation exists between the CP-50 and the postural scores derived from RULA. The ICC for all subjects and all trials was equal to 0.326, demonstrating a poor consistency of the intra and inter-subjects' ratings (CP-50 answers) with regard to the experimental conditions (bottle location on the shelf). We found poor correlation between CP-50 and postural scores, in agreement with the PCA analysis. Hence, although RULA scores enabled us to distinguish differences between the postures, our results show that discomfort reported by the subjects where inconsistent. Subject did not feel enough changes in the experimental conditions to clearly identify higher levels of discomfort for extreme postures (highest and lowest levels of the shelf for example). The CP-50 scale may also be too complex for such a task and may had resulted in a larger dispersion of the results. Concurrently, the scores derived from RULA logically reached higher levels for - assumed- more extreme postures. In the literature [16] showed a small agreement between CP-50 and RULA scores for handling task with 0 to 10 kg load. Similarly, [19] showed an agreement between RPE and physiological parameters for handling tasks with 23 kg load. Ours results seems to indicate that this agreement vanishes for the lowest load levels (1 kg). This result is in accordance with previous work [3] demonstrating that the heavier the weight is, the higher the correlation between postural and subjective assessment is.

4 Conclusion

In this study, the agreement between postural discomfort scores derived from RULA and self-report discomfort scores was investigated to explain the arduousness of the task. The major findings are:

1. The ICC of the subjects CP-50 ratings was low, indicating a poor consistency of the intra and inter subject answers with regard to the experimental conditions (here the postural changes related to the bottle placement).
2. The PCA analysis of the scores indicated that the postural assessment and the subject's answers were not correlated, in agreement with previous works.

Future works will involve a simpler rating scale to simplify the assessment for the subjects. The mass will also be increased to check the agreement found in the literature for such a task. The posture holding time will also be extensively investigated, since it is supposed to be a discriminant parameter to evaluate discomfort over time. Another interesting perspective would consist in investigating the subject fatigue with regard to repetitive tasks performed with low loads.

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Work-Related Musculoskeletal Disorders

Evolution of a Work-Related Musculoskeletal Disorder Risk Assessment Tool. The Case of CERA

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Abstract. The Composite Ergonomic Risk Assessment (CERA) is a well-known and popular tool in Hungary for estimating work-related musculoskeletal risks. CERA applies the requirements of the EN 1005 standard series and implements and practical solutions like discomfort mapping. The original paper-pencil version is available in Hungarian, English and Russian, and shortened versions are available for different jobs, e.g. office work, waste sorting and also motion-capture-based versions emerged. This paper describes the further development of this specific tool.

Keywords: Composite Ergonomic Risk Assessment · Musculoskeletal risk assessment · Hungary · Ergonomics · CERA

1 Introduction

According to the particular leading risk factor, professionals used several methodologies to assess wMSDs risk at the time of CERA publication in 2013. The aim of the development of our first paper-pencil tool was to cover all the risk factors for musculoskeletal disorders at the workplace and create a suitable instrument for performing risk assessment as an essential component of the occupational health and safety practice.

Although adaptations and translations of methods known in the international literature have provided state-of-the-art procedures, a genuinely high-level professional work required a domestic ergonomic risk assessment tool. The proliferation of CERA has related to that it is a core material in tertiary occupational health and safety training, in occupational safety inspector training and continuous professional development training for occupational health doctors.

The high-quality Hungarian ergonomics activity declined by the end of the 20th century, and the BME Department of Ergonomics and Psychology served as the only laboratory in the field, focusing mainly on cognitive ergonomics. Foreign companies entering the country following the political changes have brought with them the parent company's work culture and, as part of this, their workplace ergonomic practice and methodology. Local ergonomists responded to this challenge by adopting Western methods and educational materials, conducting studies, and launching workplace

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ergonomics development programs. Already in the mid-nineties, it was clear that sooner or later, this professional community has to develop its new ergonomic risk assessment method, to fully grasp its operation and incorporate their experience into it.

More than a decade later, at Óbuda University, emerged an opportunity to develop a new method for risk assessment of work-related musculoskeletal injuries [1]. Virtually the entire domestic ergonomic professional community was involved, tested the most modern instruments to determine the data, explored the available methodology, carried out laboratory and field tests and summarized findings in a study volume [2]. The method and the lateral scientific results were presented at conferences, and thus Hungarian workplace ergonomics became visible again in international professional forums [3].

The method was developed based on domestic practice and solutions that matched both practitioner knowledge and the needs of businesses. The method was named after the US Army Risk Assessment [4], which expresses the completeness of the risk assessment. The English CERA acronym also provides the usual sound of similar methods as REBA or WERA.

Hundreds of CERA evaluations are already made, for job evaluation and, due to its didactic design, for workplace ergonomics training. In addition to the original Hungarian and English versions, it has already been translated into Russian, and the first Russian studies are currently underway.

During the development of CERA, Hungarian ergonomists explored the limitations of risk assessment of the work-related musculoskeletal diseases and participated in the development of modern prevention tools.

2 The Paper-Based Version of CERA

The paper-based version of CERA implements the requirement of the EN 1005 standard series and consists of five sheets for assessing and summarizing posture [5], force exertion [6], manual lifting [7] and repetitive movements [8]. The design objective was to create an easy-to-use tool which enables professionals to record findings in the workspace while observing and evaluating the activity. Figure 1 shows the basic five-page paper-pencil version of CERA in English.

The first or summary sheet contains the description of the activity, the duration of the shift, the job identifiers, the portion of the standing/sitting/walking postures and the final results of the additional evaluation sheets. CERA however, it contains the following supplementary elements:

- a simplified discomfort survey evaluates the internal load and at the same time opens an opportunity to worker participation
- in the workplace history section it is possible to record the circumstances of the significant modifications of the particular workplace, and the accidents/illnesses occurring here,
- the development ideas/suggestions section provides space to document the ideas of the evaluators. The evaluation has to be strictly separated from intervention because ad hoc modifications made during the evaluation result in only corrections and prevent the real corrective actions.

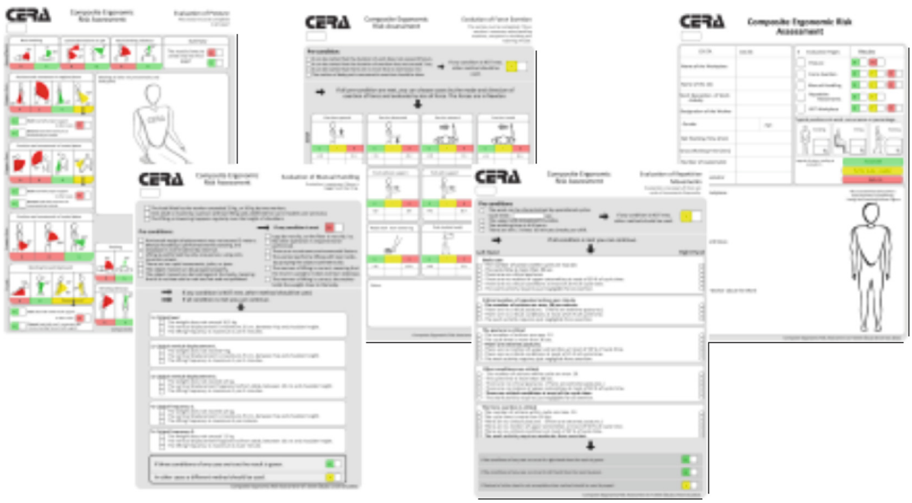

Fig. 1. Five-page paper-pencil version of CERA in English

The posture assessment sheet includes an assessment of the position of the various body parts, i.e. the joints angle sometimes with specified angular values, sometimes with the speed of movement, repetition, and supports. Most importantly, the preference is to obtain natural posture and continuous but not too fast and not too frequent movement, whereas extreme postures, poor support, excessive repetition, high frequency give negative results.

CERA uses the traffic light for the evaluation, i.e. red for inadequate, yellow for improvement needed soon, and green for OK.

The second CERA page is for posture assessment which is a compulsory part of performing a CERA assessment. The posture assessment sheet also includes an evaluation of the posture of the wrist to assess repetitive movements in addition to a general assessment of posture.

In the remaining pages serve for the evaluation of effort, manual handling and repetitive movements when the circumstances indicated in the upper right corner of that particular sheet occur during the activity.

When evaluating an effort, after identifying the effort patterns, the level of effort should be determined and then comparing this with the force limits set on the evaluation sheet to determine the levels of risk.

The evaluation of manual handling and repetitive movements begins with verification of the applicability of CERA in that situation by reviewing some risk factors. The principal part is to compare movement characteristics with the critical cases, and finally to determine the risk level for manual handling or in case of repetitive movements for the left and right hands.

3 Workbook Version of the CERA

The CERA workbook version includes the different risk factors separately in a structure similar to the paper-pencil version.

Even the paper-pencil version is available in electronic form (fill-in PDF version), but the workbook version adapts a more advanced concept, contains fewer simplifications/limitations and provides a more accurate evaluation in comparison to the paper-pencil version. For example, to assess the risk of manual lifting the paper-pencil version applies critical cases but the worksheet version calculates with the NIOSH modified lifting equation, instead. Although the workbook version allows for a more accurate evaluation, in practice, the paper pencil-shaped method is still widespread.

4 ErgoCapture

At the time of CERA's development, current leading technical solution for capturing human movements, i.e. for measuring joint angles, was experimenting with 3D camera systems around the world. The Óbuda University research team conducted a VICON - ASUS comparative study and developed its evaluation software called ErgoCapture.

In the laboratory situation controlled both the activity and the users, the research primarily focused on the combined effect of risk factors, the data acquisition and processing possibilities, and the comparison of the feasibility of two instrumentation.

The experiment raised many difficulties and besides the difficulties of using the technique highlighted the potential for developing ergonomic risk assessment methodology. It proved that one of the technologies tested requires so much data processing that only makes it suitable for short-duration investigations in industrial settings. Still, the 3D sensor system was encouraging overall, with ease of use, cumbersome installation, and unproved accuracy of the motion capture.

With the ErgoCapture system, our final goal was to improve body posture evaluations by identifying and evaluating real postures rather than independently evaluating individual joint angles [9].

5 CERA Variants

Depending on the work activity, the CERA assessments often limited to posture evaluation and no repetitive movement or movement assessed and, on the other hand, sometimes certain risk factors for the activity were missing.

As part of CERA's development, the team have developed different versions for some everyday activities, leaving out unnecessary parts of CERA and adding some indirect risk factors that are easy to assess in the workplace.

For extremely demanding work, for manual waste sorting the CERA version shown in Fig. 2 was developed [10]. This job is performed standing, with a very high frequency of arm movements, usually under poor environmental conditions, handling materials of uncertain origin and characteristics, use of personal protective equipment, and often work organisation problems. In the risk assessment sheet, the risk factors

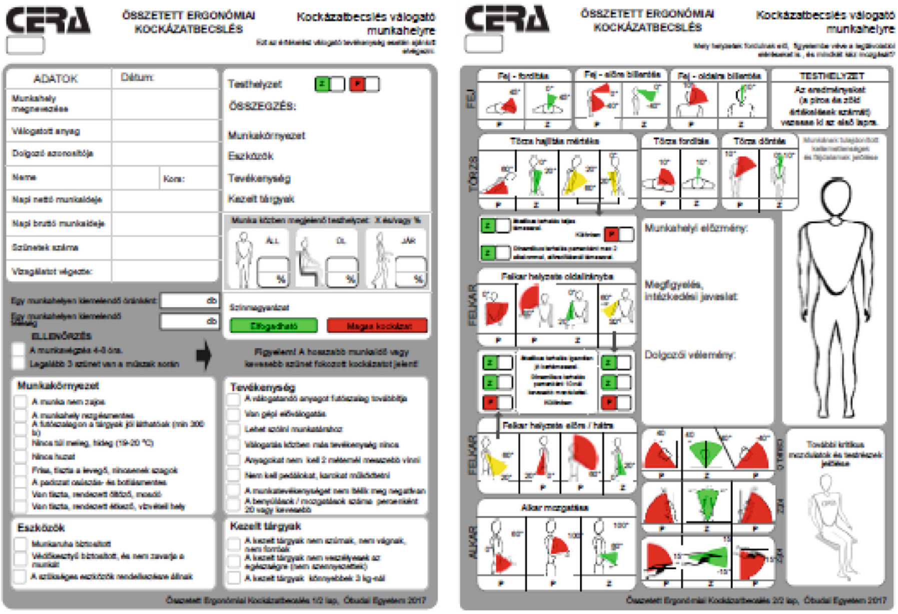

Fig. 2. CERA Waste sorting

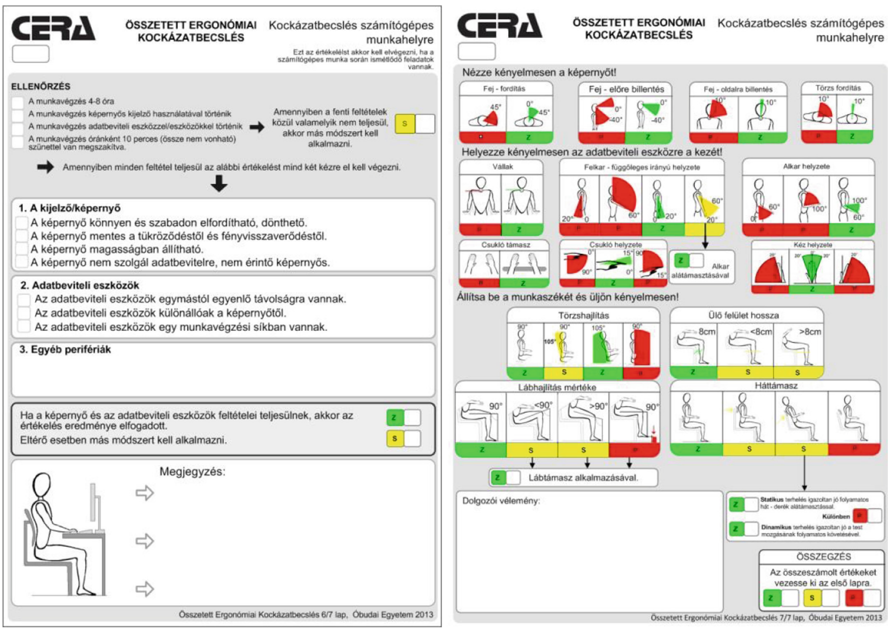

Fig. 3. CERA office

were determined based on a standard analysis of activity [11] and complemented the assessment of posture and repetitive movements.

The two-pages CERA-office shown in Fig. 3 provides an evaluation of display and input devices for a computer workstation, additionally to the more precise and more workplace-appropriate posture assessment than the original CERA version [12].

6 Summary

The Composite Ergonomic Risk Assessment is remarkable in the Hungarian workplace ergonomics. Along with the development and dissemination various versions, an ergonomics language spread about such enabling the work of those involved in job creation to work together. Through CERA development and ErgoCapture enhancement, the team gained experience with state-of-the-art instrumentation and developed solutions for the most diverse situations and identified the need for further development in the field.

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Physical Load and Preventive Measures in Metal Manufacturing Industry

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Abstract. In today's advanced work environment, workers are still exposed to ergonomic risks in the work environment and employees are exposed physically hard work that includes moving loads and frequent repetitive movements at fast pace. For the ergonomic risk analysis and workload assessment, three work operations with the high physical activity were selected: the welder's workplace, the ironing board sorting line and the ironing board's packing station. Subjective and objective ergonomics research methods were used. Research results show that employees in selected work operations are exposed to a fast work speed and often, monotonous movements at the sorting line and lifting heavy loads at the ironing board packaging workplace. Improvements in work processes and reduction of ergonomic risks are achieved through organizational and technical solutions that do not require significant material investment.

Keywords: Physical load · Ergonomics · Preventive measures · Manufacturing · Heart rate · Blood pressure

1 Introduction

Metal industry today faces new challenges due to rapid development in technology, global trade, changes in labor market and work content. The European economy is largely industry-based and provides jobs for 32 million people. One of the most important challenges of our time is population growth. Prognosis shows, that by 2050 the population in the age group of 24 to 60 will decrease by 16% [1]. As a result of these changes and the evolution of Industry 4.0 paradigms, manufacturing companies are increasingly seeking to automate manufacturing processes. Robotic equipment is used to make more efficient work processes, manufacturing would require less workforce and the skillset of the workers will also dramatically change. While it is believed that automation and robotics will replace humans, there is still a need for humans to control robots. Robotics and automation allow to achieve higher levels of productivity and accuracy that humans cannot achieve and are used for tasks that people may not be safe to perform and may not be able to perform [2].

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Despite today's rapid technical development in the manufacturing industry in today's work environment, workers are still exposed to ergonomic risks in the work environment and employees are exposed physically hard work that includes moving loads and frequent repetitive movements at fast pace [3]. The number of first-time occupational patients is increasing every year in Latvia, in 2018 the number of first-time occupational patients increased by 19% compared to the previous year, the highest number was registered in the manufacturing sector. Musculoskeletal disorders are one of the most common occupational diseases, in total accounting for 529 people [4]. Research results by other authors shows that workers in factories are subjected to physically demanding work, resulting in fatigue and poor work quality [5, 6]. This is in agreement with research findings that manual handling workers who work under increased stress may develop various musculoskeletal disorders [3, 7].

The medium sized metal processing manufacturing plant in Latvia was chosen for the research with the main production of ironing boards. Such metal operations faces various challenges in Latvian market because it is very difficult to automate many processes and work requires hard manual handling, repetitive arm movements, bent positions and physical strain on various body parts. Hence the physical workload analysis and preventive measures are very essential in this sector to reduce ergonomic risks and improve wellbeing and performance.

The aim of the research was to evaluate physical load in metal ironing boards processing operations of welding, sorting and packing as well as to elaborate preventive measures. The study was approved by the Human Ethics and Institutional Review Board at the University of Latvia in 2018.

2 Materials and Methods

In the ergonomic risk analysis, methods were selected to evaluate the physical and static load of the workers as well as the muscular load during the work. In addition, heart rate was assessed using objective assessment methods.

To determine the level of workload the *Key Indicator Methods (KIM)* was used. The *KIM – I method* determines workload in lifting and handling operations, *KIM – II method* – workload in pulling and pushing operations, *KIM – III method* – workload when often hand movements are used [8, 9].

Quick Exposure Check (QEC) method is used in ergonomic risk analysis to identify the effect of workload on the employee musculoskeletal system. The method is based on surveys of employees and expert observation data. QEC considers the condition of the back, shoulders, arms, palms, wrists and neck, as well as other factors such as stress, pace of work, even driving factor when it is related to the work performance. This method allows to determine the risk level of workload for certain body parts [8, 10].

Heart rate monitoring – experimental/ clinical evaluation method to determine the workload the employee is exposed to how dynamic and physically hard is work. This method not only determines the heart rate, but also the consumption of metabolic energy. Heart rate is measured in beats per minute [11, 12]. Heart rate and energy consumption are closely related to the work content and its severity. Classification of energy consumption and heart rate can be seen in Table 1 [12, 13].

Table 1. Work heaviness category classifications based on heart rate and energy consumption [13]

Work heaviness category	Heart rate, beat/min	Energy consumption, kcal/min	
		Males	Females
Light work	>90	2.0–4.9	1.5–3.4
Moderately hard work	100	5.0–7.4	3.5–5.4
Hard work	120	7.5–9.9	5.5–7.4
Very hard work	140	10.0–12.4	7.5–9.4
Too hard work	160 and more	12.5 and more	9.5 and more

A variety of devices can be used to measure the heart rate. Several equipment was used, such as *Polar RCX5 Heart Rate Monitor, Polar H7 Bluetooth Smart Heart Rate Monitor, Polar M430, Polar A370* un *Polar Vantage M*. The devices capture the heart rate data and convert it into the metabolic energy (kcal/min). The obtained results were processed by a special computer software - Polar Flow.

3 Result and Discussion

For the ergonomic risk and workload analysis, three work operations were selected where the workers were most exposed to physical load, i.e. welders, ironing board sorting line operators, and ironing board packing operators. In each workplace, 5 employees were analyzed, a total of 15 people, of whom 7 were males, 8 were females and they were in the age group of 25–50. The job characteristics in welding operations is to assemble and weld the ironing boards, and to lift heavy welded boards. This results in heavy overload on the hands, shoulders and neck. In the ironing board sorting line, employees need to hang ironing board frames (ironing board feet and board surface) on the automated painting line, which is moving at a certain speed, and afterwards removing, marking and assembling these ironing board parts on the trolley. Hence frequently employees are exposed to constantly lifted arms above the heart level and overload in both hands and shoulders. Workers at the ironing board packaging workplace regularly must pull the ironing board pallets, place the board on the packing line and label it. This work is physically demanding due to the pulling the pallets and lifting the ironing boards on the packing line (the weight of the ironing board can reach 9 kilograms (kg)).

3.1 Subjective Analysis Methods

KIM method results show that risk degree varies from II to III risk level, which means that there are ergonomic risks at the workplaces and employees are exposed to various workload factors. At all workplaces it was found out that workload when employees are lifting and moving heavy loads (KIM – I method) corresponds to risk level III. The weight of heavy loads is variating depending on the workplace. Range is from 1 to 2 kg – ironing board parts in assembling operations, the weight can be 5 kg and 8 to 9 kg when the ironing board is completed. Workload assessment by the KIM – II method (pulling and moving heavy loads on trolleys) shows that risk lever is higher at the packing workstation, where total weight of pallet can reach 230–350 kg. The III risk level was detected at the welding workplace for the frequent manual operations (KIM – III method).

The QEC method shows that the workload is analyzed work operations ranges from risk level II to III. Welders` workload risk level corresponds to II risk degree and the most stressed parts of the body are the hands and shoulders, as well as the wrists and fingers doing frequent arm and hand movements. Ironing board sorting line worker`s correspond to III risk degree, and the most stressed parts of the body are hands and shoulders. Worth to mention, that for sorting line operations an important factor is the pace of work, which affects the workload of employees. At the ironing board`s packing station employees are subjected to III risk degree and the highest workload is on the back due to lifting heavy ironing boards during the work process. Results of the KIM and QEC methods are summarized in the Table 2.

Table 2. Results obtained by subjective methods

Methods		Gender M-male F - female	Ironing board's welding		Ironing board's sorting line		Ironing board's packing station	
			Score	Risk level	Score	Risk level	Score	Risk level
KIM	A	M	32.0	III	40.0	III	36.0	III
	B	M	–	–	18.0	II	–	–
		F	–	–	23.4	III	26.0	III
	C	F	42.0	III	21.0	II	15.0	II
QEC			112.0	II	115.0	III	118.0	III

Comparing the data obtained from subjective methods, it can be concluded that the KIM and QEC methods have quite similar risk levels, but there are also noticeable differences. Each method has factors to emphasize, for example, the KIM method divides certain activities and can even subdivide and calculate risk levels for females and males (with KIM – II method), whereas the QEC method provides a more detailed assessment of organizational factors, such as work pace and stress, which is also very important when assessing ergonomic risks.

3.2 Methods of Objective Analysis

Heart rate monitoring research results shows, that energy consumption is variable, and the severity of the work is in the range of II to IV risk degree. Hence workers are subjected to high workload. The highest workload is identified at the ironing board sorting line, with an average energy consumption of 8.6 $\pm$ 0.6 kcal/ min, which corresponds to risk level IV for females and risk level III for males. At the ironing board packing workplace, the level of workload ranges from III to IV risk degree.

Employees need to lift heavy ironing boards (the weight of the ironing boards depends on customer orders), and can range from 7.5–9.0 kg, and 380 ironing boards are packed and lifted during the shift. Only females are employed in this workplace, so the level of workload is much higher compared to other work operations, for example welders (all males) fall in the II risk level. Results of objective heart rate monitoring data are represented in the Table 3.

Table 3. Workers heart rate (HR), energy consumption (EC), Pearson's correlation(r) and work heaviness category (WHC).

Workers	Mean HR ± SD, beats/min	Range HR, beats/min	Mean EC, ± SD kcal/min	r	WHC
Ironing board's welders (n=5)	104 ± 4	100–110	6.0 ± 0.9	0.97	**II**
Ironing board's sorting line (n=5)	113 ± 5	109–120	8.6 ± 0.6	0.90	**III/IV**
Ironing board's packing station (n=5)	108 ± 4	104–113	7.6 ± 0.5	0.98	**IV**

Results show that the most burdensome workplaces, according to heart rate monitoring, are the ironing board sorting line and the ironing board packing workstation, where the risk level IV is obtained.

Heart rate monitoring data shows how overloaded an employee is during working hours: lifting loads (ironing board packing and sorting workplace), frequent manual operations (ironing board welding workstation), doing frequent arm movements and going long distances (ironing board sorting workplace).

This results in a high amount of energy consumption and high-risk levels of overload at the work.

3.3 Preventive Measures

During the research, preventive measures were developed based on continuous cycle of improvement idea in manufacturing operations [14]. The main preventive measures were related to organizational rearrangements to distribute and reduce the workload. Technical improvements included new work equipment - adjustable work desks and anti-fatigue mats.

Improving the work process and implementing measures cannot be accomplished without individual training, such as how to properly perform work tasks, how to adjust the work desk, and relaxing exercises during rest breaks.

Additional measurements such as microclimate measurements, chemical measurements (for welders and at workstations near painting lines) are required to understand what additional risk factors may be affecting the worker. Preventive measures are summarized in the Table 4.

Table 4. Preventive measures at the workplaces

Improvement category	Preventive measures
Organizational measures	• Rotation of work operations so that the employee does not have the same and frequent work operations and work severity (the work severity in another work operation must not be higher than in current operation);
	• Informing employees about the balanced work organization and ergonomic solutions at the workplaces;
	• Observe certain rest periods (according to the severity of the work), 15 – 25 min every hour, depending on the task to be performed
Technical improvements/inventory	• Provide lifting tables to avoid awkward working postures (bent back and load in shoulder and neck regions);
	• Use an ergonomic anti-fatigue mat to transfer body weight from one foot to another
Individual measures	• Organize work in such a way that routine work operations can be carried out (at hand stroke > 50 cm) and should not extend beyond 50 cm;
	• Keep body as close as possible to the work area;
	• Adjust workplace to allow enough space to change job positions;
	• For convenient picking up of items and placement in shelves, the worker should be at a comfortable height - from knee to shoulder level;
	• Relaxing and stretching muscles (back, lumbar, shoulder, neck parts) during rest periods to reduce the risk of work related muscular skeletal disorders. Attract certified occupational therapists who can provide proper training of employees
Measurements/anthropometric readings	• Adjust the height of the work surface according to anthropometric data - the height of the worktable should be between 95–109 cm (depending on the height of the employed person);
	• Perform the microclimate measures in the workplace;
	• Perform the laboratory measurements of chemicals at the workplaces, microclimate laboratory measures to evaluate the effectiveness of ventilation and worker exposure

Such preventive measures will pay off for the company, as confirmed by scientific studies [15]. During the work, rest breaks and relaxation and stretching exercises are recommended to relieve the strain on the muscles.

The training of employees on ergonomic solutions and the principles of work organization is required as it was observed that employees frequently don't use ergonomic work principles even if the technology and equipment is provided by the management of the company.

4 Conclusion

It can be concluded that workers in all inspected groups were exposed to ergonomic risks and heavy physical workload. The objective heart rate monitoring data was in accordance with subjective research results and proved the overload for employees at the sorting and packing line operations. Improvements in work processes and reduction of ergonomic risks can be achieved through organizational and technical solutions that do not require significant material investment.

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A Convolutional Neural Network Model to Classify the Effects of Vibrations on Biceps Muscles

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Abstract. Muscle fatigue occurs after sports activities, repeated actions in a routine job, or a heavy-duty job. It causes soreness and reduces performance in athletes and workers. Various therapies have been developed to reduce muscle fatigue. Vibration therapy has been used to reduce muscle fatigue and delay muscle soreness. However, its effectiveness remains unclear. Ultrasound images provide a non-invasive diagnosis and instant visual examinations. However, it requires extensive training to analyze ultrasound images. The purpose of this study was to develop an automated classification system of ultrasound images using deep learning to assist clinical diagnosis. The ultrasound images of the biceps muscle were measured from four healthy people. The primary objective of the study was to use the convolutional neural network (CNN) models to classify between the vibration control condition (0 Hz) and vibration test conditions (5, 35, and 50 Hz) with subjects in different time duration the pattern (2 and 10-min). These images were preprocessed to resize to 224 $\times$ 224 pixels and augmentation to feed into the dataset, including the augmentation training dataset (74%), validation dataset (15%), and non-augmentation test dataset (11%). This study used the AlexNet, VGG-16, and VGG-19 of CNN models for recognition and classification ultrasound images. These models compared the differences of ultrasound images of biceps after various vibration between two conditions. The results showed that AlexNet has the best performance with the accuracy 82.5%, sensitivity 67.3%, and specificity 99.5% when 10-min 35 Hz local vibration was applied. The deep learning method, AlexNet, shows the potential for automated

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classification of biceps ultrasound images for assessing treatment outcomes of vibration therapy.

Keywords: Skeletal muscle fatigue · Ultrasound images · Deep learning

1 Introduction

Skeletal muscle fatigue occurs after sports activities, repeated actions in a routine job, or a heavy-duty job. The vigorous contraction of the muscle group causes skeletal muscle fatigue reflected in weakening the muscle strength and delayed action response [1]. Some report indicates muscle fatigue insufficient energy metabolism, decreased neural signal transport, or weakened muscle fiber contraction [2, 3]. Muscle fiber continuously contracts could intend microdamage and tissue inflammation muscle swelling to cause discomfort and affect strength performance [4]. There are some methods to restoring muscle strength including recovery rest, cold water immersion, massage, and vibration therapy. In other reports, the massage and vibration therapy effects reduce the uncomfortable symptom. [5, 6]. Although vibration therapy increased microcirculation [7] to assists recover muscle fatigue, it requires more studies for vibration frequency and duration.

The ultrasonography provides a low-cost and non-invasive examination to get instant images on the skeletal muscle and soft tissue in the clinic [8]. It has to take extensive training to interpret and analyze ultrasound images from the clinic appliance [9]. Even though a well-trained expert, they could affect clinical diagnosis through eyestrain and inattention. To resolve this problem, the computer-assisted diagnostic tool to screen the lesion to identify large numbers and complex images with the convolutional neural network (CNN) model of deep learning [10, 11].

The hypothesis of the study was that after the frequency and duration of the vibration treatment, the intervention would be changed the soft tissue graphic texture in the ultrasound image. The deep learning of ultrasound images would be used to find the correlation between vibration frequency and time duration affecting muscle fatigue. Through three different CNN models, AlexNet, VGG-16, and VGG-19, the frequency and duration of vibration therapy were classified by CNN presented with ultrasound images in the experiment.

2 Methods

2.1 Participants and Instruments

This study recruited four healthy people for gathering ultrasound images of biceps muscles. The subjects have no orthopedic history and no arm injury reports in the last six months. The research protocol was explained to the subjects who signed an informed consent form. The demographic data of participant were as follow age 28.0 ± 14.7 years, body weight 80.5 ± 14.5 kg, body height 175.5 ± 5.2 cm, body mass index (BMI) 26 ± 3.4 kg/m^2.

About the measure and data collection, the ultrasonic instrument used in this institute was a Pandora-Care wireless ultrasonic machine (40fps, E-Sono Biotech Co. Ltd., Taoyuan, Taiwan), with a linear probe (B-Mode, 6 MHz and the depth at 4.9 cm) for musculoskeletal scanning. The vibration experiment in this study uses a customized voice coil motor to massage the arm of subjects.

2.2 Data Preparation

Before the experiment, all subjects sit still for a relatively steady body and mood in 10-min. First, subjects straighten the left arm to scan the ultrasound image as a 0 Hz non-vibration image for the control condition. For the vibration condition, the vibrator fixed on the table and placed a cylindrical head on the top-end to protect the subject's skin.

The parameters of the experiment set on three different vibration test conditions at 5, 35, and 50 Hz with two different time duration pattern in 2 and 10-min [12, 13]. After vibration, the subject immediately uses the ultrasound device to get the vibration image as the experimental condition data. Every subject rested at 30 min intervals while receiving another frequency of vibration [14]. All ultrasound images were recorded as video files, and separate into individual images by Premiere PRO CC 2012 (Adobe Inc., San Jose, USA). The images have been review images were applied to resize to 224 $\times$ 224 pixels and augmentation [15]. These images review and filter out the not qualify raw material which was blank, black, or unclear images. It has to take the data augmentation that flip, scale size, rotate raw data images in the training dataset for getting better deep learning efficiency [16].

There were 55,701 original ultrasound images collected in this study, including the control condition and the test condition. After data augmentation, the 120,423 images of data augmentation were fed separately into the different datasets, including three groups: 100,428 training images (74%), 19,995 validation images (15%), and 16,482 test images (11%).

2.3 CNN and Training

This study was used Google Tensorflow as the backend framework for the CNN architecture. The deep learning model was created by Keras and uses the open-source neural network library in Python. The deep learning model was built on AlexNet, VGG-16, VGG-19 to learn the subject's biceps ultrasound images. All of these models were trained on personal computer equipped on Intel i7-7700 CPU and 32 GB DDR4 RAM with an NVIDIA GeForce GTX2080 Super GPU.

2.4 Performance Evaluation

This study uses quantitative accuracy (ACC) to evaluate the model performance of vibration classification. It also could area under the curve (AUC) of receiver operating characteristic (ROC) curves for assessing [10, 16]. It used to show the relation between model sensitivity and specificity. In addition, the performance of the model can also be evaluated through the confusion matrix of the binary classification.

3 Results

The preliminary results were as following this study compared the difference of before and after on the ultrasonic images of four healthy person's biceps muscle. The CNN model presents the outstanding effect to classify the vibration of 5, 35, and 50 Hz with a 1 mm amplitude at 2 and 10-min group.

In 2-min duration, the best test accuracy was 87.4% at 50 Hz with VGG 19. The second high accuracy was 80.6% at 35 Hz with AlexNet. In 10-min, the AlexNet present good accuracy was over 80% as 82.5% in 35 Hz and 82.4% in 50 Hz. The deep learning model shows that the ultrasound image of the biceps muscle has a high recognition rate at high-frequency vibrations of 35 Hz and 50 Hz.

This study used the ROC curve to calculate the range of AUC. The highest AUC of vibration testing models in 2-min condition was evaluated as 0.806, 0.857 for 35 Hz and 50 Hz, respectively. The highest AUC of vibration test models in the 10-min was presented in AlexNet at 0.834, 0.814 for 35 Hz and 50 Hz, respectively (Fig. 1).

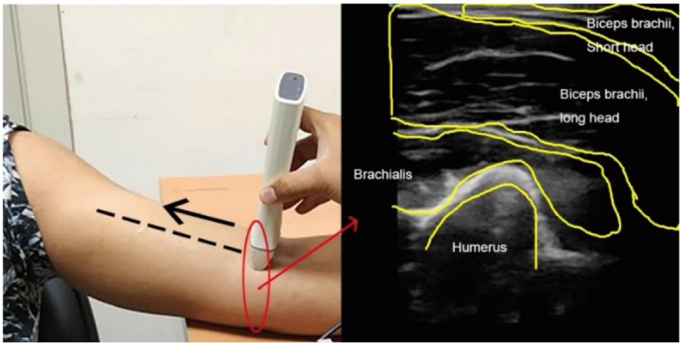

Fig. 1. The biceps muscle of ultrasound images scanned images at different frequency conditions of vibration.

4 Discussion

The ultrasound images were classified by three different models in order to find out the influence of varying vibration and time duration on the biceps muscle. The ultrasound image showed that the muscles of the upper arm surround the humerus with a long head of the biceps, the short head of the biceps and brachialis. On the non-vibration image, the edges of different muscle and tissue areas can be clearly seen. With different time and vibration changes, it shows that the texture of muscle and tissue increased in the ultrasound images [8], as shown in Fig. 2. Although shows from experiments that as time and vibration frequency increases, the model gains the feature extraction to get a better chance to identify the biceps ultrasound images (Table 1).

The deep learning requires a huge amount of images for the dataset for training, validation, and testing. Even if to execute the model of CNN require a high-speed computing process to calculate by GPU [15]. Besides, these datasets also have to set the label to correct images as the ground truth for CNN training [10]. It was the most

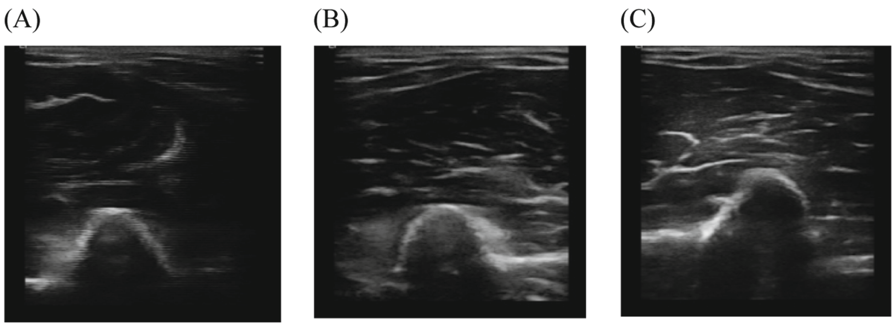

Fig. 2. The subject takes the vibration at different frequencies of ultrasound images in 10-min condition (A) 5 Hz; (B) 35 Hz; and (C) 50 Hz.

Table 1. The ultrasound images of the biceps muscle test result in different vibration conditions and time duration.

Duration	Model	Vibration Condition	Train ACC	Test ACC	Sensitivity	Specificity	AUC
2-min	AlexNet	0–50 Hz	96.2%	76.1%	59.4%	94.3%	0.769
		0–35 Hz	95.8%	80.6%*	61.6%	100.0%	0.806#
		0–50 Hz	96.2%	67.0%	37.6%	90.2%	0.857#
	VGG-16	0–50 Hz	94.2%	73.9%	50.1%	100.0%	0.676
		0–35 Hz	86.5%	55.0%	81.7%	27.7%	0.559
		0–50 Hz	96.9%	79.8%	67.6%	89.5%	0.729
	VGG-19	0–50 Hz	97.4%	76.1%	59.4%	94.3%	0.604
		0–35 Hz	84.6%	48.5%	94.5%	1.5%	0.491
		0–50 Hz	97.6%	87.4%*	71.4%	100.0%	0.517
10-min	AlexNet	0–50 Hz	94.6%	73.0%	48.5%	100.0%	0.742
		0–35 Hz	96.6%	82.5%*	67.3%	99.5%	0.834#
		0–50 Hz	94.6%	82.4%*	62.8%	100.0%	0.814#
	VGG-16	0–50 Hz	97.1%	79.9%	61.7%	100.0%	0.738
		0–35 Hz	96.9%	77.4%	58.9%	98.1%	0.727
		0–50 Hz	96.5%	75.7%	48.9%	100.0%	0.706
	VGG-19	0–50 Hz	97.0%	67.0%	37.2%	100.0%	0.594
		0–35 Hz	98.4%	61.0%	45.6%	78.2%	0.568
		0–50 Hz	94.4%	79.7%	57.2%	100.0%	0.644

Note: ACC, accuracy; AUC, area under the curve; *, higher than 80% in ACC; #, higher than 0.8 in AUC.

challenging task to get the ground truth of medical images in clinical diagnosis. The ground truth was controlled easily on a small scale. Nevertheless, the dataset has to use augmentation to enlarge the quantities in the preprocessing stage. The ultrasound images have been treated in rotating the positive and negative 45 degrees, flipping, and increase the contrast of the image.

The AUC value ranges from 0 to 1, and the larger the value presents the better reference value. If the AUC range falls between $0.8 \leqq \text{AUC} \leqq 0.9$, it means that the performance of the model has an excellent reference value. In this study, the AUC of the CNN model above 0.8 was AlexNet, where the highest AUC was 0.857 at 50 Hz in the 2-min group and the 0.834 at 35 Hz in the 10-min group.

The other tool was the confusion matrix that evaluates the performance of the deep learning model [17]. The highest sensitivity of 94.5% falls on 35 Hz of VGG-19 model in the 2-min group. However, this VGG-19 model's specificity was too low at 1.5% to support it as a good model for ultrasound images. It shows the high sensitivity of 67.3% and specificity 99.5% at the 35 Hz in the 10-min group of the AlexNet model. In this study, the good model has presented a high performance in all aspects of accuracy, sensitivity, specificity, and AUC with the AlexNet model.

For the preliminary study, it shows that different vibration patterns may affect skeletal muscle. However, it was limited by the test sample scale and clinical treatment. The other limitation could be hidden in the factor as microcirculation or neuromuscular. In the future, it can take further steps to study advanced models to recognize medical images. The vibration therapy could use this study results to design the assistive device to help the patient reduce the uncomfortable situations.

5 Conclusion

Compared with the VGG model, AlexNet has higher accuracy and more accurate detection capabilities. This study shows that classic models such as AlexNet have an excellent classification effect on musculoskeletal ultrasound images. The AlexNet presents the best model with ACC 82.5%, AUC 0.834, Sensitivity 67.3%, and Specificity 99.5%. The proposed deep learning method of this study to ultrasound images can be used as an efficient tool to help improve the diagnostic accuracy of muscle fatigue.

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Causes of Work Related Musculoskeletal Disorders in the Textile Industry

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Abstract. In Latvia textile industry workers suffer from work-related muscular skeletal disorders (WRMSD). The aim of the research is to study the causes of WRMSDs for the tailor's profession in a medium- sized enterprise. This research involved 120 tailors. Modified Standardized Nordic questionnaire, Borg Scale of Perceived Exertion, Key indicator method was used for analysis of physical workload during manual handling operations. Main survey results show that tailors suffer from pain in shoulders, wrists and fingers, have repetitive arm movements in sitting compulsory work position. Accordingly to Key indicator method tailors refer to hard work level but Borg scale results indicates the load between a low and sufficiently heavy load. To conclude tailors are exposed to tension in muscles of the wrist, neck and shoulders, due to the repetitive, monotonous movements performed by hands during the sewing process, which are the main causes of WRMSDs in textile industry.

Keywords: Sewers · Load · Upper limbs · Forced posture

1 Introduction

Textile and clothing production is one of the oldest industries in Latvia. Today it is a highly developed industry with a complex structure, advanced technology and various forms of work organization. It comprises around 4% of total manufacturing turnover, 5.5% of value added and 5%–5.5% of the country's total exports. In Latvia the industry employs about 12 thousand people [1]. Despite the invention of new technologies in the industry, workers still suffer from work-related muscular skeletal disorders (WRMSD) due to forced work postures, intensive work, and monotonous work operations. WRMSDs are disturbances of body anatomical structures, such as muscles,

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joints, tendons, ligaments, nerves, bones, and the local blood circulation system. They encompass all forms of ill health of the musculoskeletal system that may be connected with working conditions [2]. These impairments are caused or aggravated primarily by work and by the effects of the immediate environment in which the work is carried out [3]. They mainly affect the back, neck, shoulders, and upper/lower limbs, sometimes knees [4–6].

These disturbances develop over several years, during which workers experience discomfort or even pain in certain parts of the body, and that is associated with loss of working time and a fall in productivity. These diseases are often exacerbated by social risks: smoking, unhealthy lifestyles, insufficient support from employers or employees [7, 8]. Studies have shown that tailors are subjected not only to physical load, but also to mental load, visual effort, precision at work, particularly by coordinating movements of eyes, hands and feet [8, 9].

The aim of the research is to study the causes of WRMSDs in textile industry for the tailor's profession in a medium- sized enterprise in Latvia.

This research involved 120 tailors, only women in different age groups and with different length of service in the profession, all were right handed. The study was approved by the Human Ethics and Institutional Review Board of Riga Stradins University.

2 Methods

Modified Standardized Nordic questionnaire for the analysis of musculoskeletal symptoms were used in the survey [10]. This questionnaire was modified according to the tailors' profession. The questionnaire was divided into 4 parts: the first part contains socio-demographic factors (e.g., age, gender, length of service in the job, leisure time activities, smoking habits), the second part contains musculoskeletal symptoms (e.g., prevalence, degree of disability) in the period of past 12 months and during the last week, the third part deals with general working conditions (e.g., time pressure, shift work, working posture), and the fourth part includes workload issues. A total of 130 questionnaires were distributed, 120 questionnaires were filled in and returned. The data processing included all questionnaires received. A MS Excel computer program was used to analyze the resulting data.

The Borg Scale of Perceived Exertion was used to evaluate the subjective workload on the tailors' hands [11]. Scale from 6–20 was used for tailors to evaluate how hard they were working in their opinion; it is a "relative" scale.

Hand load was assessed using the Key indicator method for assessing physical workload during manual handling operations (KIM MO). This method was developed and published by the German Federal Institute for Occupational Safety and Health in 2012. KIM MO focuses on determining the physical workloads of workers involved in manual handling operations by addressing seven parameters linked to the work activity, work organization, working conditions, worker's posture, and forces used in carrying out tasks [12]. Interpretation of the results: I risk degree, if score is < 20 (low); II risk degree, if score is 20 - <50 (slightly increased); III risk degree, if score is 50 - <100 (substantially increased); IV risk degree, if score is $\geq$ 100 points (high) [13].

3 Results and Discussion

The results of the survey showed that tailors (n = 120) fall into the age group of 18–61 years. The majority of tailors (n = 54) are in the age group of 40–61 years, and for majority of tailors the length of service is more than 15 years (51%, n = 61). It should be noted that 32% of the surveyed 120 respondents, mainly in the age group of 29-39, admitted smoking during rest periods at work, as well as after work. Physical activities are regularly done by only 31% of tailors aged 18–28, only occasionally are done by 46% in the age group of 29–39, but 62% of those aged 40–61 do not do any physical activities. All respondents noted that rest breaks were regulated at work, while 45% (n = 54) indicated that their duration was not enough to overcome fatigue. This coincides with other authors' studies that a number of work-organisational factors as well as some personal factors are associated with increased prevalence of upper body disorders even after mutual adjustment for each other, underscoring the multifactor nature of WRMSDs in these workers [14, 15].

Comparing responses on the issue of feeling discomfort or pain over the past 12 months, with responses regarding discomfort or feeling of pain over the last week, one can see (see Fig. 1) that majority of respondents have noted pain in the neck. In the period of 12 months, 71% (n = 85) of respondents have indicated this pain, but over the last week - 25% (n = 30).

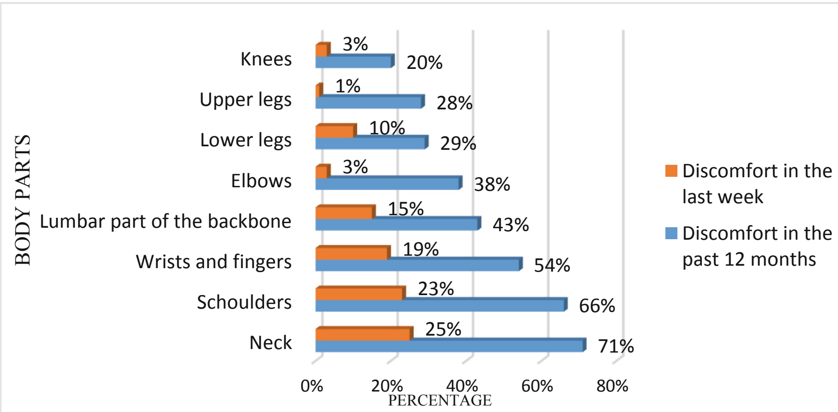

Fig. 1. Feeling of pain or discomfort over the past 12 months, compared with the responses provided for feeling of discomfort or pain during the last week.

Shoulder pain in the last 12 months has been reported by 66%, and in the last week - by 23% of respondents, while pain in the wrists and fingers in the last 12 months was reported by 54%, but 19% of respondents felt pain over the last week. In general, when assessing these indicators, it should be concluded that pain or discomfort in the neck area, shoulder, wrists and fingers, and in the lower back are marked equally in both the last 12 months and during the last week. This coincides with the literature analysis, as other authors also have indications of overload of these parts of the body for tailors

[15–18]. The analysis of how long respondents experienced pain in the above mentioned parts of the body over the past 12 months showed that 38% (n = 46) of respondents experienced pain in the neck for more than 30 days, 20% (n = 24) for 8 to 30 days, and 13% (n = 15) of respondents experienced pain for up to 7 days (see Fig. 2).

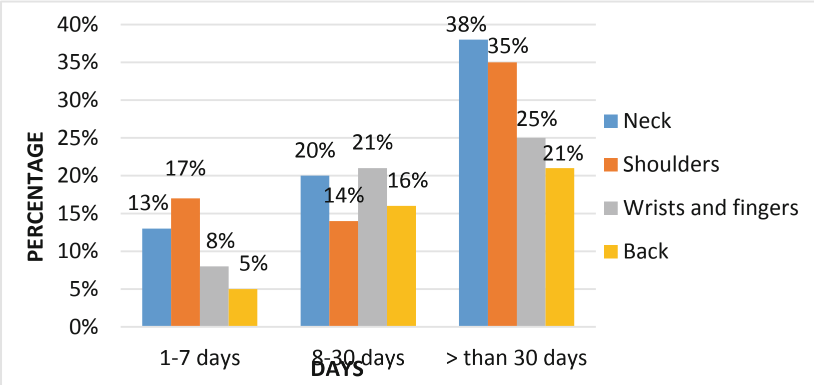

Fig. 2. Duration (days) of discomfort or pain in individual parts of the body over the past 12 months (%)

Regarding the shoulders, 35% (n = 42) of all respondents experienced pain for more than 30 days over the last 12 months, 14% (n = 17) - from 8 to 30 days, and 17% (n = 20) – up to 7 days. In wrists and fingers, 25% (n = 30) of respondents experienced pain for more than 30 days over the last 12 months, 21% (n = 25) felt discomfort or pain from 8 to 30 days, and 8% (n = 10) of respondents up to 7 days. In the last 12 months pain was also felt in the lower back for more than 30 days by 31% (n = 25), between 8 and 30 days by 16% (n = 19), and by 5% (n = 6) of respondents up to 7 days. The literature indicates that long-term pain or discomfort in tailors may be associated with inappropriate ergonomic work equipment [19].

The analysis of discomfort in different parts of the body over the past 12 months compared to the overall length of service of respondents in tailor's profession showed that respondents with the length of service for 0–7 years (n = 34) most frequently experienced discomfort in the last 12 months in the shoulder - 13% (n = 15), in the neck area - 11% (n = 13), and in the wrists and fingers 11% (n = 13), the least discomfort was felt in the elbows - 4% (n = 5), in the lower legs - 3% (n = 4), in the upper legs - 2% (n = 2) and in the knees - 1% (n = 1). The analysis of respondents with the length of service for 8–15 years (n = 61) showed that 43% (n = 51) experienced discomfort in the neck area, 34% (n = 41) in the shoulders and 27% (n = 32) in the wrists and fingers, slightly fewer respondents noted that discomfort was felt in the lower back - 18% (n = 21), in the elbows - 21% (n = 25), in the lower legs and upper legs - 9% (n = 11), in the knees - 4% (n = 5). The analysis of respondents with the length of service for more than 15 years (n = 25) showed that most of the respondents - 19% (n = 23) experienced discomfort in the shoulder region, slightly less - 18% (n = 21) in the neck area. Discomfort in wrists and fingers was noted by 17% (n = 20) of respondents. Discomfort or pain in the lower back was noted by 16% (n = 19) of those surveyed, in the elbows – by 13% (n = 15), in the lower legs – by 17% (n = 20), in the upper legs by 14% (n = 17) and in the knees - by 16% (n = 19) of respondents. It is mentioned in the literature that the pain is felt more frequently by tailors whose length of service in the profession is more than 10 years [7, 20]. It also coincides with our study, in which more than half of 120 tailors, i.e. 51% of the respondents were with length of service in the profession for over 8 years.

The analysis of the respondents' answers regarding the setting of the workplace shows that 83% (n = 100) of respondents are satisfied with sufficient area under the table for a comfortable position of legs. Of the respondents, 67% (n = 80) indicated that the chair was not adjusted for convenience, but 58% (n = 70) of respondents are dissatisfied with the area of the workspace per an employee. Nearly half of the tailors (42% (n = 50)) noted working without the back of the chair. The height of the chair can be adjusted by 57% (n = 68) of the tailors. Similarly it is with adjusting the height of the worktable, as only 53% (n = 64) indicated that it could be adjusted. This suggests the lack of conformity between working conditions and ergonomic requirements that contribute to pain and discomfort in individual parts of the body.

Analysis of respondents' answers about the workload showed that all respondents - 100% (n = 120) - replied that the load mainly went to the head since during the work it was bent downwards, 82% (n = 98) of respondents felt fatigue of the body or its individual parts, 63% (n = 76) felt load on the wrists, 40% (n = 48) - on the eyes. At the same time, 38% (n = 46) of the tailors indicated that severe head or neck turns were necessary during work.

The analysis of respondents' answers regarding the workplace revealed that mostly respondents were unsatisfied with the adjustment of the working chair to height and comfort, 67% (n = 80) indicated that the chair was not adapted to the comfort of the respondent, and 58% (n = 70) indicated that the area of the workplace per employee was insufficient, 42% (n = 50) indicated that the chair did not have a backrest, 43% (n = 52) indicated that the chair could not be adjusted for height, 48% (n = 58) indicated that the work table was not suitable for respondent's height, 43% (n = 56) indicated that the height of the work table could not be adjusted.

It was also mentioned in the literature that often tailors did not have ergonomic working environment, adjustable work table and work chair. Often, the tailors sit on an unsuitable working chair that has no back and its height cannot be adjusted. Inappropriate arrangement of work place for a tailor is a reason for the development of WRMSDs and occupational diseases [7, 19, 21, 22]. In order to reduce the development of WRMSD, the pain in different parts of the body and the fatigue caused by work, tailors must be provided with an ergonomic workplace [19, 23].

On the Borg scale, the workload of tailors corresponds to 12–13 points. Of the 120 tailors, 50 (42%) indicated that the load corresponds to 12 points, which is between a low load and a sufficiently heavy load. Overall, this load intensity category was identified by respondents aged 29 to 61. The youngest respondents of the age group 18–39 have indicated the load of 9 points. Assessing older respondents in the age group

51–61, we found that 5% of them indicated 11 points, but 13% in this age group 12 points. Previous studies suggested that the prevalence of WRMSDs in the upper body increases with years of employment as a sewing machine operator [24, 25].

Using Key indicator method for assessing physical workload during manual handling operations (KIM MO), the load on the arms has been identified to be at risk degree III. This means that the load is significant (see Table 1).

Table 1. Assessment of frequent hand movements in tailor's work

Description of handling operation	Indicators	Points
The force applied is moderate, load on fingers and hands – turning of materials 30–60 (no./min)	Force (F)	3
Process of work strictly regulated/monotonous movements during working cycle or operations	Organisation (O)	1
Parts can be small, draught, noise from sewing machines	Conditions (C)	0,5
Restricted working position – sitting only	Positional (P)	2
Hand movements limited - frequent changes in joint positions, frequent grip at a certain distance from the body	Hand movement (M)	1
Time rating points >360 min	Intensity (I)	6
Total ((F + O + C + P + M) × I = 7.5 × 6) =		**45**

In this study it was found out that the Key indicator method results that tailors refer to hard work level is not in accordance with Borg scale results. Hence, the authors recommend using objective research methods in addition to subjective research approach.

4 Conclusion

Tailors are seriously exposed to tension in various muscle groups, in particular the muscles of the wrist, neck and shoulders, due to the repetitive, monotonous movements performed by hands during the sewing process, which are the main causes of WRMSDs in textile industry. Considering the fact that psychosocial risks impact WRMSDs, the research will be continued with analysis of psychosocial risk indicators in tailor's profession.

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Construction Ergonomics: Observations

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Abstract. Construction entails exposure to a range of ergonomics hazards and risks. The study entailed observations of activities on several construction sites. Findings include that most construction activities entail exposure to a range of ergonomics hazards and risks, and that aspects/interventions can contribute to an improvement of construction ergonomics. Conclusions include: construction is physically demanding; construction activities are hazardous in terms of ergonomics; HIRAs, if conducted, are not effective, and there is a need to implement ergonomics interventions. Recommendations include: the level of awareness relative to construction ergonomics must be raised; designers must deliberate their general design, details, and specification within the context of construction ergonomics; HIRAs must be conducted prior to the commencement of all activities; the construction process and its activities must be reengineered, and employer and professional associations, and statutory councils should develop and or promote construction ergonomics-related continuing professional development (CPD) courses.

Keywords: Construction · Ergonomics · Hazards · Observations · Risks

1 Introduction

Construction is physically demanding [1]. The nature of construction work helps to explain why injuries, such as strains, sprains, and WMSDs, are so prevalent in the industry. Execution of tasks by construction workers requires lifting heavy loads, performing repetitive tasks, frequent bending and twisting of the body, working above shoulder height, working below knee level, manual handling of heavy and irregular-sized loads, adopting awkward work postures, working in confined spaces, holding the same position for long, forceful exertion and working under hot and cold temperatures/weather, which are inherent H&S risks and unfavourable ergonomic practices [2, 3].

The South African Construction Regulations [4] require in general that contractors must identify the hazards and the risks to which persons may be exposed.

The aforementioned highlight the relevance of construction ergonomics and given that limited, if any, activity-focused construction ergonomics studies have been

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undertaken in South Africa, such an exploratory study was conducted, the objectives being to determine the:

- extent to which activities expose the worker or workers to hazards, and
- potential of aspects/interventions to contribute to an improvement in construction ergonomics during the activities.

2 Review of the Literature

2.1 Legislation and Recommendations

The Construction Regulations [4] lay down important requirements with respect to clients and designers. Designers are required to, inter alia: inform the client of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is changed, and modify the design or make use of substitute materials where the design necessitates the use of dangerous procedures or materials hazardous to H&S.

The South African Ergonomics Regulations [5] require that before an activity that may expose workers to ergonomics risks is commenced, an employer must have an ergonomic risk assessment conducted. Such a risk assessment must include: a complete hazard identification; identification of all the persons who may be affected and how they will be affected by the ergonomic risks; the analysis and evaluation of the ergonomic risks, and the prioritization of the ergonomic risks.

In terms of the South African Construction Regulations [4] contractors must identify the hazards and the risks to which persons may be exposed. They must then analyze and evaluate the hazards and the risks using a documented method, and produce a plan and applicable safe work procedures (SWPs) to mitigate, reduce, or control the hazards and risks.

2.2 Ergonomic Problems in Construction

Previous research conducted in South Africa investigated, inter alia, the frequency at which ergonomic problems are encountered in construction [6–8]. The top 10/18 problems are ranked in Table 1 based upon a mean score (MS) with a minimum value of 1.00, and a maximum value of 5.00, which in turn are based upon percentage responses to a response range ‘never’ to ‘daily’. Mean MSs computed from the MSs from the four sample strata are also presented. The * denotes the findings originate from the study [6], ** denote from study [7], and *** denote from study [8].

Table 1. Frequency at which ergonomics problems are encountered during construction.

Problem	GC*		Worker*		Worker**		BPGC***		Mean	
	MS	R	MS	R	MS	R	MS	R	MS	R
Repetitive movements	4.29	1	4.56	1	3.97	3	4.78	1	4.40	1
Climbing and descending	3.88	2	4.01	4	4.23	1	4.56	2	4.17	2
Handling heavy materials	3.63	4=	3.68	10=	4.00	2	4.44	3	3.94	3
Use of body force	3.80	3	3.82	8	3.77	5	4.00	9	3.85	4
Exposure to noise	3.53	7	3.93	6	3.65	6	4.11	6=	3.81	5
Bending or twisting the back	2.96	11	4.47	2	3.38	7	4.22	4=	3.76	6
Reaching overhead	3.61	6	3.99	5	3.00	13	4.11	6=	3.68	7
Reaching away from the body	3.41	8	4.19	3	3.03	12	3.63	12	3.57	8
Working in awkward positions	2.70	12	3.85	7	3.30	9	4.22	4=	3.52	9
Handling heavy equipment	3.03	10	3.17	13	3.87	4	3.78	10	3.46	10

2.3 Improving Construction Ergonomics

Table 2 indicates the potential of the top 10/13 aspects/interventions to contribute to an improvement in construction ergonomics during the various project phases in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. The findings emanate from a study conducted among architectural technologists in South Africa [9]. The letters inserted within parentheses denote whether the aspect/intervention is construction (C), design (D), procurement (P), or multi-phase related. It is notable that all the MSs are above the midpoint of 3.00, which indicates that in general the respondents can be deemed to perceive the various aspects/interventions to have the potential to contribute to an improvement in construction ergonomics during the various project phases.

Table 2. Potential of various aspects/interventions to contribute to an improvement in construction ergonomics during the various project phases.

Aspect/Intervention	Response (%)						MS	R
	Unsure	Minor ………………… Major						
		1	2	3	4	5		
Safe working procedures (C)	2.7	2.7	0.0	10.8	21.6	62.2	4.44	1
General design (D)	0.0	0.0	0.0	13.5	32.4	54.1	4.41	2
Awareness (C & D)	2.7	0.0	5.4	8.1	35.1	48.6	4.31	3
Constructability (general) (D)	0.0	0.0	8.3	11.1	41.7	38.9	4.11	4
Details (D)	0.0	0.0	5.6	16.7	44.4	33.3	4.08	5
Contractor planning (C)	2.7	2.7	10.8	8.1	35.1	40.5	4.03	6
Design of construction equipment (C)	5.7	0.0	11.4	14.3	37.1	31.4	3.94	7
Specification (D)	2.8	5.6	5.6	19.4	33.3	33.3	3.86	8
Reengineering (C, D & P)	19.4	2.8	11.1	16.7	22.2	27.8	3.76	9
Design of tools (C)	5.6	0.0	19.4	13.9	36.1	25.0	3.71	10

3 Research

3.1 Research Method and Sample Stratum

The sample stratum consisted of 4 projects being undertaken by the regional entity of a national general contractor, and their plant yard. The regional entity's H&S Coordinator conducted 13 observations of various activities: manual loading of rubble; fixing of drywall screens using screws; painting inside ducts by means of ladder access; tiling; demolition of ceilings and partitions; manual excavation; mechanical excavation of hard rock using a hydraulic breaker; casting concrete; painting at ground level; tree felling using an excavator with a mulcher attachment; erecting hoarding; tree felling using a chainsaw, and manually offloading of scaffold.

The mean duration of the observations was 43.5 min, the shortest was 9 min, and the longest was 87 min.

3.2 Research Findings

Table 3 indicates the extent to which activities expose the worker or workers to hazards, in terms of percentage responses to 'does not' and a scale of 1 (minor) to 5 (major), and a MS ranging between 0.00 and 5.00. Given that a 'does not' option was provided, the scale effectively consists of six points, and hence the MS range.

It is notable that only 6/17 MSs are above the midpoint of 2.50, which indicates the activities expose the worker or workers to such hazards to a major as opposed to a minor extent.

It is notable that no MSs fall within the range of $> 4.17 \leq 5.00$ - between a near major to major extent/major extent.

Only 2/17 (11.8%) MSs are > 3.34 $\leq$ 4.17, which indicates the activities expose the worker or workers to such hazards between some extent to a near major extent/near major extent - repetitive movements, and bending or twisting the back.

4/17 (23.6%) MSs are > 2.50 $\leq$ 3.34, which indicates the activities expose the worker or workers to such hazards between a near minor extent to some extent/some extent - reaching away from the body, working in humid conditions, working in hot conditions, and exposure to noise.

6/17 (35.4%) MSs are > 1.67 $\leq$ 2.50, which indicates the activities expose the worker or workers to such hazards between a minor to near minor extent/near minor extent - climbing and descending, staying in the same position for long periods, reaching overhead, working in awkward positions, use of body force, and handling heavy materials.

3/17 (17.7%) MSs are > 0.83 $\leq$ 1.67, which indicates the frequency the activities expose a worker or workers to such hazards is between does not to a minor/minor extent - vibrating equipment, working in cramped positions, and handling heavy equipment.

2/17 (11.8%) MSs are > 0.00 $\leq$ 0.83, which indicates the frequency the activities expose a worker or workers to such hazards is between does not to a minor extent - working in wet conditions, and working in cold conditions.

Seven of the top ten hazards are among the top ten identified in previous South African studies [6–8] - repetitive movements, bending or twisting the back, reaching away from the body, exposure to noise, climbing and descending, reaching overhead, and working in awkward positions.

Table 3. Extent to which activities expose the worker or workers to hazards.

Hazard	Response (%)							MS	R
	Unsure	DN	Minor ………………… Major						
			1	2	3	4	5		
Repetitive movements	0.0	0.0	0.0	0.0	38.5	38.5	23.1	3.85	1
Bending or twisting the back	0.0	9.1	9.1	0.0	9.1	63.6	9.1	3.36	2
Reaching away from the body	0.0	10.0	10.0	0.0	30.0	40.0	10.0	3.10	3
Working in humid conditions	0.0	30.8	0.0	0.0	7.7	38.5	23.1	2.92	4
Working in hot conditions	0.0	30.8	0.0	0.0	7.7	38.5	23.1	2.92	5
Exposure to noise	0.0	7.7	23.1	23.1	7.7	15.4	23.1	2.69	6
Climbing and descending	0.0	23.1	7.7	15.4	23.1	15.4	15.4	2.46	7
Staying in the same position for long periods	0.0	18.2	27.3	9.1	18.2	0.0	27.3	2.36	8
Reaching overhead	0.0	27.3	9.1	18.2	9.1	27.3	9.1	2.27	9
Working in awkward positions	0.0	33.3	8.3	0.0	16.7	41.7	0.0	2.25	10
Use of body force	0.0	15.4	23.1	15.4	23.1	15.4	7.7	2.23	11
Handling heavy materials	0.0	30.0	10.0	20.0	30.0	10.0	0.0	1.80	12
Vibrating equipment	0.0	53.8	7.7	7.7	7.7	15.4	7.7	1.46	13

(*continued*)

Table 3. (*continued*)

Hazard	Response (%)							MS	R
	Unsure	DN	Minor ………………… Major						
			1	2	3	4	5		
Working in cramped positions	0.0	63.6	0.0	0.0	9.1	27.3	0.0	1.36	14
Handling heavy equipment	0.0	58.3	0.0	33.3	8.3	0.0	0.0	0.92	15
Working in wet conditions	0.0	83.3	0.0	8.3	0.0	0.0	8.3	0.58	16
Working in cold conditions	0.0	84.6	0.0	0.0	7.7	7.7	0.0	0.54	17

Table 4 indicates the potential of aspects/interventions to contribute to an improvement in construction ergonomics during the activity, in terms of percentage responses to 'does not' and a scale of 1 (minor) to 5 (major), and a MS ranging between 0.00 and 5.00.

It is notable that only 5/16 (31.3%) MSs are above the midpoint of 2.50, which indicates the aspects/interventions have major as opposed to minor potential to contribute to an improvement in construction ergonomics during the activities.

It is notable that no MSs fall within the range of > 4.17 $\leq$ 5.00 - between near major potential to major potential/major potential.

4/16 (25.0%) MSs are > 3.34 $\leq$ 4.17, which indicates the aspects/interventions have between potential to near major/near major potential to contribute to an improvement in construction ergonomics during the activities - hazard identification and risk assessment, safe work procedures, workplace organisation, and contractor planning. It is notable that these four aspects/interventions are all construction-related and that HIRAs and SWPs feature prominently in legisation and regulations.

Only 1/16 (6.3%) MSs is > 2.50 $\leq$ 3.34, which indicates awareness has between near minor potential to potential/potential to contribute to an improvement in construction ergonomics during the activities. Awareness is a multi-stakeholder aspect i.e. client, designer, and contractor-related. It is also applicable to construction project managers (CPMs), quantity surveyors, material manufacturers, and H&S inspectors.

4/16 (25.0%) MSs are > 1.67 $\leq$ 2.50, which indicates the aspects/interventions have between minor to near minor/near minor potential to contribute to an improvement in construction ergonomics during the activities minor to near minor extent/near minor extent - mechanisation, general design, specification, and details. Three aspects/interventions are design-related, and one is both design and construction-related.

5/16 (31.3%) MSs are > 0.83 $\leq$ 1.67, which indicates the potential of the aspects/interventions to contribute to an improvement in construction ergonomics during the activities is between does not and minor/minor - design of tools, design of equipment (construction), reengineering of design, reengineering of construction, and constructability (general). Four aspects/interventions are design-related, and one is both design and construction-related.

2/16 (12.5%) MSs are > 0.00 $\leq$ 0.83, which indicates the potential of the aspects/interventions to contribute to an improvement in construction ergonomics during the activities is between does not and minor - workshops on site, and prefabrication. One aspect/intervention is design-related, and one is construction-related.

Five of the top ten aspects/interventions among the top ten identified in a previous South African study [9] - safe work procedures (SWPs), Awareness (C, D &C), general design (D), specification (D), and design of tools (D). However, three included in the current study, namely HIRA (C), workplace organisation (C), and contractor planning (C) were npt included in the previous study.

Table 4. Potential of aspects/interventions to contribute to an improvement in construction ergonomics during the activity.

Aspect/Intervention	Response (%)							MS	R
	Unsure	WN	Minor ………………… Major						
			1	2	3	4	5		
Hazard identification and risk assessment (HIRA) (C)	0.0	0.0	0.0	0.0	15.4	84.6	0.0	3.85	1
Safe work procedures (SWPs) (C)	0.0	0.0	0.0	0.0	15.4	84.6	0.0	3.85	2
Workplace organisation (C)	0.0	0.0	7.7	7.7	7.7	61.5	15.4	3.69	3
Contractor planning (C)	0.0	0.0	7.7	7.7	30.8	46.2	7.7	3.38	4
Awareness (C, D &C)	0.0	0.0	7.7	15.4	23.1	46.2	7.7	3.31	5
Mechanisation (D & C)	16.7	16.7	16.7	8.3	16.7	25.0	0.0	2.20	6
General design (D)	0.0	30.8	0.0	23.1	15.4	30.8	0.0	2.15	7
Specification (D)	0.0	30.8	7.7	7.7	30.8	23.1	0.0	2.08	8
Details (D)	0.0	30.8	15.4	15.4	15.4	23.1	0.0	1.85	9
Design of tools (D)	8.3	33.3	16.7	16.7	16.7	8.3	0.0	1.45	10
Design of equipment (construction) (D)	0.0	50.0	8.3	16.7	16.7	8.3	0.0	1.25	11
Reengineering of design (D)	15.4	53.8	0.0	0.0	23.1	7.7	0.0	1.18	12
Reengineering of construction (C)	7.7	61.5	0.0	7.7	15.4	7.7	0.0	1.00	13
Constructability (general) (D)	0.0	69.2	7.7	0.0	7.7	15.4	0.0	0.92	14
Workshops on site (C)	9.1	63.6	9.1	0.0	9.1	9.1	0.0	0.80	15
Prefabrication (D)	0.0	84.6	0.0	0.0	0.0	15.4	0.0	0.62	16

4 Conclusions

Given the extent to which activities expose the worker or workers to hazards, it can be concluded that construction is physically demanding, and that construction activities are hazardous in terms of ergonomics.

Given the existence of ergonomics hazards it can be concluded that HIRAs, if conducted, are not effective.

Given that seven of the top ten hazards encountered are among the top ten identified in previous South African studies, it can be concluded that ergonomics hazards continue to persist in construction, and that there is a need to implement ergonomics interventions.

Given that five of the top ten aspects/interventions are among the top ten identified in a previous South African study, it can be concluded that ergonomics hazards can be mitigated. Furthermore, the former conclusion is reinforced by HIRA achieving the highest rank among aspects/interventions.

5 Recommendations

In general, the level of awareness relative to construction ergonomics must be raised among all project stakeholders.

Designers must deliberate their general design, details, and specification within the context of construction ergonomics, and review the former in terms of constructability.

HIRAs must be conducted prior to the commencement of all activities.

The construction process and its activities must be reengineered.

All South African statutory built environment councils and professional associations should evolve construction ergonomics practice notes, and promote continuing professional development (CPD) relative to construction ergonomics.

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Prevalence and Risk Factors Associated with Musculoskeletal Disorders Among Cashew-Nut Shelling Workers in India

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Abstract. Cashew-nut shelling is an important operation in cashew industries in India. The work of Cashew-Nut Shelling Workers (CNSWs) is characterized by repetitive movements, prolonged standing, and awkward working posture. However, CNSWs are understudied worker population with respect to musculoskeletal health and risk factors. A cross-sectional study was conducted on 150 CNSWs in cashew industries across three states of India. The objectives of the study are to identify the prevalence of musculoskeletal (MS) disorders and associated risk factors among CNSWs in cashew industries in India. The data were collected using a questionnaire via the standardized Nordic Musculoskeletal Questionnaire (NMQ) and by direct observations of working posture (Rapid Entire Body Assessment [REBA] method) to determine ergonomic risks. The highest prevalence of MS disorders was mainly found in knees (56.0%), lower back (53.3%), shoulders (48.0%), and hands/wrists (47.3%). The REBA grand score (4–7) indicated that most CNSWs' postures were at medium risk level, necessitating further investigation and changes to their working habits and workstations to decrease the level of risk. In addition, the results of multivariate logistic regression models revealed that work-related factors including work experience (>5 years) and working posture, were significantly associated with MS disorders in different body regions. Individual factors including gender (being female), age, and educational level, were also associated with the occurrence of musculoskeletal complaints. These study results indicate the prevalence of MS disorders and emphasize the need for ergonomic design interventions for the prevention of MS disorders among these working populations.

Keywords: Musculoskeletal (MS) disorders · Rapid Entire Body Assessment (REBA) · Cashew-Nut Shelling Workers (CNSWs) · Cashew industry

1 Introduction

Over the past ten years, the cashew-nut industry has been recognized as an economically important and export-oriented business for many developing countries worldwide, including India. The number of people employed in this sector is gradually

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increasing. Currently, India plays the most important and dynamic role in cashew production and employment [1]. According to International Nuts and dried fruits Corporation (INC) report, India has produced 0.18 million metric tons of cashew during 2018–19 [2], and half-million workers were employed in these industries throughout the country [3]. However, although the cashew industry in India is accelerating at pace, on the other hand, workers were exposed to various ergonomic risk factors in these industries [4], particularly in cashew-nut shelling operation.

The cashew-nut shelling is an important operation in traditional Indian cashew industries [1, 4], where the main job of the workers is to cut the hard shell of cashew-nut to separate kernels and shells. Shelling work is labor-intensive and tedious because individual cashew-nut is shelled manually using a hand-*cum* pedal-operated shelling unit. These units are mounted over the specially designed table, which is operated by hand and leg simultaneously. Cashew-nut shelling is a highly repetitive task. Moreover, it is performed in a standing work posture. Besides this, the shelling task often involves the coordination of hand and eye, fine manipulative skills, forward inclined neck and trunk, and poor knee posture. Apart from that, other job demands such as achieving target productivity, minimizing kernel damages, and fast working pace, all together, impose physical and psychosocial workloads on CNSWs. Eventually, which may lead to the development of musculoskeletal (MS) disorders in this occupational group.

It is a well-known fact that MS disorders are one of the most common occupational health problems in industrially developed and developing countries [5–7]. MS disorders impose an additional burden on individuals and organizations and also significantly affect workers' performance and quality of working life [7, 8]. According to the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO) report, MS disorder accounted for 29–35% of all occupational injuries in the United States (US) alone, during 1992–2010 [9]. In addition, previous epidemiological studies reported that the occupational factors (including awkward posture, work experience, long duration of work, etc.) and non-occupational factors (including age, educational level, marital status, Body mass index (BMI), etc.) were considered in developing MS disorders [4, 6, 7].

Even though the CNSWs are exposed to various risk factors in cashew industries, unfortunately, these workers have not received much attention in the literature to date. In light of this, more work is needed regarding the occurrence of MS disorders and associated risk factors among CNSWs. An attempt was, therefore, made to address this issue and objectives of the study were to (i) characterize the occurrence and severity of MS disorders among CNSWs (ii) explore MS disorder risk levels associated with typical CNSWs working postures (iii) assess the association between MS disorders and their contributing risk factors (demographic, work-related characteristics, and working postures).

2 Materials and Methods

2.1 Study Design, Sample, Procedure

This cross-sectional study was carried out in cashew industries located across three states (Andhra Pradesh, Assam, and Orissa) of India, between May and July 2019. The study included randomly selected 150 workers (48 males and 102 females) from 14 cashew industries. Inclusion criteria were: (i) at least one-year continuous work experience in cashew-nut shelling (ii) age greater than 18 years old. The workers who had a history of previous injuries and pre-existing MS disorders were not included in the study. Participation was voluntary; no money was paid for participation.

2.2 Data Collection

The data were collected using a questionnaire for demographic, work-related, and prevalence of MS disorders. The demographic (gender, age, height, weight, BMI (as weight/height^2), marital status, education level, and smoking habit) and work-related characteristics (work experience, daily working time, perceived speed of work, job satisfaction, and satisfaction with design of tool) were recorded.

The presence of MS disorders in different body regions was measured using the standardized Nordic Musculoskeletal Questionnaire (NMQ) [10]. The workers were asked to indicate if they had experienced pain or discomfort in nine different body regions during the past 12 months. Those who reported symptoms were asked to rate the severity of symptoms on a scale (1 - very low pain to 5 - very severe pain) for corresponding body region.

Rapid Entire Body Assessment (REBA) method [11] was used to evaluate posture in this study. REBA method analyses postural and biomechanical loading by measuring articular angles, observing force or load, repetitive movements, and frequency of changes in postures [11]. In the present study, working postures of CNSWs were evaluated in real-time on-site work observation. These were confirmed with video recording captured during the study.

2.3 Data Analysis

The data analyses were performed using SPSS version 20. (IBM Corp., Armonk, NY, USA). The prevalence and severity of symptoms among CNSWs were presented as percentages (%) and mean (SD). The relationship between study variable and MS disorders was assessed using the chi-square test. Gender differences were assessed by binary and ordinal logistic regression analyses (for the prevalence and severity of MS disorders, respectively). Multivariate logistic regression was also performed by including those variables significant in univariate analysis with MS disorders. Odds ratios (ORs) and 95% confidence intervals (CIs) were used to describe the associations between MS disorders and independent variables. The fit of the models was verified using the Hosmer-Lemeshow goodness-of-fit tests. Statistical significance level, P values < 0.05 were considered for all statistical tests.

3 Results and Discussion

The study sample was comprised of 150 CNSWs, of which the majority (68.0%) were female workers. Generally, most of the cashew industries were dominated by female workers; the possible explanation may be that they are more compliant in their work [4] and also organizations pay lower wages to female workers than male. The mean age of workers was 34.92 years (SD = 9.4 years), and their mean work experience in the job was 6.5 years (SD = 3.2 years). Majority (78.6%) of workers were married and had a mean BMI of 19.53 kg/m^2 (SD = 2.5 kg/m^2). More than half of the works were illiterate (55.3%). This means their work does not require high-level education. The mean daily working time reported was 11.0 h (SD = 1.68 h). This could be explained as the shelling is a slow and time-consuming task; therefore, CNSWs were working for prolonged hours. Sixty-eight percent of workers felt that they were working very fast and only 22.6% of workers reported that they were satisfied with their work. As expected, the majority (80%) of CNSWs reported low-level satisfaction with shelling tool design.

Table 1. Distribution of REBA scores for the study population (n = 150).

REBA score	Neck	Trunk	Leg	Upper arm	Lower arm	Wrist	Score A	Score B	Grand score
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1	25.3	–	–	51.3	57.3	–	–	–	–
2	46.7	66.7	45.3	48.7	42.7	40.7	16.0	–	–
3	28.0	33.3	54.7	–	–	59.3	52.0	55.3	–
4	–	–	–	–	–	–	–	35.3	68.0
5	–	–	–	–	–	–	32.0	–	22.7
6	–	–	–	–	–	–	–	9.3	–
7	–	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	9.3
10	–	–	–	–	–	–	–	–	–
≥ 11	–	–	–	–	–	–	–	–	–

The percentages of workers with each REBA score (i.e., score A, score B, and grand score) for different regions are presented in Table 1. The neck score for the workers was 2 (46.7%), which means that the worker's neck was flexed between 10° and 20° angle and also side flexed. The trunk score for most of the workers was 2 (66.7%), indicated that the worker trunk lean forward between 0° and 20° angle. Majority of workers' leg score was 3 (54.7%), which revealed that most of the workers stood on a single leg and other at an angle between 30° and 60°. Most upper arm (51.3%) and lower arm (57.3%) scores for workers were 1, indicated that the upper arm was between 20° flexion and extension and while the lower arm was flexed between

20° and 100° angle. Most of the worker's wrist score was 3 (59.3%), which means that the wrist of workers flexed/extended more than 15° and also twisted. The percentage of workers with the final REBA grand score of 4 to 7 was 90.7%, which indicates that most of the workers' postures were at medium risk. Hence, further investigation is needed to change their working postures to reduce their risk level.

The prevalence of MS disorders reported by CNSWs in different body regions is presented in Table 2. The severity of symptoms in those body regions was also presented in this table. The main finding of the study was that the prevalence of MS disorders among CNSWs was very high and a total of 78.6% of the CNSWs had experienced some kind of musculoskeletal discomfort in at least one body region during past 12 months preceding the data collection. The most common body regions affected were knee (56.0%), lower back (53.3%), shoulders (48.0%) and hands/writs (47.3%). The severity of symptoms reported by workers found to be moderate to severe pain. The frequency of symptoms reported in shoulders, lower back, knee, and ankles/foot region were found to be significantly different between males and females. The severity of complaints reported also differed between males and females. Males reported more severe pain in the shoulder, hands/wrists, and lower back, whereas the severity of neck pain was higher in females than in males. These findings confirm that MS disorders pose a major problem among CNSWs.

Table 2. Prevalence of musculoskeletal symptoms reported by CNSWs (n = 150).

Body region	Prevalence of MS disorders			Severity of pain (scale 0–5)		
	Male	Female	All	Male	Female	All
	%	%	%	Mean (SD)	Mean (SD)	Mean (SD)
Neck	35.4	37.2	36.7	2.7 (0.9)	3.4 (1.0)	3.2 (1.0)*
Shoulders	35.4	53.9	48.0*	4.4 (0.8)	3.6 (1.0)	3.8 (1.1)*
Elbows	39.6	30.4	33.3	3.2 (1.1)	2.9 (0.9)	3.0 (0.9)
Hands/writs	43.7	49.0	47.3	4.4 (0.7)	3.8 (0.9)	4.0 (0.9)*
Upper back	10.4	10.8	10.7	2.8 (0.8)	2.9 (0.8)	2.8 (0.8)
Lower back	31.2	63.7	53.3**	4.4 (1.1)	3.8 (0.9)	3.9 (0.9)*
Hips/thighs	14.6	9.8	11.3	2.4 (1.2)	2.7 (0.8)	2.5 (1.0)
Knees	35.4	65.7	56.0**	3.8 (1.1)	3.6 (1.0)	3.6 (1.0)
Ankles/feet	14.6	33.3	27.3*	3.5 (1.3)	3.6 (0.8)	3.6 (0.9)
Any region	66.7	84.3	78.6*	–	–	–

*p < 0.05, **p < 0.001

The results of chi-square test showed that the risk factors including gender (p = 0.014), age (p = 0.001), education level (p = 0.001), marital status (p = 0.001), experience (p = 0.03) and job satisfaction (p = 0.001) were significantly related with MS disorders. Multivariate logistic regression analyses of risk factors associated with MS disorders in different body regions among CNSWs is presented in Table 3. Gender (being female) was significantly associated with lower back and knee symptoms with an odds ratio of around 4.6 to 5.2. In a recent study conducted among surgeons and pineapple peeling workers, it was found that gender has a significant effect on knee region especially in prolonged standing jobs [5, 6]. The age of the workers was significantly associated with the presence of MS disorders in the knee and ankles/foot regions (OR = 1.96–5.36). A study on standing sewing machine operators highlighted that age was a significant risk factor associated with knee symptoms [5, 7]. Higher education level of workers was found to be significantly associated with shoulders and lower back complaints among CNSWs. This finding is in parallel with the previous study conducted among vineyard workers that had also reported that the higher education level of workers showed significantly lesser MS disorders [13]. Regarding work-related characteristics such as work experience (>5 years) was significantly associated with neck symptoms. The work experience of pineapple peeling workers in small fruit units was also significantly associated with pain in different body parts [5].

Table 3. Risk factors associated with MS disorders among CNSWs.

Body region	Variables	OR	95% CI	p
Neck	Work experience	2.39	1.15–4.94	0.018
Shoulders	Gender	2.79	1.31–5.93	0.007
	Educational level			
	Illiterate	1.00		
	Primary school	0.47	0.22–1.02	0.058
	Secondary school	0.23	0.08–0.67	0.007
Lower back	Gender	5.20	2.20–12.27	0.001
	Educational level			
	Illiterate	1.00		
	Primary school	0.42	0.17–1.09	0.055
	Secondary school	0.12	0.03–0.39	0.001
Knees	Gender	4.60	1.72–12.30	0.002
	Age	5.36	2.10–13.69	0.001
	REBA score B			
	2–3	1.00		
	4–7	1.30	0.14–0.65	0.002
Ankle/foot	Age	2.52	0.99–7.52	0.050
	REBA score B			
	2–3	1.00		
	4–7	2.38	1.01–5.59	0.046

As reported in this study, the results of logistic regression have confirmed that the working posture was significantly associated with knee and ankles/foot symptoms. This is perhaps not surprising as the most common posture adopted by workers while performing shelling task was standing for an extensive period of time on one leg while the other being flexed at 30°–60° angle. Such working postures impose biomechanical and physical workloads [7, 12], which can consequently lead to the development of musculoskeletal problems. From the current research findings, it can be noted that the work of CNSWs is one of the most physically demanding jobs.

4 Conclusion

Prevalence of MS disorders in the industrial sector has received greater attention in the industrialized world over the past two decades. Although the effect of the etiology of MS disorders is complex, studies have identified the significant role of occupational risk factors on the occurrence of MS disorders. In the current study, the prevalence of MS disorders and associated risk factors among CNSWs in Indian cashew industries have been identified and reported. A higher prevalence of MS disorders among CNSWs indicates an immediate need for necessary work improvements to enhance their quality of working life. The research finding also highlights the associated risk factors in the shelling task. This may help managers while they devise possible ergonomic intervention in their manual cashew-nut shelling task. The current study was conducted primarily with the usage of self-reports for ergonomic exposure assessment, which is often considered to be less reliable [6]. It is, therefore, important to explore direct exposure assessment methods (e.g., Electromyography and motion measurement) in future studies.

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Effects of Reduced Work Pace on the Risk of Developing Upper-Limb Musculoskeletal Disorders in a Poultry Slaughterhouse

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Abstract. This paper aimed to evaluate the risks in relation to repetitive movements of the upper limbs in a poultry slaughterhouse, verifying the relationship between the OCRA checklist scores and each risk factor, as well as analyze the effects of a reduced work pace on the risk levels. The study was carried out in a poultry abattoir with 2,100 workers, in which 310,000 chickens were slaughtered daily. To assess the risks, 10% of the workers were evaluated by OCRA checklist. The overall mean OCRA checklist score was 22.8 ± 3.3 (high risk). The scores for the right upper limb (22.1 ± 4.1) were significantly higher than the left (21.3 ± 4.4) ($p = 0.008$). The technical action scores for frequency, force, shoulder, wrist and overall posture were correlated with the OCRA Checklist score. Reducing only the work rate (−50.4 ± 7.7%), it was possible to achieve very low levels of risk in 46 of the 47 tasks analyzed.

Keywords: Ergonomics · Risk assessment · UL-WRMSDs · Slaughterhouse

1 Introduction

A large number of factors have led Brazil to a privileged position in the world chicken meat market, highlighting the abundance of land, fertile soil to produce food, favorable climate and the ability of companies to overcome challenges [1]. Therefore, Brazil became the world leader in the exportation of chicken meat [2]. Most of these exports are made up of meat cuts (66%) [2], which are processed manually (hand tools – knives) or by specific machines (saws). Thus, meat processing industry workers are at high risk of work-related musculoskeletal disorders (WRMSDs) due to a high physical work demand, including frequent use of forceful exertions, rapid work pace, repetitive motions, and nonneutral body postures sustained over a long period [3, 4].

The OCRA Checklist was developed to analyze workers' exposure to tasks featuring various upper-limb injury risk factors (repetitiveness, awkward postures and movements, force, lack of recovery periods, and others, defined as "additional") [5]. This method is a Consensus Document, drafted and published in 2001 by the International Ergonomics Association - Technical Committee on Musculoskeletal Disorders, with the endorsement of the International Commission on Occupational Health [6].

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Despite several recent studies have evaluated the risks inherent to repetitive movements of the upper limbs in chicken slaughterhouses [7–11], studies on interventions to reduce occupational risks in slaughterhouse tasks are scarce. Thus, this paper aimed to evaluate the risks in relation to repetitive movements of the upper limbs in a poultry slaughterhouse, verifying the relationship between the OCRA checklist scores and each risk factor, as well as carry out a simulated intervention to analyze the effects of a reduced work pace on the risk levels.

2 Method

The procedures for this study were approved by the local Human Research Ethics Committee, in accordance with the Declaration of Helsinki.

The study was conducted in a Brazilian slaughterhouse with 2,100 workers, divided into two work shifts, in which 310,000 chickens were slaughtered daily. In order to calculate the risks associated with repetitive movements of the upper limbs, 10% of the workforce was evaluated while performing their work tasks, using the checklist proposed by the OCRA method [5]. The analyzed tasks were considered individually, regardless of whether they were part of job rotation schemes. A 10-cycle sampling of each task was recorded with a Sony® HDR-XR160 digital camcorder.

Based on the data resulting from the application of the OCRA checklist, simulated interventions were implemented in order to reach borderline risk levels by reducing the work pace for each of the analyzed tasks. The scores for all examined risk factors on the checklist were weighted in proportion to the proposed work pace reductions.

Descriptive statistics were used (mean, standard deviation and percentage), as well as the Student t-test (SPSS 17.0), in order to compare the risk between the sides of the workers' body. The Pearson correlation was used to substantiate the relationship between the OCRA checklist score in the actual work condition and the results of each risk factor: the technical action frequency classification score, postural scores (scores for the shoulder, wrist, hand and general posture) and force demands. For all tests, a statistical significance level of $p \leq 0.05$ was adopted.

3 Results and Discussion

Considering that the total duration of the work shift was 08 h 48 min with three rest breaks of 20 min each, the net duration of the repetitive work was classified in the range of 421 to 480 min ("duration" multiplier 1). For the risk factor "recovery", the multiplier 1.16 was used. The scores of the other risk factors evaluated by the OCRA method (frequency of technical actions, force, posture with stereotyped movements, and additional factors) were assigned according to the particularities of each task and the operative mode of each worker.

The workers performed 77.0 ± 22.5 occupational repetitive actions per minute (10/10 points on the OCRA checklist) (Table 1). Several studies have also shown a high frequency of technical actions in poultry slaughterhouses, with averages between 63.7 and 79.8 [8–12]. Kilbom [13] suggests that workers ought to not exceed 25–33 actions/min. for tendon disorders to be prevented, since higher rates provide insufficient pauses for the recovery of fatigue between contractions (micropauses).

The work in poultry slaughterhouses is repetitive and strenuous [14]. Upon arriving at the slaughterhouse, live chickens are received and then transferred to a production line that requires workers to hang, slaughter, pluck, clean, eviscerate, cut, pack and box chicken parts at a high pace. In addition, they clean and repair equipment, assemble boxes and move packaged poultry pallets. Thus, there is a potential risk of injury from overuse in each of these occupational tasks [14].

The average score on the OCRA checklist was 22.8 ± 3.3 (high risk). Reis et al. [9] analyzed 30 poultry slaughterhouse tasks and found similar results (22.8 ± 5.6 points – high risk). On the other hand, a series of other studies in Brazilian slaughterhouses have found a medium risk level [7, 8, 10, 11]. In an Italian poultry slaughterhouse, Colombini and Occhipinti [5] found that 22.4% of workers exposed to medium risk tasks (an average of 20 points on the OCRA Checklist) were diagnosed with UL-WRMSDs (based on clinical evaluation and complementary medical examinations).

The OCRA checklist requires that the analysis be performed on both sides of the body, but the final score for each task considers the side of the body that presents the greatest risk [5]. It was found that the OCRA checklist score for the right upper limb (22.1 ± 4.1 - medium risk) was significantly higher than the contralateral limb (21.3 ± 4.4 - medium risk) ($p = 0.008$). Corroborating these results, Tirloni et al. [15] interviewed 312 workers at a poultry slaughterhouse and found that 71.2% reported body discomfort, and there was a predominance of complaints on the right side of the body.

Considering the five risk levels by the OCRA method, 26 were classified as high risk (55%) and 21 presented medium risk (45%). Although studies have found that high-risk tasks predominate in slaughterhouses in Brazil (56.5%) [7], Iran (67%) [16] and Italy (90%) [12], several recent studies indicate that medium-risk tasks prevail in Brazilian slaughterhouses [8–11]. It is speculated that the decrease in the number of high-risk activities, observed in these studies, may have occurred due to the implementation of the Brazilian Regulatory Standard 36 (NR-36) [17]. The NR-36 establishes parameters for the assessment, control and monitoring of occupational risks in meat processing industries [17]. Among the parameters defined by this standard, the mandatory inclusion of the periods of psychophysiological recovery directly influences the results of the OCRA checklist [17]. Applying these parameters, the time of exposure to repetitive tasks was reduced throughout the Brazilian meat processing industry. As a result, in analysis using the OCRA checklist the "recovery" score is reduced and, consequently, the risk of UL-WRMSDs is reduced as well.

The technical action score for frequency was associated to the OCRA Checklist score ($r = 0.407$; $p = 0.004$). In this way, it can be stated that 17% of the score variation is explained by the frequency of technical actions performed by workers. Most of the tasks (60%), considering the side with the highest risk, received a score of 10 – "very high frequency of technical actions (≥ 70 per minute), no interruptions are possible".

There was a correlation between the OCRA Checklist score and the force ($r = 0.536$; $p < 0.001$), as well as the posture for the shoulder joint ($r = 0.366$; $p = 0.011$), wrist ($r = 0.438$; $p = 0.002$) and overall posture score ($r = 0.478$; $p = 0.001$). The results showed that 29% of the final score variation of the OCRA Checklist was explained by the force score and 23% by the overall posture score.

Most of the tasks evaluated were scored 1 for shoulder posture (40%) (upper limbs not supported in the work plan), scored 2 for wrist (68%) (posture was maintained for 1/3 of the cycle), and scored 4 for hand-fingers (85%) (posture was maintained for more than 1/2 of the cycle). The most frequent total score for the posture factor was 7 (64%) (posture score + stereotypy score). It is noteworthy that 85% of tasks received the maximum score for stereotypy (3) due to the fact that the work cycle was less than 8 s or repeated identical movements during almost the entire cycle. Therefore, this fact highlights the repetitiveness of the analyzed tasks.

The organizational aspect, including additional factors, most evident in the tasks of this sector was the work pace completely determined by machines (66%), justifying the model that emphasizes the reduction of wasted time.

Table 1. Risk assessment by the OCRA checklist and simulations to reduce risk by reducing the pace of work.

Tasks	Current situation				Simulations for risk reduction			
	Units/min	TA/min	OCRA score	Risk level	Units/min	TA/min	OCRA score	Risk level
Placing wings in scale	*	84.5	31.3	5	*	35.0	11.0	2
Meat transfer – bowl to box – secondary packing	3.4	47.7	30.2	5	#	#	#	#
Remove breast	22.2	88.9	29.0	5	7.5	30.0	11.0	2
Pack whole chicken with funnel – bowl side	2.0	69.4	27.8	5	0.9	30.0	11.0	2
Boneless leg screening	*	78.6	26.7	5	*	30.0	11.0	2
Re-hanging chicken	25.0	75.0	26.7	5	10.0	30.0	11.0	2
Boning leg – drumstick	6.9	88.3	26.7	5	2.3	30.0	11.0	2
Boning leg – thigh	6.0	87.3	26.7	5	2.0	30.0	11.0	2
Fueling breast fillet machine	23.0	69.2	26.7	5	10.0	30.0	11.0	2
Weighing wings	7.4	80.0	25.5	5	2.8	30.0	11.0	2
Re-hanging large chicken	21.4	64.3	25.5	5	10.0	30.0	11.0	2
Packing whole chicken – funnel – conveyor side	20.0	60.0	24.4	5	10.0	30.0	11.0	2
Cutting kakugiri	4.0	68.7	24.4	5	2.0	35.0	11.0	2
Sealing packages – whole chicken	11.5	110.8	24.4	5	3.2	30.0	11.0	2
Re-hanging chicken – post scale	20.7	62.1	24.4	5	10.0	30.0	11.0	2
Liver screening	*	93.3	24.4	5	*	30.0	11.0	2
Boning defective breasts	4.6	93.0	24.4	5	1.5	30.0	11.0	2
Packing boneless breast	*	89.5	24.4	5	*	30.0	11.0	2
Weighing drumette	5.2	89.2	23.8	5	2.0	35.0	11.0	2
Secondary IQF packaging	1.2	51.0	23.2	5	0.7	30.0	11.0	2
Feet screening – B	*	72.0	23.2	5	*	30.0	11.0	2
Feet screening – small	*	113.0	23.2	5	*	30.0	11.0	2

(*continued*)

Table 1. (*continued*)

Tasks	Current situation				Simulations for risk reduction			
	Units/min	TA/min	OCRA score	Risk level	Units/min	TA/min	OCRA score	Risk level
Packing boneless leg	3.5	94.6	23.2	5	1.1	30.0	11.0	2
Hanging live chickens	21.4	64.3	23.2	5	10.0	30.0	11.0	2
Trimming breast	3.9	65.5	23.2	5	1.8	30.0	11.0	2
Fueling breast refill line	*	65.0	23.2	5	*	30.0	11.0	2
Secondary breast packaging	1.7	43.0	22.0	4	1.0	25.0	11.0	2
Wing parts screening	*	133.0	22.0	4	*	35.0	11.0	2
Breast screening	*	79.4	22.0	4	*	35.0	11.0	2
Trimming sassami	15.4	92.3	22.0	4	5.7	35.0	11.0	2
Gizzards screening	*	115.0	22.0	4	*	35.0	11.0	2
Fueling wing cutter	46.0	138.5	22.0	4	11.8	35.0	11.0	2
Fueling chicken cutter	37.5	75.0	22.0	4	17.6	35.0	11.0	2
Fueling leg deboning line	*	105.0	22.0	4	*	35.0	11.0	2
Fueling sealer - boneless legs	3.6	63.2	21.5	4	2.0	35.0	11.0	2
Interfold legs	0.5	59.5	20.9	4	0.3	30.0	11.0	2
Fueling conveyor with wing parts	*	65.0	20.9	4	*	35.0	11.0	2
Interfold big wings	0.3	99.4	20.9	4	0.1	35.0	11.0	2
Secondary packaging of trays – pack	1.7	51.0	20.3	4	1.0	30.0	11.0	2
Interfold small wings	0.1	80.6	19.7	4	0.1	40.0	11.0	2
Remove sassami	23.0	46.2	18.6	4	15.0	30.0	11.0	2
Opening packages – whole chicken – conveyor side	20.0	60.0	18.6	4	11.8	35.0	11.0	2
Opening packages – whole chicken – bowl side	2.0	61.0	17.4	4	1.3	40.0	11.0	2
Weighing breast bowls	3.5	57.2	17.4	4	2.1	35.0	11.0	2
Weighing sassami tray	3.9	81.4	16.2	4	1.9	40.0	11.0	2
Secondary packaging of trays – tag	23.0	46.2	16.2	4	17.6	35.0	11.0	2
Secondary packaging – whole chicken	4.0	50.0	15.7	4	2.7	35.0	11.0	2
Average	11.4	77.0	22.8	5	5.3	32.3	11.0	2
Standard-deviation	11.5	22.5	3.3	–	5.3	3.3	0,0	–

Risks: 5-high; 4-medium; 3-low; 2-very low; 1-acceptable; TA-technical actions; * Task with variable work rate; # The task needs to be restructured due to the high force requirement.

The risk factors that achieved the highest scores regarding the limits established by the OCRA method were stereotypy (90%), frequency of technical actions (89%) and hand posture (48.8%). Corroborating these results, Tirloni et al. [18] found that 28.9% of workers at a poultry slaughterhouse reported discomfort in their hands.

Based on epidemiological data concerning work-related musculoskeletal disorders, the precursors of the OCRA method used statistical procedures (regression analysis) to establish hypotheses for the prevalence of UL-WRMSDs according to the occupational conditions [5]. Specific percentages were defined for each level of UL-WRMSDs incidence. As an example of the data that gave rise to the method, Colombini and Occhipinti [5] found an incidence of 47.7% of UL-WRMSDs in meat boning workers, who were classified with 28 points (high risk) on the OCRA checklist. Thus, the workers analyzed in the present study had a probability of developing UL-WRMSDs > 21.5% for high-risk tasks, and between 10.8 and 21.5% for medium-risk tasks.

Due to the predominance of tasks with high repetition of movements of the upper limbs [8–11, 19], previous studies have suggested that the reduction of the work pace decreases the risk of UL-WRMSDs in chicken slaughterhouses [8–11]. In this sense, simulated interventions were carried out, reducing the work pace to achieve very low risk levels on the OCRA checklist. By only reducing the work pace (−50.4 ± 7.7%), it was possible to achieve very low risk levels in 46 of the 47 tasks analyzed. In task “meat transfer – bowl to box – secondary packing” it was not possible to reach a very low risk level just by reducing the work pace, in view of the high demand for strength. Likewise, previous studies [8–11] also executed simulated interventions to lower the risk by reducing the work pace (−42.1 ± 14.5%; −44.9 ± 13.7%; −48.5 ± 11.8% and −38.8 ± 4.8%, respectively) and were successful in most tasks (24/26, 28/30, 15/15 and 33/35, respectively), except for those with excessive strength demand.

4 Conclusion

Based on results of this study and the postulation of the literature, it is possible to conclude the following:

- In the analyzed slaughterhouse there was a predominance of high-risk tasks, increasing the chances of developing UL-WRMSDs by four times compared to the population that was not exposed;
- The risk of developing UL-WRMSDs was higher for the right side of the body;
- Correlations were found between the OCRA Checklist score and the technical action score for frequency, force, shoulder, wrist and overall posture;
- Simulated interventions, reducing the working pace, showed the effectiveness of this organizational measure to reduce the risk of UL-WRMSDs in most of the analyzed tasks;
- Future studies are necessary to verify if the results of the present study can be generalized to other slaughterhouses.

Finally, to reduce the risk of UL-WRMSDs in poultry slaughterhouses, it is recommended to perform a series of organizational measures, highlighting: reduce the work pace, adopt efficient job rotation (between tasks with different biomechanical requirements), take rest breaks every hour, expand the workforce in each task, keep knives sharp (avoid unnecessary effort), and constantly monitor the risk level of work tasks using objective tools, such as the OCRA checklist.

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Supervisor's Roles and Responsibilities in Preventing Prolonged Disability in Workers with Musculoskeletal Disorders

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Abstract. The objective of this article is to present courses of action for supervisors and verify their feasibility and applicability. A multi-part sequential qualitative study proposed course of actions for supervisors and verified their relevance, feasibility, and applicability by on-line questionnaire, and two focus groups with nineteen supervisors and other stakeholders from 19 Quebec organizations in 6 different sectors. Overall, respondents found courses of action as relevant, well formulated, and applicable in some favorable contexts. These contexts depended on the formalization of the supervisor's role and responsibilities, the organization's culture and resources, the decision-making flexibility given to supervisors regarding temporary work changes, and the possibility of training supervisors regarding the actions required as part of a worker's reintegration. For organizations, two main challenges stand out: formalizing in clear and unambiguous terms each party's responsibilities; and gathering knowledge, experience, and know-how regarding sustainable RTW for all parties involved in the RTW process.

Keywords: Return-to-work · Course-of-action · Action · Supervisors' role and responsibilities

1 Introduction

Work-related musculoskeletal disorders (MSDs) are one of the main causes of work disability [1, 2]. In addition to their personal impact, MSDs generate major costs for the healthcare and compensation systems and for employers, due to loss of productivity and absenteeism [3].

Work disability prevention studies show that clinical rehabilitation interventions alone do not ensure the sustainable return to work (RTW) of workers following an MSD [4]. Given the essential role played by supervisors in the RTW of workers who have sustained a work-related musculoskeletal injury [5–7], their activities warrant

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examination, particularly regarding their responsibilities in workplace activities essential to supporting a sustainable return [7–10]. According to Durand et al. [5], during a worker's sick leave, it is vital to (1) contact the absent worker to maintain his or her relationship with the workplace, and then to (2) evaluate the current work situation, as the basis on which to (3) offer, plan, and implement the RTW solution. To facilitate the RTW, it is essential to (4) welcome the worker back and implement and adjust the RTW solution. After the worker's return, it is also necessary to (5) do follow-up of the RTW. During the RTW process, it is important to (6) communicate with the worker and (7) collaborate with the work team in order to support the worker. Lastly, for maximum effectiveness, it is essential to (8) coordinate the concrete actions aimed at facilitating a sustainable return to work, (9) formalize policies and procedures, and (10) build knowledge, experience, and skills in order to promote a sustainable RTW.

Certain conditions within organizations may influence these activities. For example, depending on the workplace, it may be harder or easier to find jobs that can be temporarily or permanently adjusted to accommodate the returning worker [11, 12]. Likewise, supervisors may feel caught between having to meet production quotas and grappling with the RTW of workers who have not fully recovered and who may be on temporary assignments or returning to work gradually [7, 8]. The general objective of this study is to propose courses of action for supervisors in the process of returning and sustaining workers with work-related MSDs and to verify their applicability in different organizational contexts and sectors of activity in Quebec. The specific objectives are to: 1) Describe the concrete actions taken by supervisors during the return-to-work and long-term job retention process for workers with work-related MSDs; describe the various problems they face, as well as the strategies put in place to solve them; 2) Study the conditions that are favourable and unfavourable to the supervisor's involvement in the prevention of work disability; 3) Develop courses of action to harmonize the supervisor's role and responsibilities with his or her other roles in the organization (e.g. production, accident prevention) and with the responsibilities of the other players in the company working to prevent work disability; 4) verify the relevance, feasibility and applicability of these courses of action in different.

2 Methods

A three-part sequential qualitative study was used to achieve the objectives. For component 1, a literature review was conducted based on a systematic search of three specialized databases. This made it possible to document the international evidence on the role and responsibilities of supervisors, as well as their involvement in the essential activities of the return-to-work and sustainable retention process (Objectives 1 and 2 - international component). Descriptive analyses of the content of the various publications were carried out for component 1. For component 2, a secondary analysis of data from a case study conducted in Quebec in four large companies from two sectors of activity was carried out to describe the involvement of supervisors in these essential activities from the different perspectives of Quebec workplaces: workers, supervisors, managers, union representatives (Objectives 1 and 2 - Quebec context component). Analyses of interview content were carried out for this component. The synthesis of the results of these first two components was used to develop courses of action and specific related actions. To this end, the essential activities and actions from the literature review served as a starting point before being adapted based on data from the secondary analysis of the workplace interviews (Objective 3 - Development of courses of action component). Finally, component 3 consisted of verifying the relevance, feasibility, clarity of formulation and applicability of these courses of action in different contexts and sectors of activity in Quebec (objective 4 - applicability component). Content analyses of the participants' comments collected by action area made it possible to draw conclusions on their feasibility and applicability and to propose an operational model for the supervisor.

3 Results

For the international component, the literature review identified 788 references. After elimination of duplications and application of selection criteria, 16 publications were selected, to which we added three publications found through the references of the selected publications. In total, 10 essential activities and 22 actions were associated with the return-to-work and sustainable retention process for supervisors based on the literature review. The literature review made it possible to highlight, for supervisors, on the one hand, the types of problems they encounter and the strategies for solving them and, on the other hand, the favorable conditions to their involvement in the return and sustainable retention process.

For the Quebec context component, overall, the concrete actions mentioned by supervisors in the return to work (RTW) are related to the role and responsibilities assigned to them in the organizations and correspond to the actions identified from the literature review. The actions, issues and strategies mentioned relate mainly to assessment or planning, including information sharing between supervisors and human resources (HR) managers. Supervisors report having difficulty reconciling their roles and responsibilities associated with production objectives with those associated with return and sustainable retention at work. Also, supervisors appear to be more familiar with preventive actions, particularly with respect to documenting the circumstances of accidents, than with actions that enable sustainable reintegration into the workplace.

Two types of conditions emerge in relation to the fulfilment of supervisors' roles and responsibilities in the four organizations. The first type concerns the importance of managing relational problems and accompanying the worker, whether in his relations with teammates or in ensuring that he does not do more than he is capable of. Both supervisors and other stakeholders interviewed (manager, human resources advisor, SR manager, worker, teammate) mentioned this type of condition. The second type of conditions concerns the culture of the organization: a climate favourable to returning to work and remaining at work in a sustainable manner, resources, clear and unambiguous procedures with respect to the responsibilities of supervisors and other actors, sufficient latitude with respect to the choice and implementation of adjustments and accommodations during the SR, training (supervisors and other actors). For example, it appears that supervisors very much appreciate benefiting from discussion forums and having greater decision-making latitude for problem solving when permitted by the organization. The synthesis of the essential activities and concrete actions from the literature review and the results of the secondary data analysis allow identifying 8 courses of action and 23 specific actions.

For the applicability component, 19 participants (4 supervisors and 15 other players) from 19 Quebec organizations in six different sectors of activity completed the questionnaire. Overall, the 19 respondents found the courses of actions and actions to be relevant, adequately and exhaustively formulated and applicable to Quebec in favorable organizational contexts. These favourable contexts concerned the formalization of the supervisor's role and responsibilities with respect to return and sustainable retention at work, the organization's culture, organizational resources, the decision-making latitude granted to supervisors in temporary work organization changes, and the possibility of training supervisors on the actions required in the context of a worker's reintegration. The comments collected also made it possible to specify elements of applicability related to the intrinsic characteristics of companies: size, location, unionization, prevalence of cases of work stoppages, nature of the work.

4 Conclusion

This study helped to better precise the role and responsibilities of supervisors related to the return-to-work and sustainable retention process in different organizational contexts. In particular, this research made it possible to accurately describe the actions of supervisors, the problems they encounter, and the strategies used to overcome them, as well as the conditions conducive to their involvement in the process. In addition, this study made it possible to formulate precise action to be implemented by the organizations and the supervisors themselves to promote the return and long-term job retention of workers who have had work-related musculoskeletal disorders. These courses of actions were considered by the participants to be relevant, feasible and applicable. The organizational context appears to influence the application of the courses of action, as do the conditions under which they are implemented [9–15]. This study provides an interesting starting point for developing a sustainable return-to-work process that includes supervisors and reflects the realities of practices in the field. More than drawing up observations on the need for clarification between the role of the supervisor and that of the other stakeholders in the return to work and sustainable job retention, and on the relevance and feasibility of the courses of action, two recommendations were put forward for organizations.

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Appendix: Courses of Action and Specific Actions

Courses of action	Associated specific actions for the supervisor
Course of action 1: Formalize the role and responsibilities of the supervisor in the procedures designed to facilitate a sustainable RTW	Clarify role and responsibilities as a supervisor in the procedures designed to facilitate a sustainable RTW Distinguish your RTW responsibilities as a supervisor from those of other actors participating in the sustainable RTW process Participate in developing policies and procedures based on your experience Distinguish between accident prevention actions and RTW actions
Course of action 2: Communicate with the absent worker to maintain contact	Contact the worker as soon as possible after the sick leave begins, to: - reassure the person about his or her employment relationship - find out his or her perceptions of his or RTW Reach an agreement with Human Resources about a mechanism for transmitting relevant information to you about the worker's needs
Course of action 3: Collaborate with the other actors involved in facilitating the worker's ability to return to and stay at work	Collaborate with the worker when planning and implementing the RTW solution Collaborate with the work team when planning and implementing the RTW solution Collaborate with the actors responsible for managing the worker's compensation claim (e.g. the person filling the role of RTW coordinator)
Course of action 4: Assist the worker during his or her return to work and efforts to stay at work	Assist the worker in the various physical and organizational adjustment and accommodation measures Assist the worker if conflicts arise with other members of the work team
Course of action 5: Plan the worker's RTW and ways to help him or her stay at work	Plan the workforce during the worker's sick leave (e.g. task distribution, schedule) Develop an action plan and consult with the worker to identify the options that would facilitate the RTW Plan the worker's RTW based on his or her needs (e.g. the welcoming back, review of safety measures, information on new tools or procedures) Plan the RTW with the other actors concerned (e.g. meet with the work team)
Course of action 6: Carry out the RTW	Meet with the worker as soon as he or she returns to resume the tasks expected of him or her in light of his or her capacities and

(*continued*)

(*continued*)

Courses of action	Associated specific actions for the supervisor
	resources, and reassure him or her of your support and that of the work team Make the necessary physical and organizational adjustments and accommodations in collaboration with the actors concerned Ensure that the worker and other members of the work team respect the worker's limitations
Course of action 7: Do regular follow-up of the work activities and their distribution among the members of the work team	Meet with the worker when he or she returns (e.g. information and follow-up meeting about his or her capacities and satisfaction with the work) Inform the work team of the RTW plan before the worker returns In collaboration with the persons concerned, resolve any problems that may arise during RTW process
Course of action 8: Train the supervisor on the actions expected of him or her to help workers return to and stay at work	Acquire the skills needed to conduct ergonomic evaluations of work situations, plan, and resolve problems related to the implementation of RTW solutions (e.g. temporary assignments, physical and organizational adjustments or accommodations) Identify your needs for training (e.g. communication skills) on the expected actions

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An Investigation in Muscle Activity of Student's Neck and Back in Various University Rooms

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Abstract. This study investigates the effects of three different sitting positions on neck and back of students in two various class layouts under class activities. One of the classrooms is traditional in which students sit parallel to the screen and the other one which is more recent one, seats are perpendicular to the screen. Sitting positions include seats in various part of classroom. In this approach, the activity of back muscle, Trapezius Pars descendens (TRP-UP), and neck muscle, Sternocleidomastoid (SCM), are explored. Results show that class layout has a significant effect on both SCM and TRP. Yet, students sitting positions has significant effect only on SCM. Moreover, based on questionnaires' output, students feel more comfortable in both their neck and back, when they sit in the middle of traditional classes.

Keywords: Muscle activity · Classroom layout · Sitting position · TRP-UP · SCM · ANOVA

1 Introduction

With the increase in simultaneous usage of laptop and projection screens in the classrooms, classroom layouts and sitting positions play an important role in the student comfort levels [1]. When the sitting arrangement is not parallel to the blackboard, students need to rotate their neck and trunk every time to look at the blackboard for the whole lecture, but they don't need to move their neck and trunk when they are sitting parallel to the blackboard. In general, the preference is given to accommodate maximum number of people in a classroom without considering the psychological and physical aspects of sitting arrangements on student's body. But physical environments of classrooms have a vital role in student's satisfaction both physically and cognitively. In fact, a higher level of satisfaction can increase the level of skills, mentality, and knowledge of students [2].

Now days most of the universities have new classrooms which contain desktop computers and projection screen. In these classrooms, students have to move their neck and back muscles repeatedly to use computers and focusing on the screen together to follow the instructor that may cause fatigue [3]. Muscle activities in both neck and

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back, also comfortability are considered as response variables in many researches [5, 6] and [7]. Type of classroom layout is a key factor which has been investigated in some studies [4]. Moreover, as sitting place has a drastic effect on student's posture [8], researchers consider it as another key variable [5].

Hence, this study aims to investigate the effect of various sitting positions in different classroom layouts on the students' neck and back while they look at the screen display and work with their desktop computers simultaneously.

2 Materials and Methods

To study the effect of the sitting position on neck and back of the students, surface electromyography (sEMG) was used. Furthermore, muscle activities of participants in six different positions in two classroom layouts were recorded while they use laptop and look at the projection screen simultaneously. Two class layouts (a and b) [1] and three sitting position (1, 2 and 3) are shown in Figs. 1 and 2. Besides, expected long term comfort ratings are recorded by questionnaire after each experiment too. In these questioners, to summarize different conditions, layout and sitting arrangement are signed with alphabets. Therefore, letter A is in class a and sitting position 1, B is in class a and sitting position 2, C is in class a and sitting position 3, D is in class b and sitting position 1, E is in class b and sitting position 2 and F is in class b and sitting position 3.

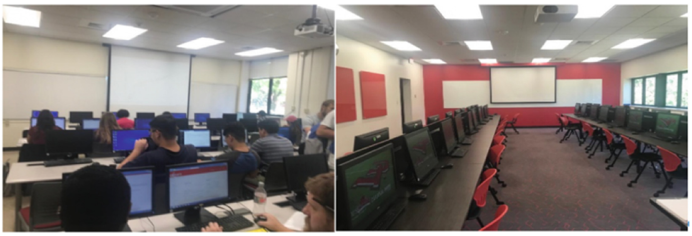

Fig. 1. Actual classrooms.

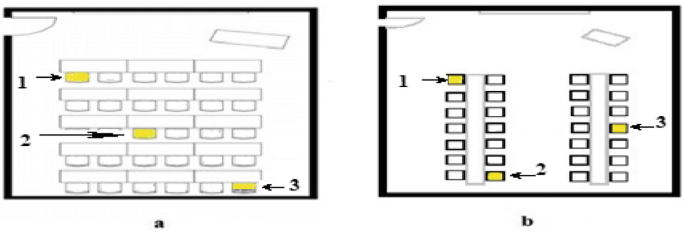

Fig. 2. Different sitting positions and classroom layouts (a and b).

2.1 Participants, Experimental Setup and Stimuli

Five participants were selected from Lamar University for the study, who has no physical complaints. The average weight and height of the participants was 162 lbs and 176 cm respectively. The experiments carried out at Human factor and ergonomics lab at Lamar University in Beaumont, USA.

sEMG was used to measure the muscle activity in both TRP-UP and SCM for 5 min in 6 positions in two classroom layouts. Here participants were asked first to lay down on a mattress for 5 min to relax the muscles. Then they were asked to sit in different positions and perform the tasks shown on projection screen on the laptop. To cover various course content, the experiment contains three different tasks such as typing, programming and computation in Microsoft Excel. The experiment lasts 30 min for every participant.

To stimulate the classroom posture for layout a, projection screen is placed parallel and for layout b, the projection screen is placed perpendicular to the sitting arrangement, sitting distances is changed according to the sitting position with respect to the projection screen. Moreover, as it can be seen in Fig. 1, classrooms usually have desktop computers, but for the convenience in this investigation, laptop was used instead of the desktop computers.

After each condition participants were asked to fill the questionnaire on their expected long-term comfort. A score needed to be given from 1 to 5 for the neck and back in each position. Also, to measure muscle tension in terms of maximum muscle contraction (MVC), MVC of neck and back is recorded at the end experiment.

2.2 Muscle Selection

For turning and holding the head up to look at computer and the projection screen, flexion and extension muscles have major role. Therefore, SCM and TRP-UP are selected for the study which are responsible for the flexion and extension [9].

2.3 Apparatus

A wireless Biometrics EMG system (sampling rate 2000 Hz) and a computer with Biometrics Data LITE were used to measure muscle activity. An Epson vs-250 projector is used to display the projection screen and a Lenovo ThinkPad X1 Carbon 14″ laptop is used to perform the task by participants.

2.4 Preparation

After determination of the EMG sensors positions [9], the position was cleaned by razor and alcohol wipes and the sensors were placed on TRP-UP and SCM. In the next step, seat was placed according to the sitting position in classroom layout with respect to projection screen. Participants were asked to sit on chair, chair and laptop were adjusted to be suitable for participant's comfort and eye height.

2.5 Maximum Voluntary Contraction

At the end of the experiment to record MVC for each participant, first for the SCM, participants were asked to lay down. Next, downward force was applied on their head and they were asked to lift their head up as much as they can. For TRP-UP students were asked to raise their hands and lateral force was applied at both the elbows outwards and they were asked to oppose it. These positions were held for 5 s each and then the muscle activity as the MVC was recorded.

3 Results and Discussion

3.1 Muscle Activity

The muscle activity of the TRP-UP and SCM in different class layouts and sitting positions for each participant are shown in Table 1.

Table 1. % MVC for TRP-UP and SCM in different levels.

	TRP-UP			SCM		
	Sitting position			Sitting position		
	1	2	3	1	2	3
Class a	32	44	53	6	4	3
	45	40	42	6	9	6
	11	8	9	16	5	7
	22	13	6	3	3	2
	36	26	15	3	8	4
Class b	37	29	58	52	3	3
	55	34	36	25	10	11
	10	7	8	27	26	4
	11	8	11	10	2	3
	29	25	19	13	3	4

The data in Table 1 shows that the maximum amount of TRP muscle activity in class a, is in position three (last row in class layout) while for SCM it is in the first row position one (first row in class layout). The minimum amount of TRP and SCM muscle activity is in the last row, position three, of classroom a. In class type b, maximum amount of activity in TRP goes with position three which is the last row, which for SCM the maximum amount is associated with the position one. But the minimum amount of muscle activity in recent classroom layouts assigns to sitting position two which is in the middle of the class b, for both TRP and SCM.

In the next step, the effect of class layout and sitting position is investigated using ANOVA. As indicated in Table 2, class layout has a significant effect on TRP-UP but sitting position does not have a significant effect on TRP-UP. The interaction effect between class layout and sitting position is also significant. Furthermore, in Table 3.

ANOVA evaluation of SCM, the results show that both class layout and sitting position have a significant effect on the activity of neck.

Table 2. ANOVA evaluation of TRP-UP.

Source of process parameters	Sum sq	DF	Mean sq	F-value	Pr (>F)
Class layout	0.27840	1	0.27840	28.696	1.69e−05
Sitting position	0.05054	2	0.02527	2.605	0.094681
Class layout × Class layout	0.19409	2	0.09704	10.003	0.000693
Residuals	0.23284	24	0.00970		

Table 3. ANOVA evaluation of SCM.

Source of process parameters	Sum sq	DF	Mean sq	F-value	Pr (>F)
Class layout	410.7	1	410.7	5.741	0.0247
Sitting position	713.9	2	356.9	4.990	0.0154
Class layout × Class layout	477.6	2	238.8	3.338	0.0526
Residuals	1716.8	24	71.5		

Therefore, regarding the ANOVA outputs of Table 2, the hypothesis that sitting in different classes have effect on the back muscle of students, TRP-UP, could be supported in this study. Regarding the obtained results in Table 1, the maximum amount of activity in the back of the students, is in classroom b and the minimum is in classroom layout a, which needs less trunk movement. This result is confirmed by [3] research which claims that one of the key risk factors which causes low-back fatigue in workplace is twisted trunk posture.

Furthermore, Table 3 confirms that muscle activity was significantly different in participant's SCM, in different sitting position and class layout. As it can be seen in Table 1, the maximum neck activity is seen in class b and position one which may be because of the short distance between screen and seat place. It can cause the students turn their neck more any time that they want to look at the projection screen. Also, the minimum amount of muscle activity is seen in both class layout. Maybe one reason to achieve theses amount of SCM in position three of class a and position two of classroom b, is that only the muscle activity of one side SCM is measured in this investigation while when students turn their neck both SCMs have movement. These outputs are confirmed by [10] which claimed dual computer screens have significant effect on neck-shoulder muscles activities.

3.2 Comfortability Analysis via Survey

Expected comfort scores regarding comfort questionnaire for the neck and back of participants are shown in Fig. 3. As it demonstrates in this Figure, participants feel more comfortable in both neck and back while programming, typing and doing Microsoft Excel in position B, which is sitting position 2 in class a. But they don't feel that much comfortable in position D, which is position 1 in class b for all three tasks.

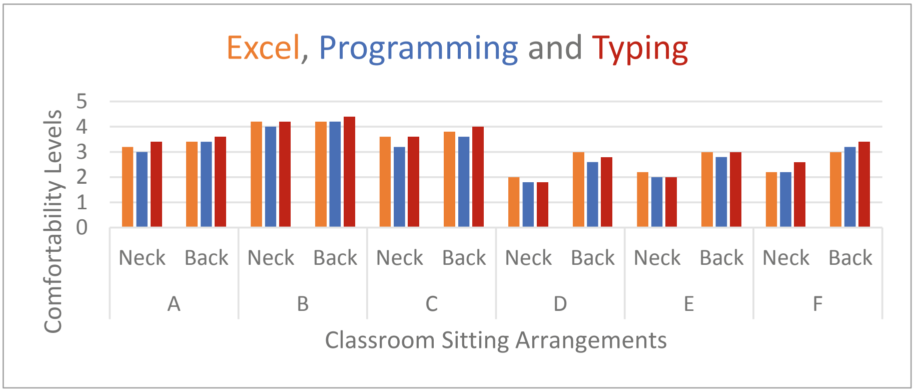

Fig. 3. Participants comfort level while programming, typing and using Microsoft Excel (neck & back).

As it has mentioned, the highest rate of the expected long-term comfort of participants' neck and back belongs to classroom a and sitting position two which is the middle row of the mentioned class. It may be because of that students get used to sit in traditional classes and people feel more comfortable through stability rather than moving their body which may cause discomfort in long time [6]. This can be confirmed by the discomfort results in Fig. 3, which implies people do not feel that much comfortable in position D, which belongs to the seat near the screen display in class b. In this position participants need not to be static and have to move their body to look at the screen which makes them uncomfortable.

It is needless to mention that comfortability rating is qualitative and just can give an insight to participant's preference. In other words, predicting long term experienced comfort [11], for example 1.5 h regarding the classes time, does not seem always possible because participants may show different comfortability level during time.

4 Conclusion

This study investigated the effect of different classes' layout with various sitting positions for students. First, using EMG, the muscle activity in TRP (back) and SCM (neck) of students is discussed. A significant difference in TRP muscle in different class layout is found, indicating that using various class layout cause more activity in back muscles. This research also finds a significant difference in SCM activity in both different class layout and sitting positions. This is confirmed by the questionnaire results, which indicate that participants with various level of familiarity with experiments' task, feel more comfortable in sitting in the middle of the traditional classroom. While it could be expected that new classroom layout is more helpful, the outputs of this research does not confirm this hypothesis.

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Occupational Risk Assessment of Municipal Solid Waste Collectors in a City Subdivision in the Philippines

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Abstract. According to Philippine statistics report in 2013, majority of the Philippines' solid wastes come from residential areas. Solid waste collection workers are regularly exposed to risks of occupational injuries and work-related musculoskeletal disorders (WMSDs). With the aim of assessing the occupational risks of municipal solid waste collectors, this study was conducted in a city subdivision in the National Capital Region of the Philippines. Workers were asked to answer the Cornell Musculoskeletal Discomfort Questionnaire and an occupational risk survey. Images of worker postures taken during their work were analyzed using the Rapid Entire Body Assessment. Risk factors for possible occupational injuries were determined. Results showed that gathering trash, giving trash to segregators, and garbage segregating exposed the workers to poor postures with high to very high risk. Open wounds were most likely to occur. Recommendations for both subdivisions and contractors were provided in order to mitigate the risks identified.

Keywords: Solid waste collection · Residential areas · Human factors

1 Background of the Study

In 2016, the National Solid Waste Management Commission estimated that the Philippines generated 40,087.45 tons of solid waste per day [2]. Majority of the nation's solid wastes are generated in the National Capital Region, with around 9,212.92 tons per day in 2016 [2]. In 2013, 57% of all solid wastes came from residential areas [2]. From an interview with the Senior Environment Management Specialist Chief, Garbage Collection Section, of the Environmental Protection and Waste Management Department of Quezon City (Q.C.), as of 2019, there was a per capita waste generation of 1.0711 kgs/person/day. This value increases annually by 3.33%.

Solid Waste Management is not without risk, posing numerous health hazards and exposing workers to various occupational diseases and injuries. In the Integrated Survey on Labor and Employment (ISLE), one of the regular establishment-based

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surveys conducted by the Philippine Statistics Authority (PSA), in establishments employing 20 or more workers, the average workdays lost as a result of temporary incapacity due to work-related event or occupational injuries in the WSSWMRA industry increased from 3.4 in 2013, to 13.19 in 2015 [4].

2 Objectives of the Study

The objectives of the study are to identify and provide ways to mitigate the occupational risks of solid waste collectors in a city subdivision in the Philippines.

3 Methodology

3.1 Data Collection: Administering Worker Surveys

Worker surveys were administered to identify the most frequent and prevalent WMSDs and occupational injuries incurred by solid waste collectors. To determine the former, the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) for Standing Male Workers was used, while the latter was determined by using a second survey based on the PSA's Integrated Survey on Labor and Employment (ISLE). A total of 30 responses were gathered for each survey.

3.2 Data Collection: Observing Solid Waste Collection in a Subdivision

Images and videos of solid waste collectors during collection of the trash were gathered. These were randomly sampled to determine which tasks expose workers to poor postures and most frequently to occupational injuries. The data collection was conducted within a city subdivision. Two collectors & 2 segregators were observed in the morning and 1 collector & 2 segregators in the afternoon. A total of 7 workers were observed.

3.3 Analysis of CMDQ Responses and Rapid Entire Body Assessment (REBA)

Data from the CMDQ were interpreted by identifying probable causes and relating worker tasks to the symptom identified by the respondents.

The process of collecting solid wastes was first divided into smaller, unique, and distinguishable tasks. Images of postures collected were categorized according to the task being done by the worker. A random sample of these images per worker were analyzed using REBA, a tool used to determine the risk for Musculoskeletal Diseases (MSDs) associated with one's posture. Recommendations were primarily be given to tasks with high REBA scores for these require immediate change.

3.4 Occupational Injuries Risk Analysis

For each image selected, occupational injuries were identified as "present" "not present" or "possibly present". Risk factors for each identified occupational injury were enumerated. Recommendations focused on the frequency of risk for occupational injuries and on which tasks expose workers to the most risk for occupational injuries. This analysis was repeated per worker.

Data from the ISLE-based survey were used to determine which among the occupational injuries identified in the ISLE were frequently experienced by the solid waste collectors, and therefore, have the highest probability of happening. Probable causes identified through this survey were also used as a basis for determining sources of risk for occupational injuries.

4 Results and Discussion

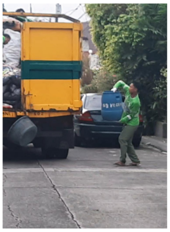
Based on the data collected from observing solid waste collection, three types of methods were used by the collectors, workers who search for and bring solid wastes back to the garbage truck: (1) Collectors held solid wastes in their hands then returned to the truck (see Fig. 1); (2) Collectors carried solid waste bins, delivered the bins to the truck, then returned the bins to their original location (see Fig. 2); (3) Collectors stacked solid wastes in a 'bucket' then dragged the bucket, with a form of rope or straw, back to the truck (see Fig. 3).

a. Getting Trash: 11 b. Return to Truck: 6 c. Give Trash to Segregator: 9

Fig. 1. REBA scores for type 1 collection: collector 1 (AM)

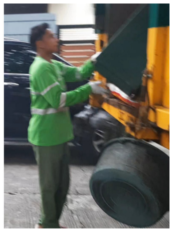
On the other hand, segregators, workers who receive, segregate, and organize solid wastes given by the collectors, follow two types of methods which depend on their position in the truck: (1) Generally, segregators only receive solid wastes from the collectors, then immediately start segregating (see Fig. 4); (2) Segregators nearest to the entrance of the truck receive trash bins from collectors, empty the bin's contents, return the trash bin, then start segregating the trash. These segregators are also tasked to compress garbage bags, using their feet, after sorting out its contents (see Fig. 5).

a. Getting Trash Bin: 7



b. Return to Truck with Trash Bin: 9

c. Give Trash Bin to Segregator: 11

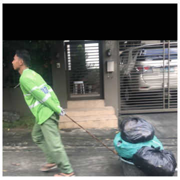


d. Receive Trash Bin from Segregator: 3

Fig. 2. REBA scores for type 2 collection: collector 1 (AM)

NO DATA

a. Putting Trash in Bucket



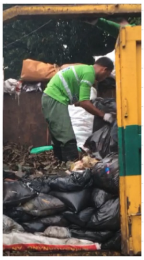
b. Returning/Pulling Bucket Back to Truck: 9

NO DATA

c. Giving Trash from Bucket to Segregator

Fig. 3. REBA scores for type 3 collection: collector 1 (AM)

a. Sort Garbage: 7



b. Pick up Garbage: 4

c. Inspect Garbage: 3

Fig. 4. REBA scores for type 1 segregation: segregator 1 (AM)

4.1 REBA Scores

From the REBA scores of each collector, regardless of the type of method used, high REBA scores (8–10: Action is Necessary Soon; 11–15: Action is Necessary Now) were associated with tasks that involved gathering trash and giving trash to segregators. Returning to the truck, Type 1 Collection (Fig. 1) garnered significantly lower REBA scores compared to Type 2 Collection (Fig. 2), where trash bins were being carried, or

a. Sort Garbage Using Feet: 10

b. Compress Garbage Using Feet: 12

c. Sort Garbage Using Hands: 11

d. Get Trash Bin: 8

e. Empty Trash Bin: 7

f. Return Trash Bin to Collector: 7

g. Transfer Trash Using Two Hands: 8

h. Transfer Trash Using One hand: 10

Fig. 5. REBA scores for type 2 segregation: segregator 2 (AM)

Type 3 Collection (Fig. 3), where a bucket was being pulled. However, after the segregators have been given the garbage, REBA scores for returning tasks in Type 2 Collection were lower.

For segregators, regardless of the type of method used, high REBA scores were given to tasks that involved sorting garbage. For Type 2 Segregation (Fig. 5), in addition to segregating, tasks that involved moving or transferring garbage, such as receiving the trash bin, were also given high REBA scores.

It should be noted that large differences in REBA scores for certain tasks may be a result of other factors. For example, in Type 2 collection, collectors gave trash bins to the segregators differently (ex. throwing trash bags compared to directly giving them to segregators). The same can be said about receiving trash bins - the difference in scores can be associated with the size of what was being received and how it was given by segregators.

4.2 CMDQ Responses

Based on the CMDQ, solid waste collectors generally do not believe that body pains are too uncomfortable and interfere with their work. The workers experience pain most often in their hips, lower back, upper back and shoulders. These may be associated to twisting movements or frequent side-bending when picking up trash, improper lifting or transferring heavy trash above shoulder level, frequent bent-over postures over long periods of time.

4.3 ISLE-Based Survey Responses

According to the ISLE-Based Survey, open wounds and foreign bodies in the eye (e.g. dust, from the garbage, which may not necessarily damage one's vision) are generally the most frequent occupational injuries incurred by the workers. A number of respondents also incurred fractures, sprains, and concussions. Most of the respondents believed that open wounds, fractures, and strains affected their work performance the most. Open wounds were commonly associated with sharp objects such as syringes, broken glass, open cans, sticks, etc. Fractures and Sprains were caused by accidents such as falling off the garbage truck or tripping over certain objects.

4.4 Occupational Injuries Risk Analysis

For collectors, open wounds were the occupational injury most likely occur. Fractures, sprains, and concussions were also likely to happen. In general, these risks were associated with tasks that involved getting or moving trash and giving trash to segregators. Figure 6 indicates the risks present in each task of a collector. For segregators, the presence of risk factors for certain occupational injuries depended on which Type of segregation method would be used. For Type 1, open wounds, concussions, and foreign bodies in the eye were the occupational injuries most likely to occur. For Type 2, in addition to the aforementioned occupational injuries, risk factors were present for sprains as well because garbage bins were being handled. Figure 7 indicates the risks present in each task of a segregator.

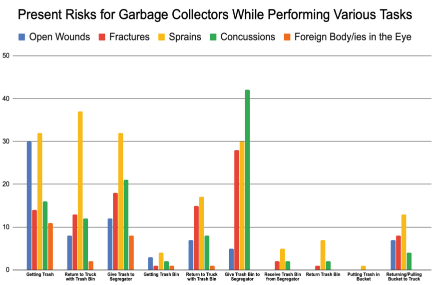


Fig. 6. Occupational injuries risk analysis per collector task

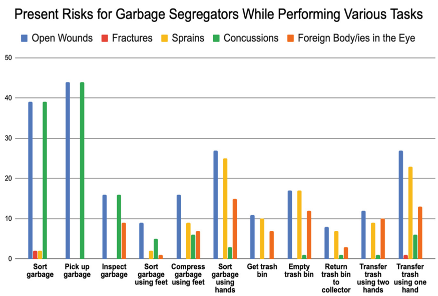


Fig. 7. Occupational injuries risk analysis per segregator task

Overall, the occupational injury with the greatest number of present risk factors is open wounds, at 29.39% of all recorded instances of risks. This is followed immediately by risks for sprains at 27.81%, then risks for concussions at 22.78%. The results of the occupational injuries risk analysis coincide with the responses from the ISLE-Based Survey.

5 Recommendations

Based from the analysis, recommendations include (1) ensuring that homeowners follow proper segregation of non-biodegradable, biodegradable, and hazardous wastes to eliminate the risk of incurring open wounds, (2) determining a shortest route and setting up collection stations along the route to reduce the total collection time, decreasing the exposure time to risks of WMSDs and occupational injuries, (3) providing workers with knowledge on proper lifting procedures, (4) providing elevated collection areas somewhere between 87.66 cm to 104.14 cm., the mean hip height and elbow height of a male Filipino manufacturing worker [13], respectively, since the strongest hand forces and most useful mobility are between elbow and hip heights, (5) ensuring that workers wear Personal Protective Equipment (PPE).

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Workplace Design and Ergonomics

An Empirical Investigation of Factors Influencing Energy Saving Behavior in the Workplace

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Abstract. Buildings are estimated to account for 40% of the EU's energy consumption. Thus, there is a growing body of research on the behaviors of building users and what influences these. While there has been substantial research on energy saving behavior in households, far less research has focused on the context of non-residential buildings. We report on a study to understand energy saving behaviors in the context of workplace, drawing on the theory of planned behavior. A hierarchical regression analysis was performed on data from employees in a Norwegian organization ($N = 251$). We find energy concern to be a significant predictor of energy saving behavior at work, and that this relationship is partially mediated by perceived behavioral control. In addition, routinization of energy saving behavior seem to be of great importance for engaging in such behavior also at work.

Keywords: Energy saving behavior · Workplace · Theory of planned behavior · Human and organizational factors

1 Introduction

In Europe, expected increase in energy demand due to economic growth surpasses that of expected increase in energy production [1]. Consequently, there is a greater focus on energy efficiency as evident in the Energy Efficiency Directive (2012/27/EU) by the European Union (EU). In line with political goals of sustainability, there is increased focus on understanding energy consumption related to development and operation of buildings and how this can be reduced. This follows as buildings are estimated to account for 40% of the EU's energy consumption [2]. The interest in buildings from a sustainability perspective is further emphasized as buildings "offer near-term, highly cost-effective opportunities to curb energy demand growth rates, even to reverse them in developed economies" [3, p. 5]. To exploit this potential, it is necessary to change user behaviors which has a major effect on buildings' energy use [4].

While there has been substantial research on energy saving behavior in households, far less research has focused on the context of non-residential buildings [1, 5], despite such buildings being responsible for a large percent of the overall energy consumption in developed countries. For example, in Norway, non-residential buildings are estimated to account for 15% of domestic energy consumption [6]. Nonetheless, important

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contributions to our understanding of building users' behaviors have been made by different disciplines including social sciences, economics and engineering [7]. Currently, there seem to be two main purposes of research on energy saving behavior set in the context of workplaces: one is to derive knowledge of behavior patterns in use of buildings that allows for prediction of buildings' energy consumption [8–10], while the other is to derive knowledge of individual and organizational factors that explain and influence the behavior of building users [11–14]. In this paper, we focus on the latter. Such knowledge is of value for both commercial building tenants and owners, policy makers and research community as it can inform efforts aiming to influence the behavior of building users to improve energy efficiency and reduce costs associated with consumption.

2 Factors Influencing Energy Saving Behavior in the Workplace

A narrative literature review was performed to identify the state of art in research on understanding how factors at the individual and/or organizational level are related to occupant's energy conservation behaviors.

Among the research identified, the model of behavior that is most frequently applied to explain individual differences in energy consumption behavior is that of theory of planned behavior (TPB). Several studies support the notion of TPB and its explanatory power regarding energy saving behavior in the workplace. TPB proposes that attitudes (i.e. the degree to which people have a favorable or unfavorable evaluation of the behavior), norms (i.e. the perceived social pressure to perform or not perform the behavior), and perceived behavioral control (i.e. the perceived ease or difficulty of performing the behavior) shape an individual's intention to perform a specific behavior which, in turn, influences the likeliness that s/he does so [15, 16]. In several studies, energy concern (attitude) have been shown to positively influence energy saving intention [11–14]. In the workplace context, organizational support creates perceptions of social pressure to engage in certain behaviors. Frequently, top management support is referred as a key factor in influencing employees' behavior and has been shown to be of importance for pro-environmental behaviors at work [17, 18]. Therefore, we anticipate that top management support will be positively related to intentions to engage in energy saving behaviors. In line with TPB, we further anticipate that perceived behavioral control and behavioral intentions predict energy saving behavior at work [15, 16].

Although TPB views perceived behavioral control as one of three unique predictors, [11] found perceived behavioral control to mediate the effect of energy concern on energy conservation intention. Hence, perceived behavioral control may not only be a predictor of energy saving behavioral intentions and behavior, but it may also mediate the relationship between the other predictors and intentions to engage in energy saving behaviors and actual behavior.

In addition, we want to explore potential spillover-effects between energy saving behavior at home and the workplace. While context is seen to be an important defining feature of behavior, studies have not found there to be a spillover effect in terms of energy behaviors [12, 19]. However, [19] argue that a spillover effect is most likely to occur where categories of behavior are similar. Figure 1 provides a summary of our hypotheses based on the existing literature.

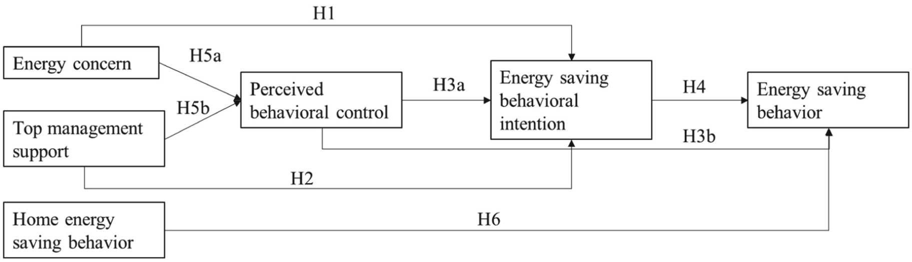

Fig. 1. Conceptual model of predictors of energy saving behavior in the workplace

3 Method

3.1 The Study

This study reports on responses to a web-based survey administered in Norwegian and English to employees in an organization with two premises in South-Eastern regions of Norway. The survey was administered in August 2019. Email invitations were sent out to 618 employees from the communication department in the organization with a pre-written invitation text explaining the purpose of the study, management of individual responses in which confidentiality would be ensured, and contact information for the research team. In addition to the email invitations, respondents were also invited to participate through advertisement on the organization's intranet.

The total number of participants in this study was 251 (a response rate of 41%) and included Norwegian (N = 219) and non-Norwegian (N = 32) nationals. The age distribution of respondents was representative of the age distribution of all employees. 18% were under 35, 23,5% were between the age of 35 and 44, 28% were between the age of 45 and 54, 28,5% were between the age of 55 and 64, and 1% were 65 or older. The respondents were representatively distributed between the various departments of the organization and its premises. The two premises of the organization mainly consist of buildings with individual offices and meetings rooms. However, a few buildings rather contain larger industrial equipment in open spaces.

3.2 Survey Design

Measures. The questionnaire included measures used in previous research related to energy saving behaviors. The complete questionnaire was tested by three colleagues who did not work on this subject. After having reviewed their responses and their feedback, only minor changes were made in terms of wording before administering the questionnaire to the sample. Table 1 provides an overview of measures used.

Table 1. Summary of measures

Variable	No. of items	1–5 Likert scale from	Chron-backs α	Inter-item corr.
Workplace energy saving behavior (adapted from [20])	10	Never - always	.63	.15
Home energy saving behavior	6	Never - always	.62	.22
Energy concern (adapted from [12])	3	Disagree - agree	.70	.45
Top management support (from [17])	3	Disagree - agree	.88	.71
Workplace perceived behavioral control [11]	3	Disagree - agree	.80	.57
Energy saving behavioral intentions [13]	2	Disagree - agree	.83	.71
Control variable Habits (from [24])	3	Disagree - agree	.94	–

Control Variables. Habits have also been found to play a significant role in explaining energy saving behavior [14, 21]. Furthermore, age has been identified to influence pro-environmental concern and behavior [22, 23]. Therefore, we include these as control variables in our model. Habits was measured by use of an adapted scale from [24], previously used in the context of energy-saving behaviors [14]. Respondents were asked to indicate the extent to which they agree with four statements concerning turning off electronic equipment when not in use, closing the door to rooms that are not in use, and turning on additional heating sources or adjusting heating when feeling cold. Respondents were asked to indicate their age by choosing an age group to which they belong.

4 Results

To test our hypotheses, we performed a hierarchical multiple regression analysis on the data collected data from building users in the organization. Prior to running the analysis, we performed data screening to ascertain that assumptions regarding normality, linearity and homoscedasticity were met. We first performed a stepwise regression analysis of each predictor on behavioral intention. The results are provided in Table 2. The analysis show that energy concern, top management support and perceived behavioral control are all significant predictors of intentions to engage in energy saving behaviors at work. Hence, H1, H2 and H3a are supported.

Table 2. Summary of hierarchical regression analysis for variables predicting workplace energy saving behavioral intention

Variable	*Model 1*	*Model 2*	*Model 3*	*Model 4*
	β	*β*	*β*	*β*
Age	−.07	−.09	−.07	−.07
Habit (el. equipment)	.09	.01	.04	.03
Habit (doors)	.19	.16**	.16**	.12*
Habit (heating)	.15***	.13*	.10	.09
Energy concern		.35***	.27**	.19*
Management support			.22**	.21**
Perceived behavioral control				.18*
R^2	.12	.18	.21	.23
F	8.45***	10.34***	10.75***	10.21***

**p < .05. **p < .01. ***p < .001*

Next, we performed the analysis of each predictor on workplace energy saving behavior. This allowed us to test H3b, H4 and H6, as well as testing that there is an effect to be mediated in accordance with H5a and H5b. Table 3 shows that perceived behavioral control is a significant predictor of energy saving behavior at work, hence supporting H3b. In contrast, behavioral intentions do not predict behavior. H4 is therefore not supported. H6 is supported with home energy saving behavior being the strongest predictor of behavior when all other predictors are included in the model. The results indicate that there is an effect of energy concern on energy saving behavior that is potentially mediated, but not by behavioral intention. H5b is not supported given that neither top management support nor behavioral intention predict behavior.

Table 3. Summary of hierarchical regression analysis for variables predicting workplace energy saving behaviour

Variable	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	β	*β*	*β*	*β*	*β*	*β*
Age	.06	.05	.05	.05	.05	.05
Habit (el. equipment)	.25***	.18***	.19***	.18***	.18***	.13***
Habit (doors)	.09**	.03*	.07*	.04	.04	−.01
Habit (heating)	−.05	−.06*	−.07*	−.07*	−.07*	−.08*
Energy concern		.31***	.30***	.25***	.24***	.17***
Management support			.04	.03	.03	.05
Perceived behavioral control				.12**	.11**	.11**
Behavioral intention					.04	.03
Home energy saving behavior						.31***
R^2	.27	.38	.38	.40	.40	.47
F	22.12***	29.15***	24.49***	22.87***	20.17***	23.65***

**p < .05. **p < .01. ***p < .001*

The results in Table 2 made us discard behavioral intentions from the further analysis. Instead, we tested for mediation effects between energy concern and energy saving behavior at work with perceived behavioral control as a mediator. Table 4 shows that energy concern is a significant predictor of perceived behavior control. From Table 3, results show that inclusion of perceived behavioral control slightly reduces energy concern in predicting energy saving behaviors which indicates a partial mediation. Subsequently we used a Sobel test to determine that the direct effect of energy concern on energy saving behavior with mediation is significantly different from the total effect of energy concern on behavior. The Sobel test ($Z = 2.62$, $p < 0.01$) support our interpretation that perceived behavioral control partly mediates the relationship between energy concern and energy saving behavior in the workplace.

Table 4. Summary of hierarchical regression analysis for energy concern predicting perceived behavioral control

Variable	*Model 1*	*Model 2*
	β	β
Age	.03	.01
Habit (el. equipment)	$.10^{*}$	.00
Habit (doors)	$.23^{**}$	$.20^{***}$
Habit (heating)	.03	.01
Energy concern		$.44^{***}$
R^2	.15	.26
F	10.58^{***}	17.03^{***}

*$p < .05$. **$p < .01$. ***$p < .001$

5 Discussion and Conclusion

This study set out to assess if the predictors outlined in TPB affect energy saving behavior in the context of workplace, and to provide empirical evidence of predictors of such behavior when at work. In contrast to other research, we do not find top management support to affect energy saving behavior at work. Instead, we found energy concern to be a significant predictor of energy saving behavior, and that this relationship is partially mediated by perceived behavioral control. These results suggest that engaging in energy saving behaviors at work is mainly influenced by employee's individual appraisal and control beliefs rather than a social factor. In addition, routinization of energy saving behavior seem to be of great importance for such behavior to be undertaken also at work. This is evident in habits related to use of electronic equipment and heating being significant predictors. Furthermore, that there is a spillover effect between energy saving behavior at home and at work also suggest that routinization of such behavior transcends the context in which the behavior is performed. Of greatest surprise in our findings is that no relationship between behavioral intentions and actual behavior was established. This could, however, be explained by the wording on the measurement scale used in which each item was future oriented. Hence, the respondents might have intentions to alter their energy saving behavior in the future (i.e. do more of), but that this was not currently reflected in their actual behavior. If that is the case, we would expect that there would be a significant difference in behavior if the same study was undertaken at a later point in time.

These results suggest that efforts to influence employees to engage in energy saving behaviors will benefit from targeting behavioral beliefs and control beliefs. Hence, information campaigns may be useful in targeting both types of beliefs by providing employees with information relevant for forming appraisals of energy saving behavior, as well as knowledge regarding what each employee can do within their own control. Further, our findings point to efforts made to influence energy behaviors at home are important also in the context of workplaces because these behaviors can transcend contextual boundaries.

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Workplace Design and Ergonomic Analysis for Workers with Disabilities

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Abstract. It is generally known that an appropriate workplace design has long-term consequences on worker and can prevent musculoskeletal discomfort, improve productivity and work efficiency, reduce production costs and optimize human well-being. Worker is actually the center of production system and is the employer's most important resource. To achieve an optimum balance between the workers' and the company's interests a systematic approach to the workplace design is very important. The benefits of well-designed jobs, equipment, and workplaces are numerus and can be summarized in improved productivity, safety, health, and increased satisfaction for the employees.

Although the literature in the field of ergonomic workplace design is extensive, there is a lack of expert knowledge regarding workers with disabilities and ergonomic workplace design for these workers. The aim of our research was therefore to address this defectiveness and to propose corresponding modes to overcome exposed problems.

Keywords: Workplace design · Ergonomic analysis · Workers with disabilities

1 Introduction

Workers with disabilities are usually more vulnerable than healthy workers are and have more barriers in the process of getting an appropriate employment. Employment rate among people with disabilities is significantly lower than among workers without disability. For example, in Peer Review on "Work-capacity assessment and employment of persons with disabilities" published by European commission we can read about the case of Latvia, where only one of four persons with disabilities is employed [1]. Stated example is comparable to information's we can find e.g. in the World report on disability, dated on 2011 [2]. Workers with disabilities are not a homogeneous group. They may have different disabilities such as physical, sensory, intellectual or mental [3, 4]. Beside the wage, subsidies and employment quotas ensured by government, different supportive measures could be very effective [1]. On-the-job training and work trials, mentoring, job coaching and the presence of a support person, providing support to both employees with disabilities and employers are shown to be particularly helpful to support sustainable integration of workers with disabilities into the open labor market.

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During a practical workplace design, employers usually face the question, how to perform ergonomic analysis for workers with disabilities? Taking into account all additional challenges, shortly mentioned before, an appropriate workplace design is even more important for workers with disabilities and requests additional knowledge and efforts. The basic topics for effective workplace design are as follows:

- anthropometric measurements (body postures, body measurements),
- working tasks,
- working environment, and
- work organization.

Individual or tailor-made approach following these basic steps is very suitable for workers with disabilities, too, but it does not include possible workers limitations. Although well-known ergonomics methods do not include assessment measures for workers with disabilities [5, 6]. The same situation is with the software packages that use digital human models for workers' movement simulation and analysis.

Following research methodology, a detailed literature review of the topic was made focusing on case studies performed in different working environments using different ergonomic analysis for workers with disabilities and then synthesized in general recommendations and directions. The aim of our research was therefore to address defectiveness that is still present in the field of ergonomics workplace design for workers with disabilities and to propose corresponding modes to overcome exposed problems.

2 Methods

2.1 Screening Process

The first step in searching process was made using database Web of Science (Fig. 1). Search item 'workplace design' gave us 14.317 results for the period 1972 to 2020. From these 14.426 papers, 53 papers were highly cited in the field. Examination of titles and abstracts showed that regarding workplace design in the last 10 years (2009 to 2020) the most important topics were:

- leadership/behaviour/creativity/innovation,
- safety climate/workplace promotion (wellness)/physical activities at workplace,
- mental health problems/burnout symptoms,
- bullying and harassment at work,
- medical issues e.g. carpal tunnel syndrome, long working hours and coronary heart disease
- workplace diversity/resilience training for mental health and well-being of employees,
- gender stereotypes
- height-adjustable workstation/sit – stand workstations to reduce office sitting time,
- open plan offices (benefits vs. obstacles),

Workplace design for workers with disabilities is not on the list of most cited papers but with refined search from 14.317 results related to 'workplace design' we got 582 items connected to 'disability'. Examination of titles and abstracts showed that only a few papers match the topic we were researching. In the next step, our search was refined with the item ‘ergonomic analyses’ and we got 251 results. However, the examination process gave us the similar results as before, rarely any paper was about research topic. We did not get any paper with all three key words (workplace design, disability and ergonomic analyses). Therefore, we selected some representative papers from the list of 582 papers from refined search with ‘disability’ for final literature review.

2.2 Results Suitability

From the list of 582 papers gained with key words ‘workplace design’ and ‘disability’, 165 papers were in open access that enabled us an in-depth examination. The most research themes can be summarized as follows:

- return to work/rehabilitation,
- intellectual disability,
- discrimination and avoidance due to disability,
- fluctuation, invisibility, fatigue,
- inclusion of people with disabilities,
- medical aspects (neck pain, back pain, rheumatoid arthritis, headache),
- specific work groups (nurses, teachers, firefighters),
- cost-effectiveness of employability interventions,
- employer politics and practices,
- workplace health promotion.

Identification	⇒ 14.317 results found in the database Web of Science for search item 'workplace design' ⇒ refined search results using search item 'disability': 582 ⇒ refined search results using search item 'ergonomics analysis': 251
Screening	⇒ From 582 items connected with disability 165 items were in open access and were in-depth examined ⇒ From these 165 items only 25 used case study approach
Suitability	⇒ From 165 full text articles the most common reasons for exclusion were: ○ not physical disability, ○ general reflections about disability, ○ sensory, intellectual or mental disability, ○ rehabilitation, ○ general medicine & medical viewpoint, ○ social issues, ○ education, ○ environmental studies.

Fig. 1. Research process

3 Results and Discussion

A detailed literature review of research topic, made using database Web of Science did not give us expected results. As starting point, we focused on case studies performed in different working environments using different ergonomic analysis for workers with disabilities. The examination process gave us rarely any paper about research topic. The majority of papers was focused on not-physical disabilities, general reflections about disability, sensory, intellectual or mental disabilities, rehabilitation, medicine & medical viewpoints, social issues, education and environmental studies.

Our previous experiences based mostly on cooperation with companies and regarding their needs show that individual or tailor-made approach is the most suitable for workers with disabilities. Problem with existent ergonomics methods is that do not include possible workers limitations nor assessment measures for workers with disabilities [5]. In Table 1, a short review of selected methods for workplace assessment is presented. Some of these methods consider time/duration of movements/operations but others not. Additional time after each movement or operation (Fig. 2) could assure enough time to include workers with disabilities, too and enables to include them in working environment with other workers (not in a segregated environment where they usually are).

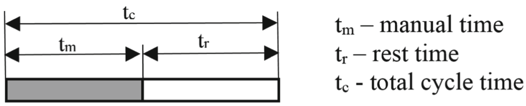

Fig. 2. Rest time as part of cycle time

The same situation is with the software packages that use digital human models for workers' movement simulation and analysis. The possible solution is that during the process time additional times are added, considering longer resting times. In software packages, additional time is visible on the timeline (Fig. 3).

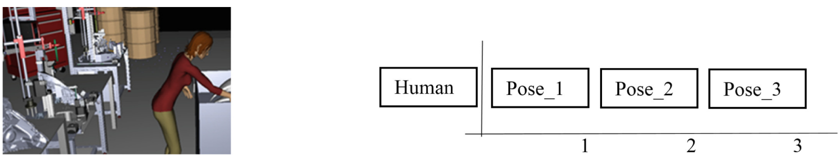

Fig. 3. Timeline in ergonomics software Jack

Recently, human-robot collaborative workplace design and evaluation as part of industry 4.0 is frequently mention. This is a complex problem that has gathered the attention and effort of both industry and academia [17–19]. The development of workplace and collaboration design methods requires the integration of multiple submethods and extended considerations on ergonomics. Where in this process are workers with disabilities is hard to foresee. The fact is that by ergonomic workplace design it is possible to adapt work to a human's physical and mental characteristics and to reduce or prevent additional adverse effects on health.

Table 1. Short overview of selected methods for workplace assessment

Method	Body part	Postures	Benefits	Limitations	Recommendations
OWAS [7, 8]	Whole body load	Back – 7 Upper limb - 4 Arm – 3 Lower limb – 9 Head – 5	Widely used and documented	Doesn't separate left and right upper extremities. Time consuming. Doesn't consider repetition or duration of the sequential postures. Requires training and specific skills	For researchers familiar with the method
RULA [9]	Whole body load	Upper arm – 5 Forearm – 3 Wrist - 4 Neck – 4 Trunk – 4 Legs – 2	Focus on the most relevant body segments. Easy to use. Public computerized software available	Not applicable for tasks involving manual materials handling and whole body movements. Right and left have to be assessed separately. Does not consider duration of exposures	To occupational safety and health practitioners for identifying risk for musculoskeletal disorders of neck shoulder and upper limb
REBA [10]	Whole body load	Neck – 4 Trunk – 6 Legs – 4 Upper arm – 6, Forearm – 2, Wrist – 3	Rapid to use. Computerized registration. Public domain	Time-consuming. Right and left have to be assessed separately. Time aspects not considered	To occupational safety/health practitioners

(*continued*)

Table 1. (*continued*)

Method	Body part	Postures	Benefits	Limitations	Recommendations
NIOSH [11]	Whole body load	Defined by the horizontal and vertical position of the load in relation to the trunk	Well documented and tested in several studies	Requirement of several technical measures and calculations means increased requirements for skills and time to make the estimation	For researchers to assess individual lifting situations in detail
OCRA [12, 13]	Upper limb load	–	Considering all repetitive tasks. Easy and quick to use	Time consuming. Allows only the estimation of exposures, not a precise risk evaluation. Needs well trained observer	To occupational safety/health practitioners, ergonomists
LUBA [14]	Upper body load	Based on deviation from neutral position of the joints	Easy to use. Comprehensible concerning postures	Either the right or left upper limb can be assessed. Does not consider force, duration and repetition	For ergonomists with limitations (the method assess only the postures)
ERIN [15]	Upper limb load	Trunk – 4, Shoulder/arm – 5 Hand/wrist – 3, Neck – 3	Easy to use. Difficult to observe hand postures	Lower limb assessment missing	Can be used by non-experts with minimal training
SI [16]	Upper limb load	Hand/wrist – 5	Assesses all main risk factors for distal upper limb disorders	Subjective assessment. Does not consider vibration and contact stress. Subjective assessment	To occupational safety/health practitioners, ergonomists
PEIL	Upper limb load	Hand/wrist – 9, Trunk – 8 Shoulder/arm – 12, Head/neck – 3, Head – 3	Exact method. Easy to use	The method was made for ergonomics analysis in manufacturing companies. Demands team work	For ergonomists and practitioners

Legend: OWAS – Ovako Working Posture Assessment System, RULA - Rapid Upper Limb Assessment, REBA – Rapid Entire Body Assessment, NIOSH – National Institute of Occupational Safety and Health, OCRA – Occupational Repetitive Actions, ERIN – Evaluacion del Riesgo Individual (Individual Risk Assessment), PEIL – Potential Ergonomics Issue List, SI – Strain Index

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Incidence of Varicose Veins and Associated Risk Factors Among Factory Workers to Develop an Ergonomically Sound Workplace

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Abstract. The high prevalence of Varicose Veins among adults is continually imposing the interest of the public worldwide. Since varicose veins problems affects about one (1) of five (5) adults and sixteen percent (16%) of adults at the age sixty (60) years old and above and around twenty-two (22) millions of women and eleven (11) millions of men worldwide. Discovering that there's also a higher risk of women having a varicose vein or about 50% of American women. Furthermore, a new study also shows that aside from women, tall person is great risk of developing a varicose vein. Alongside with non-modifiable risk factors is the nature of work of an individual which contribute to acquiring varicose veins especially those with stationary jobs. Therefore, the researchers conducted an epidemiologic study to measure the prevalence, measure of association and identifying the risk factors in the development of varicose veins. Prevalence rate is found out to be at fifty eight percent (58%) of which both identified risk factors and odd ratio re both in positive numbers. Leaning bas, and kinesthetic activities are recommended to mitigate the risk in developing the disease.

Keywords: Varicose vein · Factory worker · Risk factors · Ergonomically workplace

1 Introduction

Varicose veins affect about one (1) of five (5) adults and sixteen percent (16%) of adults at the age sixty (60) years old and above [5] and around twenty-two (22) millions of women and eleven (11) millions of men have varicose veins [1]. More than 23% of adults reportedly are affected of varicose veins, about 1 of 4 adults in United State experience discomfort of varicose vein and 80% of patients are female with the average age of 40 years old [4]. There's a higher risk of women having a varicose vein about

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50% of American women [10]. A new study also shows that aside from women, tall person is great risk of developing a varicose vein [17]. Alongside with non-modifiable risk factors is the nature of work of an individual which contribute to acquiring varicose veins. Having a stationary job requiring either standing or sitting may not help the muscles to move the blood flow legs back up to heart have greater tendency of having varicose veins [12]. However, despite the increasing count of people with varicose veins there's still some people who think of it as cosmetic problem. Some cases with varicose veins are not often need of treatment or asymptomatic but if the patients suffer complication including, Bleeding, Venous Ulcer, Blood Clot treatment must be applied [13].

Common forms of varicose vein problems include Telangiectasia, Reticular, Spider Veins, Trunk Veins and Varicose Eczema. The cause of having Telangiectasia is by chronic exposure to the sun heat [6] which comprises high risk work like traffic enforcers during their day shift duties [20], associated factors of telangiectasia are excessive alcohol consumption, acne and genetics of which females are affected 4 times more frequently than males as to represent the norm [18]. Base from the study [7], Reticular also referred to as feeder veins, in which condition exists when enlarge veins allow the outgoing blood to flow the opposite direction (backward). Women are in greater risk of having this kind of vein. Meanwhile, spider veins are small, twisted blood vessels that are visible through the skin [7]. They can be red, purple, or blue in color, and usually appear on the legs, chest, or face [8]. It was also known that people who stand for a long time, such as factory workers, tend to increase the amount of pressure in the veins of the legs and are more likely to develop spider veins [2]. Lastly, a conducted study by HSE (Health Service Executive) about varicose eczema, also known as venous eczema or gravitational eczema, proved that it is caused by the faulty valves in varicose veins, which allow blood to flow in the wrong direction [9]. Furthermore, the same study found out that people having an eczema were also 48% more likely to have high blood pressure [14].

According to (Buatista-Yao 2016) undergoing sclerotherapy said to be the most common procedure for varicose vein with an estimated cost Php 4,000 per session [21]. According to the American Society for Aesthetic Plastic Surgery, the average cost of a single sclerotherapy procedure in 2017 was $369 in the United States of America [19] but the cost of laser treatment for deeper varicose veins ranges from $2,000 to $7,000 [16]. In addition, the newly invented surface therapy (laser) is one of the most suitable treatments available for varicose spider veins [3].

Generally, varicose veins can be prevented by certain healthy lifestyle and avoiding the disease risk factors that is associated with demographics and exposures. The prevention to each kinds of varicose veins like telangiectasia advice keeping away to practice such as topical steroids, minimizing of exposure to extreme hot or cold temperature, using of mild cleanser on skin and applying of sunscreen, wearing of sun glasses and hat as a protection are some of the preventive tips for telangiectasia [11]. Meanwhile, some effective recommendations for preventing reticular veins involves exercising regularly, maintaining a healthy body weight, wearing sun protection while outdoors, avoiding standing for a long period of time and wearing of modern, comfortable compression stocking as often as possible [7]. According to studies related to prevention of varicose veins tend to conclude that without maintaining healthy lifestyle and seeking potential treatment, spider veins and all other types of varicose veins get worse over time [15]. Prioritizing care of the legs can prevent this kind of condition, caring in a way of not standing or sitting for prolonged periods, using of emollients or moisturizers to keep the skin supple and avoiding of bath products and soap that dry the skin [4].

2 Methodology

2.1 Sampling

Through utilizing a simple random sampling design, survey questionnaires were distributed to the chosen factory workers of Fisher Farm Incorporation located in the province of Bulacan. A total of one hundred four (104) respondents have been able to encourage to participate in the study.

2.2 Research Instrument

The survey used is modified form of Edinburgh Claudication Questionnaire. It consists of five (5) items question which was comprised into disease symptoms diagnosis, work time stationary diagnosis, legs comfortably diagnosis. While, the first part of the questionnaire is intended to acquiring data about the demographics of the participants such as age, work duration, and work shift are included, name is asked to be answered optionally to give away for future cohort study.

2.3 Data Analysis

The data gathered using the modified form of Edinburgh Claudication Questionnaire was analyze using statistical measures namely Measure of Prevalence or the percentage of individuals with the disease over the total population of a case control study; Measure of Incidence or the percentage or tendency of an individual without the disease to acquire the said disease by being expose to risk factors in a given period of time; and the Measure of Association or the strength in percentage of a risk factor to contribute in the development of a disease which includes Relative Risk and Odds Ratio.

3 Result and Discussion

3.1 Demographic Profil*e*

The 104 surveyed factory workers form Aquaculture Inc. in Dampol 2nd-A, Pulilan, Bulacan was composed of 66 females (63%) and 38 males (37%) with age ranging from 19–30 (65%), 31–40, (23%) and 41–59 (12%) in relation to risk factors. There were 27 individuals (26%) from the total surveyed population who have experience pregnancy and among those individuals 13 were obese (46%). Base from the entire data gathered and tallied, 28 individuals or (27%) were obese. Meanwhile, 15 individuals (54%) of the obese respondents have not or will not undergo pregnancy.

3.2 Epidemiological Measures of Disease

3.2.1 Measure of Prevalence

The Prevalence rate is found out to be at fifty eight percent (58%), which means that the workers age ranging from nineteen to fifty-nine (19–59) years old. The percentage is comprised of sixty three percent (63%) female and thirty-seven (37%) male workers. It is significantly higher compared to the estimated percentage of fifty percent (50%) of American women [10].

3.2.2 Measure of Association

The association between the risk of developing a disease and an exposure was further analyze through a measuring association using a single summary parameter introduce by epidemiologist. These calculated measures of association drawn on two concepts: the probability of an event or disease and the odds of an event or disease (Fig. 1).

RISK FACTOR PREGNANT	DISEASE	NO DISEASE	TOTAL
EXPOSURE	27	33	60
NO EXPOSURE	16	28	44
TOTAL	43	61	104

Fig. 1. Risk relative and odd ratio for pregnancy

The tables above present the Risk Relative Equation for one of the risk factors being analyzed by this study which is pregnancy. The Table presents usage of Risk Relative Equation to Pregnancy as a risk factors, where in twenty-seven (27) were identified positive of the disease and the exposure to the risk factor, while thirty-three (33) identified negative to varicose veins despite being expose to the risk factors. In terms of those participant without the risk factor of pregnancy, sixteen (16) are identified as positive while twenty-eight (28) are identified as negative to the Varicose Veins. Odds-ratio which is one point ninety-eight (1.98) of the participants were pregnant and the Risk Relative found out to be one point seventeen (1.17) which means the risk factors is in positive association to Varicose Veins or in an increased risk among those exposed to the factors (Fig. 2).

RISK FACTOR OBESITY	DISEASE	NO DISEASE	TOTAL
EXPOSURE	28	32	60
NO EXPOSURE	18	26	44
TOTAL	60	44	104

Fig. 2. Risk relative and odd ratio obesity

The Table above present the usage of Risk Relative of Obesity as a risk factors, where among the participants, twenty-eight (28) were discovered to be positive to varicose veins and exposed to the said risk factors, while thirty-two (32) identified negative to varicose veins despite being expose to the risk factors. On the contrary, eighteen (18) are identified as positive to varicose veins despite of not being exposed to the risk factors, while twenty-six (26) are identified as negative to Varicose Veins and unexposed to the risk factors. Odd-ratio of acquiring a Varicose Veins. One point ninety-one (1.91) were the risk factors of obesity and the risk relative fount out to be One point twenty-two (1.22).

4 Conclusion

Aquaculture Inc. workers is prone of acquiring varicose vein. After verifying the risk factors contributing to the occurrence of Varicose Veins and as directed in the application of the principle of Ergonomics specifically Anthropometry, Biomechanics and Occupational Ergonomics the following are the suggested to the employees particularly working as a factory worker;

The propose exercise plan for lessening the risk factors of varicose veins. Obesity and pregnancy are identified as the most common risk factors. Therefore, inclined with this, with the support of a license physical therapist for an ideal workout plan that will not affect their working schedule. Exercise using the body weight are the most ideal exercise for the workers. Thus, it does not need to use equipment or going to the gym. Push ups, Planking, Squats, Lunges, jumping jogs are the body weight exercise that can do at home or outdoors.

I. The Following are the List of Propose Exercise Workout (Table 1):

Table 1. Activity

Exercise plan	
Obesity	Pregnant
1. Self-stretching of both lower extremities towards all monitors	1. Walking
2. Jogging, Running tread mill at least 1 h once a day	NOTE: Pregnant women are obliged to consult to a physical therapist or a wellness coach regarding for their Exercise Plan. A modifications Exercise is offer for their desires since extraneous exercise can lead to miscarriage or other complications during pregnancy
3. Leg elevations with ankle pumps after work everyday	
4. Planking at least 1 min, squats 30 reps 3 sets, Lunges 30 reps 3 sets	

II. Propose Installation of Leaning Bar

Additionally, Proposing the installation of leaning bar to reduce the risk factors of varicose veins. Leaning bar or “leaners” are an excellent alternative to benches primarily where there is minimal space on working space. The value of leaning bars is that they provide a perfect solution for those who don’t want or need to sit down but need a place to temporarily rest on work station. Based on an annotated body dimensions data gathered, the 95th percentile the weight will be 63 kg and the height is 170 cm, as mentioned this proposing the installation of leaning bar will be suitable for the factory workers in the production area.

The research studies of Incidence of Varicose Veins and Associated Risk Factors Among Factory Workers to Develop Ergonomically Sound Workplace become a vital to identify the risk factors of varicose veins. It became a significant to the Aquaculture Inc. workers. As well, the studies should be done to comparable industries to further validate the claim. Also, other risk factors may be identified.

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Situational Assessment of Noise and Ergonomic Factors in Welding Activities: Implications on the Well-Being of Ghanaian Informal Auto-Mechanics

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Abstract. This study assessed the noise and ergonomics factors associated with the welding operations of Ghanaian informal-auto-mechanics and the implications it has on their personal well-being and productivity. Using the 2014 OSHA Hazards Assessment Checklist, the noise and ergonomics factors associated with welding operations in three selected shops were firstly assessed expertly. This was followed by interviews with the informal-auto-mechanics, using the checklist as interview-guide. The results showed that welding operations in all the shops were very noisy, with operators oblivious to the health hazards of their noisy operations. Additionally, all the informal-auto-mechanics' reported ergonomics constraint in their welding operations, manifested as musculoskeletal disorders caused by inappropriate work postures, repetitive-motion and insufficient pause-periods in tasks performance. It is concluded that Ghanaian informal-auto-mechanics' are oblivious of occupational hazards associated with their welding activities caused by noise and ergonomics constraints, and the negative consequence they have on their personal well-being and work productivity.

Keywords: Welding activity · Situational assessment · Noise factors · Ergonomics factors · Informal auto-mechanics · Ghana

1 Introduction

In Ghana, majority of auto-mechanics have low level formal education and mostly operate in the informal industrial sector [1]. The sector consists of micro and small firms with workforces of between five and seven persons [1]. Thus, the informal auto-mechanics offer a 'one-stop' mechanical services to clients and operate in makeshift garages that are mostly dotted along-side roads as well as within residential spaces [1]. An essential element of health and safety practices in the operations of informal auto-mechanics is the condition of the work environment in which they operate. According to [2], there exists some level of ignorance among the informal sector workers concerning issues relating to safety in their various fields of work, or they simply cannot

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afford protective gadgets that protect them from unpleasant environmental and other perilous conditions that constitute threat to health and safety.

Due to the unregulated characteristics of the informal industrial sector in which they operate, informal auto-mechanics suffer from exposure to variety of occupational health hazards within their work environment [1, 2]. As it was reported by [3] and [4], the work environment entails physical hazards (such as noise, fire outbreaks), chemical hazards (such as, fume inhalation, smoke, and dusty environment), psychosocial hazards (such as stress due to long working hours), and ergonomic challenges (related to poor work posture as well as the manual lifting of heavy gear-boxes and engine-blocks). Yet, the level of occupational health hazards awareness, relative to noise and ergonomics challenges among informal auto-mechanics engaged in welding activities in Ghana remains unexplored.

This study, therefore, assessed the occupational noise hazards and ergonomics challenges associated with the welding operations of Ghanaian informal-auto-mechanics and the implications it has on their personal well-being and productivity.

2 Noise Hazard, Ergonomics Challenges and Well-Being in Welding Task Performance

According to [5], 'blue collar' occupations are most affected by both noise and vibration hazards. Occupational noise-induced hearing loss is classified as one of eight priority diseases [5]. Thus, informal auto-mechanics who engage in welding activities, and whose occupation fits the "blue collar" categorization, are known to face a wide range of occupational health hazards that have the potential of causing them injuries as well as deteriorating their health [1].

The occupational health hazards faced by informal auto-mechanics engaged in welding activities ranges from physical, accidental, chemical, and biological to noise and ergonomical. [6]. Welding activity, especially on automobiles, produces so much noise from its processes and allied operations, such as hammering, grinding and drilling of cars or metals [7]. According to [5] and [7], the short-term consequences are temporal hearing loss, stress, irritability and may also cause hypertension, while the long-term effects are permanent hearing loss and increased risk of cardiovascular disease.

According to [5], identification of noise hazards in the workplace is fairly simple. However, because of the cumulative nature of noise exposure and the complicating impact of leisure noise as well as age-related hearing loss, awareness of individual hearing deficit may be delayed [5]. Arguing from the perspectives of Australia, [5] pointed out that, though regulations and guidance for noise hazards that emphasize the importance of control at source have existed for many years, hearing protectors are reported to be the predominant control measure. As such, there is a need for change in the approach to control of noise hazards in many workplaces.

Ergonomically, welders may work in uncomfortable positions, engage in repetitive work, lift heavy objects [7]. These activities tend to put severe strain on the wrist, elbow, arms, shoulders, neck and back of welders. There is also the tendency of welders slipping or falling when working from heights, which could result in health effects such as musculoskeletal pains which include back pain, muscle fatigue and injuries. Thus, [5] argued that the generalist Occupational Health and Safety (OHS) professional has a role in identifying, assessing and controlling noise and vibration hazards, and particularly in implementing a noise and vibration management program as part of an OHS management system. In this regard, specialist expertise may be required to conduct noise or vibration surveys, and to advise on development of control strategies.

As it was reported by [8] from a study on welders' awareness of occupational hazards, information is vital and helpful in designing intervention strategies towards promoting safety standards for this category of work-groups.

3 Methodology

3.1 Data Collection Approach

A stepwise approach was used in the data collection. Firstly, the OSHA Hazard Assessment Checklist [9] was used to expertly assess the noise and ergonomics aspects of the welding operations and identify their occupational hazards relative to the well-beings of the informal auto-mechanics. This was followed by interviews with three purposively selected informal-auto-mechanics, using the checklist as interview-guide. Each interview duration was forty-five minutes on the average.

The Hazard Assessment Checklist is multi-dimensional instrument which consists of several components of work-factors, including noise and ergonomics. In the data collection approach, formal contact was firstly established with the informal auto-mechanic garage owners to inform them about the study. Upon receipt of their approval, the garage owners were informed by the researchers about the purpose of the study and assured of confidentiality.

3.2 Data Analysis Approach

A two-steps analytical approach was used. In the first step, the observational data generated using the OSHA Hazards Assessment Checklist [9] was analyzed. In the second phase, the transcribed interviews data were analysed using descriptive analysis qualitative approach.

4 Results and Discussion

4.1 Analysis of Respondents Demography

The demographics of the respondents who were all males, showed their ages to range from 40 to 60 years, with each having been operating in the informal auto-mechanic industry and also engaged in welding activities for more than 10 years. All the respondents operate for a period of 8–10 h daily.

4.2 Assessment of Noise and Ergonomics Factors in Welding Operations

The result from the researchers' situational assessment of occupational noise and ergonomics factors in the informal auto-mechanics' welding activities using the OSHA Hazards Assessment Checklist [9], is summarized in Table 1 below.

Table 1. Assessment results of noise and ergonomics of welders' activities in welding shops.

Assessment indices	Assessment results		
	Garage 1	Garage 2	Garage 3
Tried to isolate noisy machinery from the rest of operation	No	No	No
Employees are properly fitted and instructed in the use and care of ear protectors	No	No	No
When engaged in a welding activity, the neck and shoulders have to be stooped in order to view task	Yes	Yes	Yes
When engaged in welding activity, pressure points are felt on parts of the body, such as the wrists, forearms, back of thighs	Yes	Yes	Yes
Sufficient breaks, in addition to regular rest breaks, are taken when engaged in a welding activity in order to relieve the stress from repetitive-motion tasks	No	No	No

The results show that aside all the 3 garages did not meet the standard requirements of isolating noisy machinery from the rest of the welding operation and also ensuring that welders are properly fitted and instructed in the use and care of ear protectors. Additionally, welding activities in the all the 3 garages are undertaken with welders having to stoop their necks and shoulders in order to be able to have a good view of their operations. In this vein, welders in all the 3 garages reported feelings of pressure points sensations on parts of their bodies, inclusive their wrists, forearms, and back of thighs, when engaged in welding operations. The results also indicate that welders in all the 3 garages did not meet the standard requirement of taking sufficient breaks, in addition to regular rest breaks, when engaged in a welding activity in order to relieve the stress from the repetitive-motion associated with their operations. Figure 1 below shows informal auto-mechanics engaged in welding operations in the three Garages (G) assessed.

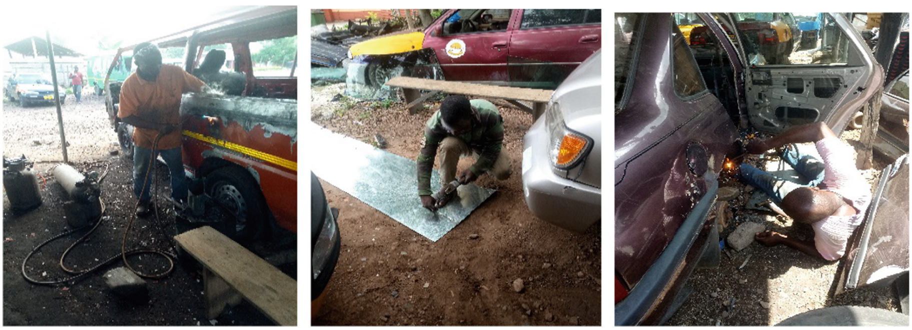

Fig. 1. Welding activity in G 1 (left), G 2 (middle) and G 3 (right)

It is evident from the above results that the informal auto-mechanic welders generally encounter noise hazards and ergonomic constraints when engaged in the welding activities. In this respect, the respective owners of the three garages were interviewed for further understanding of why noisy machinery were not isolated from the rest of the operations in the shops. The shop owners stated that grinding and cutting were some of the noisiest works that were carried out in the shops. In acknowledging how noisy some welding activities were, added that apart from the shop, they did not have any place to isolate the machines to. The machines were part of the entire shop and machines were used in the shops. The garage owners therefore stated that in the absence of options regarding isolation of noisy machinery they were used to the noise. As it is observed by the owner of garage 3 in the following comment:

> We do not have any place that we would say we are isolating noisy machines to. Within the garage, you would still hear the noise no matter where the grinding is taking place. Definitely, it is in the shop that you will use the machine. Then, it is only drilling that we can say it can get contact with the one who is using it direct so, it can have contact. But for the grinding machine, when in use, we do not allow other people to go near it, but the noise can be heard everywhere in the shop. There is no place for us to isolate our drilling and grinding operations. [Owner, G 3].

Furthermore, the owners noted that ear plugs were one of the rarest personal protective equipment (PPEs) in the shops. Only few ear plugs were available in the shops. Though ear protectors were not common in the shops, the workers indicated they did not like using them. Moreover, they were used to the noise already, as it is intimated in the following comments by owners of garage 1 and garage 2 respectively:

> We have a few of the ear plugs too, but the workers say they do not like using them, they feel heavy. So just like the other protective things, they do not use the ear plugs. [Owner, G 1]

and;

> I do not have the full complement of protection equipment; the ear protector is one of the things I don't buy or use. We are used to them already. [Owner, G 2]

Again, interviews were conducted with the garage owners (1, 2 and 3) for further understanding as to why sufficient breaks were not observed to relieve the stress form repetitive-motion tasks. In some of the garages the owners indicated that, breaks were not observed, however during the course of work any worker who felt tired or hungry could go on break briefly to rest or eat. In other shops, specific break times exist where the workers all came together to eat and went back to continue their works. Though these options were available, there were workers who preferred to finish tasks given to them before taking a break. Where a person was trained the owners indicated, would determine whether the person would be hardworking or lazy. This is observed in the following comments by the respective garage owners;

> If you are working and you get tired the only thing you can do is to sit down, you sit down and relax, the workers themselves are the ones who wish to finish before resting. [Owner, G 1]

and;

> When we are working and you are hungry, you can go and eat. Sometimes, when we get really busy and our eyes are red, we even forget that we have not eaten. The way I was trained, you cannot be working and say you are tired or hungry and leave the job. You will force to work and

finish it. We were not brought up that way. It is laziness, so we are used to it. We were not born with it, but we learnt it, if you learn laziness, you will be lazy. What happens is that, if you continue that way, you will end up spending more time on the work, you will spend the money that you are supposed to use for the work and end up running away from the customer who brought the work because you have not been able to complete but the money is finished. Then you become a liar too! [Owner, G 2]

and;

When it is break, we all come together and eat by this table. But, once there is job to be done, your mind will not even tell you that you are tired or hungry, but we eat during break time. However, no extra hours are given for break unless on days when we are not busy. It is not always that you will come and meet us working in the shop. [Owner, G 3]

Based on the analysis, it is established that though the welders could easily identify noisy machinery, they appear to be unaware of the occupational hazards caused by their noisy work environment and the impacts it has on their well-beings. The garages did not meet the standard that calls for noisy machinery to be isolated from the rest of operations. It is found that the welders know about the personal protective equipment that could be used to mitigate the effect of noise. Yet, they consciously choose not to use them. The welders appear to know the consequences of ergonomic hazards on their personal-selves since they usually experience them. This signify their limited knowledge and usage of PPE [1, 5]. It is found that, all the welders encounter ergonomic constraints by positioning their necks and shoulders in awkward viewing positions whenever they are engaged in welding activities. As such they all reported musculoskeletal disorders associated with parts in their wrists, forearms, and the back of their thighs. It is also found that the welders work routine did not meet the ergonomic requirement of providing sufficient pause periods to relieve them of stress from their repetitive-motion tasks.

5 Conclusion

This study has shown that informal auto-mechanics in Ghana who are engaged in welding activities encounter significant occupational safety management challenges relative to noise hazards and ergonomics awareness. Based on the findings, it is concluded that even though informal auto-mechanics engaged in welding activities are conscious of the noise hazards and ergonomics challenges associated with their operations, they showed a sense of ignorance of the consequences of such hazards and challenges on their personal well-being and work productivity. This therefore calls for the need to develop occupational health and safety management systems for such garages. The implication is that a further step, informed by the insight obtained from this study, should be taken towards the design and implementation of intervention strategies to promote safety standards in the work environment of informal auto-mechanics engaged in welding activities. This should incorporate both occupational noise and ergonomics management program as part of an effective occupational health and safety management system for such garages.

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BACKS 2020: Criteria for Occupational Spine Disease in a Social Security Compensation System

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Abstract. BACKGROUND: Previously of work-related chronic low back pain has been established. With development of new understanding of medical science, better and improved requirements were needed in defining occupational spine disease. OBJECTIVES: To identify the variables that would be associated with occupational spine diseases. To develop an objective measurement in determining occupational spine diseases using the relationships of these variables. DESIGN: Cross-sectional study. SETTING: Workers registered for low back pain claims for chronic work-related compensation in Malaysia from 2017 to 2018. PARTICIPANTS: Workers who were between 20 to 60 years old that had previously submitted claims for chronic low back pain. MEASUREMENTS: Workers who applied for employment injury scheme, based on history of chronic low and had their applications reviewed by the Social Security Medical Board. Subjected were then interviewed at their workplace using the BACKS prototype questionnaire that had incorporated the Oswestry Disability Index (ODI). RESULTS: 200 workers were interviewed (mean age 41.7, SD: 8.12 years old). Linear regression analysis identified that chronic occupational back pain was associated with absence of disc bulge, history of accident or fall, smoking behaviour and individuals with non-communicable diseases ($p < 0.05$). Increasing age in the form of increased exposure to manual labour over years was also associated to occupational low back pain. These variables explained 78.5% of their relationship in determining chronic occupational low back pain. LIMITATIONS: The interview relied on workers recollection of their workplace. The recall bias was reduced using the aids of the BACKS questionnaire to illustrate their previous working conditions. CONCLUSIONS: Manual labour workers that were involved with significant chronic back disabilities, lifting and twisting objects along with colleagues whom had similar past spinal injuries at work were criteria for occupational spinal disease.

Keywords: Chronic · Back pain · Occupational · Regression

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1 Introduction

In the US, the annual expenditure related to chronic low back pain (LBP) ($86 billion) has reached levels comparable to the care of diabetes ($98 billion), cancer ($89 billion), and nonspine arthritis ($80 billion) [1]. LBP often would lead to various forms of spinal diseases; commonly prolapsed intervertebral disc (PID) or slip disc, sponydylosis, spinal stenosis and other degenerative diseases. Degenerative changes of the spine had been documented using magnetic resonance imaging (MRI) [2, 3] and had noted that degenerative changes occurred as a result of mechanical micro insults or damage secondary to macro-insults in the form of spinal fractures, spinal surgery not related to degenerative disc disease or significant metabolic processes, such as ochondrosis or mucoplysaccharidoses [2]. Although the degenerative changes had been noted to be rather rapid among females compared to males [3–5] and individuals with pre-existing congenital spinal anomaly such as spinal bifida occulta [2, 4, 6–9], features such as a disc bulge on the MRI would often be due to a sudden increase in the intradiscal pressure which resulted in formation of annul fissure among asymptomatic individuals.

Kushchayev et al. [2] illustrated the amount of intradiscal pressure of an individual lying on a prone position (91 kPa) would increase to more than six times during sitting (623 kPa) and more than 10 times at forward bending position (1324 kPa), respectively. The physical activities or manual labour at work [8] would suggest an increase exposure and cumulative traumatic disorder to the spine predisposing them or increasing the risk of the individual to develop spinal diseases with time. Therefore, spinal diseases or back pain related to work has been greatly debated and discussed in various criteria (Bradford-Hill) and systemic reviews [6]. Determining occupational or work-relatedness has been very challenging [11, 12] and confusing to inexperience physicians. To complicate matters, evidence had been inconclusive [12] which lead to a need to develop certain guidelines [10, 12] or criteria [10, 11] in deciding work-relatedness of an individual with chronic back pain. To add into the confusion, numerous different modalities [3, 12, 13] in management of LBP [12–14] would have financial implications.

According to Tam et al. [15] ergonomic factors such as twisting, forward bending, pain severity, age (younger workers), psychological and physical demand at work were good criteria to determine work-relatedness of chronic back pain. However, a stronger study methodology and criteria would be needed to be used by agencies dealing with compensation for chronic spinal diseases. Tam et al. [11, 15, 16] did illustrated the complication of identifying occupational spinal diseases would require input from both ergonomists and physicians for a solid decision and collaborative partnership for the benefit of the employers and workers. For example, the manual labour exposure that present at workplace had moderate evidence on disc degeneration as compared with disc narrowing or bulge [15].

In Malaysia, the social security system among workers encompassed of numerous activities ranging from preventive to rehabilitation services. The Medical Board that dealt with medical and compensation benefits were structured and its members were independent government specialists and consultants. Assessments were made for various benefits from permanent disabilities, invalidities and occupational diseases.

The objective of this study was to develop criteria for occupational spinal diseases that could be of reference among medical consultants especially young specialists. Identified variables associated with occupational spine diseases would be used to develop an objective criteria or indicators in determining occupational spine diseases.

2 Methods

Data of LBP claims registered with the social security from 2017 to 2018 were used. In this study, only claims that referred to the Appellate Medical Board were selected upon the requested by the Insured Person (the worker) after the Primary Medical Board decision had been announced. Participant selection included workers aged between 20–60 years old with history of chronic or recurrent LBP. A significant LBP is defined as chronic hoistory of LBP > 12 weeks in the past year, Visual Pain Analog above 0.20 unit and *Oswestry Disability Questionnaire (ODQ) to be above 20.0%* [17]. Cluster sampling and matching between occupational and non-occupational claims, decided by their respective Appellate Boards at each state/province was performed.

LBP due to a fall from height, vehicle, stairways, flat surfaces (e.g. toilets) were not selected. Other cases such as pregnant workers, workers with pyogenic back conditions, cancer, back injuries due to commuting and non-commuting injuries at work were also excluded. Once the decision of the Appellate Board and workers' working addresses hads been obtained, the workers were contacted for an interview. This cross-sectional study involved obtaining variables from a Likert-scale BACK Prototype [15] questioannire that had previously undergone face validity. The Likert scale response was analyzed using linear regression via Statistical Package for Social Science (SPSS) Version 25.0. The predictive model (via regression analysis) of occupational spine disease was developed (Summarized from Chan. [18]);

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \ldots + \beta_n x_n \quad (1)$$

Whereby Y = predictive outcome

x = variables

n = number of variables

β = constant

β_0 = outcome intercept.

For the regression to be accepted, the following assumptions have to be fulfilled;

a) Absence of outliers
b) Satisfactory level of independence
c) Residuals were normally distributed
d) Variance constance
e) Acceptable or similar levels of linear collinearity.

3 Results

It is estimated thousands of LBP claims that were registered all over the country from 2017 to 2018. Of these, there were 350 cases that were referred to the Appellate Board in a year. Once at the Appellate Board, it is estimated 27.8% would fulfill the occupational spine disease criteria among consultants. Table 1 showed the distribution of registered cases according to states from 2017 to 2018 and the actual samples that was successfully contacted and collected. Johor cases were un-contactable and did not consent to participate in our study. Figure 1 showed the distribution of low back pain that were included in this study. Majority of the cases were prolapsed intervertebral disc (71.0%), followed by spondylosis (14.0%) and disc bulge (7.5%). In fact, most operators and technicians (72.1%) were diagnosed with PID.

Table 1. Distribution of registered LBP cases for appellate by states in 2017 to 2018

No.	State	Registered	Sample	Actual
1.	Selangor	400	114	110
2.	Kedah	66	18	27
3.	Negeri Sembilan	60	17	10
4.	Melaka	60	17	19
5.	Penang	46	13	15
6.	Kuala Lumpur	32	10	7
7.	Pahang	16	5	4
8.	Perlis	8	3	3
9.	Johor	8	3	0
10.	Terengganu	4	0	4
11.	Perak	1	0	1
	Total	701	200	200

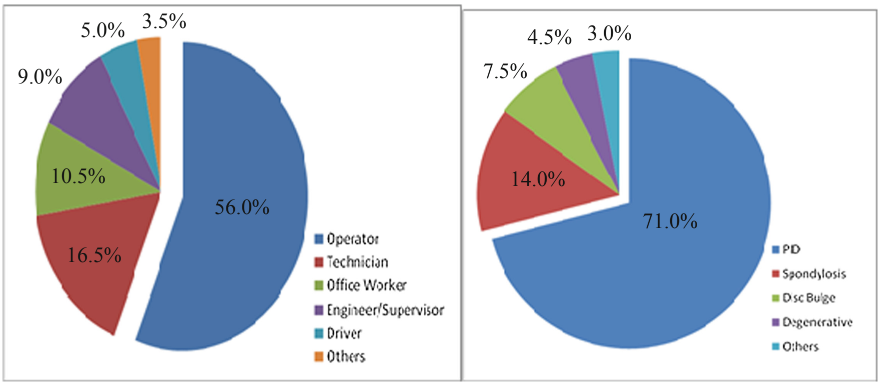

Fig. 1. Distribution of occupations and spine diseases

Table 2. Comparison with significant difference of means

No.	Variables	t value	95% CI	No.	Variables	t value	95% CI
1.	Age (onset of pain)	−15.005	−2.003 to −1.537	13.	Bending 30°	5.885	0.452 to 0.908
2.	NCD	−6.120	−7.576 to −3.884	14.	Bending 90°	6.701	0.536 to 0.984
3.	Body mass index	−6.118	−5.311 to −2.722	15.	Twisting 20°	5.198	0.372 to 0.828
4.	Prev. back injury	8.892	0.840 to 1.320	16.	Twisting 40°	6.211	0.485 to 0.935
5.	Past surgical Hx	9.944	0.930 to 1.390	17.	Vehicle/tool use	4.000	0.309 to 0.911
6.	Structured exercise	5.153	0.060 to 0.134	18.	Colleague in pain	12.490	0.749 to 1.031
7.	Physical activity	5.814	0.067 to 0.137	19.	Physical demand	4.050	0.046 to 13.382
8.	Smoking	−4.729	−0.949 to −0.391	20.	Psychological dm	3.300	0.242 to 0.962
9.	Lifting 5 kg/h	3.824	0.257 to 0.803	21.	Pain VAS	3.151	0.544 to 2.387
10.	Lifting 5 kg/day	3.200	0.177 to 0.743	22.	ODI	4.151	5.382 to 15.124
11.	Lifting 10 kg/h	3.100	0.131 to 0.589	23.	Previous accident	−18.051	−2.030 to −1.630
12.	Lifting 10 kg/day	2.206	0.029 to 0.511				

Table 3. Multivariate analysis using linear regression

No.	Variable	OR_{adj}	Beta	95% CI	Collinearity statistics	
					Tolerance	VIF
1.	Twisting posture 20°	1.406	0.341	0.038 to 0.305	0.091	10.934
2.	Lifting $\geq$ 10 kg/h	1.303	0.265	0.022 to 0.219	0.138	7.263
3.	No surgery	1.236	0.212	0.042 to 0.161	0.426	2.346
4.	Oswestry dis index	1.184	0.169	0.001 to 0.008	0.307	3.260
5.	Colleague with LBP	1.174	0.160	0.012 to 0.202	0.320	3.126
6.	Disc bulge	0.892	−0.114	−0.362 to −0.007	0.539	1.854
7.	Lifting $\geq$ 25 kg/day	0.776	−0.253	−0.221 to −0.046	0.234	4.277
8.	Previous accident/fall	0.738	−0.304	−0.187 to −0.076	0.388	2.577
9.	HPT/DM	0.725	−0.321	−0.181 to −0.078	0.393	2.544

level of significance, $p < 0.05$
OR_{adj}: Adjusted Odd Ratio

$$\begin{aligned}
&\text{B20 score}\,(Y \geq 1.660) \\
&= 0.457 + 0.172\text{Twisting}20^{\circ} + 0.121\text{Lift}10\,\text{kg/hr} + 0.101\text{NoSurgery} + 0.107\text{ColleagueLBP} \\
&+ 0.004\text{ODI} + 0.002\text{AgeonsetLBP}^{\circ} - 0.184\text{DiscBulge} - 0.133\text{Lift}25\,\text{kg/day} \\
&- 0.132\text{PreviousAccident/fall} - 0.129\text{HPT/DM}
\end{aligned} \tag{2}$$

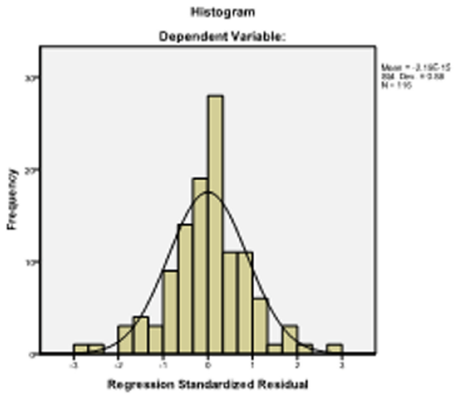

Fig. 2. Final B2020 equation

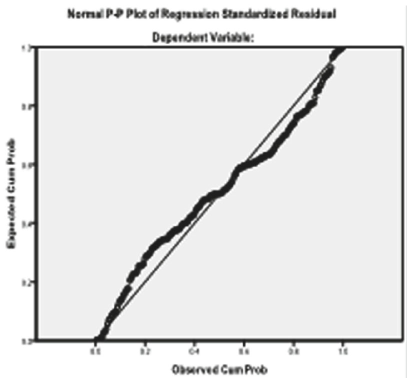

Fig. 3. Normality assumptions of residuals

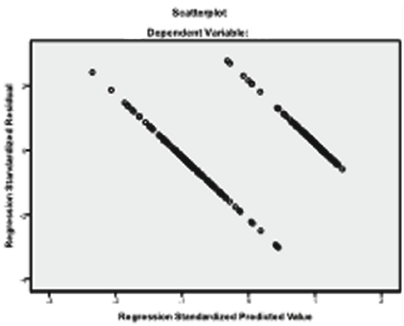

Fig. 4. Constant variance

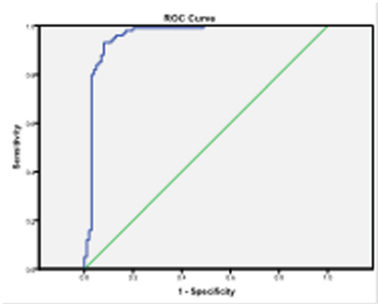

Fig. 5. ROC curve of BacKS

Table 2 showed the variables that were significant via the bivariate analysis. The variables were then subjected for multivariate analysis as shown in Table 3. The regression model of B2020 equation was developed with a selected cut-off point was obtained (2). To support the model, the histogram and the multi-collinearity models are shown in Fig. 2, 3 and 4. During the multivariate analysis; age, body mass index, structured exercises, physical activity, smoking, all forward bending tasks, 40° twisting, previous back injuries and Pain Visual Analog Scale were noted to be not significant ($p > 0.05$). The weight of object seemed to have an interesting relationship with occupational spine disease.

Relatively light task such as weight lifting of >5 kg once in an hour and lifting of >10 kg once in a day was not significant ($p > 0.05$) to be related occupational attributes. However, it was noted that lifting weight of >10 kg in an hour was associated with occupational spinal disease while it was rather unlikely a spinal disease to be work related when the lifting involved lifting >5 kg weight in a day ($p < 0.05$). Finally, the equation was plotted using the ROC curve in Fig. 5. The equation's sensitivity was 80.0% while specificity was 97.0%. The area under the ROC curve was 95.7%. The percentage of the explained was 81.2% while the Dubin-Watson value was 1.547.

4 Discussion

Therefore, it is important for physicians and radiologists to distinguish the imaging difference of a disc bulge versus the pathological annular bulge [2]. Macedo and Batties [19] reported that the occupational loading has moderate association with spinal disc degeneration only as compared to the low association with narrowing or bulging of the intervertebral disc. This systemic review alone [14] warrant radiologists and orthopaedic surgeons to be more detail and specific of their diagnosis when assessing disc herniation cases. Individuals that are wrongly diagnosis with slip disc with disc bulge features would unethically cause psychological harm to healthy individuals. The mental and social trauma in severe cases would become irreversible not mentioning social benefits limitations or even removal by employers, insurance or social security agencies. Therefore, irresponsible diagnosis, inappropriate surgical intervention or management by unethical stakeholders should never be acceptable [3].

With regards to this study, the decisions from only consultants (Appellate Medical Board) were referred to standardize as well as achieve stronger data collection and analyses as compared to previous studies [15, 16]. With this method, the selection bias of the medical personnel, claims and quality of compensation decisions had been reduced. Therefore, this current study had a stronger methodology to a similar study [16]. At the same time, it was noted that on both accounts (studies), the ergonomic hazards [12] of workers exposure to repetitive twisting motions at 20° and workers with colleagues that had similar LBP were again associated to occupational spine diseases. Such findings supported the need to inspect the workstations and the procedures at work during site investigations. If large numbers of LBP and affected workers were identified, an ergonomic redesign/engineering of the workstation would be inevitable [6].

In previous studies [3, 15, 20], age had been reported to be associated to low back pain related to work (complains peaked between 30 to 50 years old). In this study, age of onset was also noted to be statistically significant at bivariate analysis. However, it was noted that other confounding variables had stronger influences in identifying occupational spinal diseases. Commonly, studies [2, 3, 12, 15], had reported of degenerative changes with increasing age. Degenerative changes could be accelerated by metabolic syndrome/conditions. Metabolic changes such as diabetes mellitus, mucopolysaccharidoses and ochronosis would affect proteoglycan synthesis and the development of bone and cartilages [2]. With regards to low back pain, researchers [19] should appreciate the small distinct differences of epidemiological of low back pain in a community or population versus occupational back/spine disease among workers. Both presentation of back pain (such as age [2, 15, 20] and gender [3–5]) have been different. Gender association had correlations to the study community culture. As compared to certain countries [5], female workers would be discourage or limited in handling manual labour.

However, one should be aware that an early presentation of pathological spine disease among workers of 30 to 35 years old in the absence of spinal bifida occulta [3, 9] warrants some work-relatedness consideration. Adults with bifida occulta often presents with an accelerated degenerative spine [9]. This study had 9 cases (4.5%) (Fig. 1) of degenerative spine that was statistically not significant between the LBP-occupational relationship. In fact, disc bulge diagnosis is noted to be a common finding among asymptomatic workers [19] and should not be rendered pathological. However, findings did indicate that the premature progression of degenerative changes were significant among spinal occulta individuals. Purely disc bulge presentation had been noted to be unlikely criteria for occupational spine disease in this study. This finding would be important both in terms of rehabilitation and management of an affected worker with LBP [3]. Physicians should not be overzealous in considering disc bulge to be similar or an early presentation of prolapsed intervertebral disc (PID). Such unethical diagnosis would give tremendous psychological as well as social impact to ill-informed individuals or workers. Apart from inconsolable fear, the quality of life of some of the workers would be affected including the possibility of removal or denial of their medical or employment benefits, unnecessary.

Other similar variables previously reported [15], such as the physical or psychological demands and the Pain Visual Analog scale were only statistical significant at the bivariate analysis. Instead, the Oswestry Disability Index (ODI) became a significant assessment or criteria for occupational spine diseases. Finally, this study also supported previous studies that standing and walking had poor association with LBP [9]. Management of back pain encompassed from preventive to rehabilitate effort that involved many stakeholders. Variable medical modalities from legislations, guidelines, education [21], psychological counseling [22] to post surgical rehabilitation, return to work [23] and even medical benefits are involved in the matrix of spinal diseases prevention. With this added value of the occupational criteria, various stakeholders including the employers could play their role not only at their existing workplace/station designs but to intervene at the appropriate time in referring the workers to the physicians and physiotherapists that would reduce the dependency on surgical measures in addressing spinal diseases. Workers that are assessed at early stages would receive better prognosis with physiotherapy as compared to conditions that were presented late.

Similar to other 3D job specifications (dirty, dangerous, demeaning), LBP would always be the commonest complain among manual handlers. As professionals, especially public health physicians, we serve as guardians to acknowledge and address the ergonomic hazards associated to LBP. From inappropriate designs, insufficient administrative controls [8] to broken equipments or vehicles, it has been in our oath to do no harm and address the welfare of these 3D workers. In conclusion, ergonomic risk factors [8] do exist in deciding occupational spine diseases. Therefore, both medical (physicians) and engineering (ergonomists) personnel have the role to play in preventing occupational spine diseases.

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Subjective and Objective Measures to Assess Postural Instability: Their Linear Correlations and Abilities to Detect Effects of Work-Related Factors

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Abstract. The linear correlations between one subjective - perceived postural instability (PPI) and fifty-one objective postural instability measures were investigated, and their abilities in detecting the main and interaction effects of three work-related factors were compared. Results showed thirty-five objective measures had large correlations ($|r| \geq 0.5$) with PPI. Center of pressure (COP) related measures had stronger abilities for detecting the factors' effects than the other objective measures. Especially, ten of them, together with PPI, successfully detected ($p < 0.05$) both the main and interaction effects of all studied factors. High discriminating power, an overall high intra-class correlation coefficient and a small mean absolute difference between test-retest illustrated the PPI is reliable and sensitive for postural instability measuring. COP movement-related (velocity, acceleration, time to contact), and phase plane parameter, planar deviation in velocity, distance to the closest base of support boundary are recommended objective measures.

Keywords: Postural instability measures · Balance and falls · Correlation · Reliability

1 Introduction

It has been reported that there is a positive relationship between postural instability and one serious occupational accident-occupational falls [1]. Both individual's intrinsic and environmental extrinsic factors could affect the postural steadiness, especially the work-related extrinsic factors for the workers who likely to be exposed to a complex working environment or complicated working tasks, e.g. construction workers [1]. Static postural steadiness was defined as the characterization of postural sway during quiet standing [2]. Various tools have been adopted to assess postural instability. The derived measures from these tools can be broadly classified into subjective and

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objective measures, and both of them are quite popular due to the advantages of each [3, 4]. The perceived postural instability (PPI) rated by using a visual scale is a typical subjective measure, it could provide a reasonable indication of postural sway [4, 5]. The objective measures are usually estimated based on the equipment data, such as force plate, inertial measurement unit (IMU) sensor, optical or IMU-based motion capture system, etc. Especially, the objective measures for characterizing the center of pressure (COP) trajectory have been widely studied and applied in various research settings [6–9]. In addition, the measures derived from IMU sensors data are also increasingly being used in the human balance assessment [10–12].

Some previous studies compared these measures, for example, Kaufman et al. [13] compared subjective and objective measurements of balance disorders following traumatic brain injury; Chaudhry et al. [3] reviewed the methods to measure balance in computer posturography; Raymakers et al. [9] compared the parameters of body sway derived from COP in their practical usefulness. However, the subjective tools used in previous studies were usually tests or evaluation scales (e.g., Berg Balance Scale) in which the rating was given by the examinee or clinicians, not the subjects. Limited studies have been conducted to investigate the correlations between subjective-PPI and objective postural instability measures, and/or systematically compare their discriminating power for detecting the effects of work-related factors, including the main and interaction effects. Based on these reasons, this study aims to investigate the linear correlation between PPI and objective postural instability measures and compare their abilities in detecting the main and interaction effects of three work-related factors: working posture, lifting load and standing surface. The findings were expected to provide recommendations of postural instability measures for use in some specific situations.

2 Methods

Thirty healthy young males (28.2 ± 4.7 years old) participated in this study, and a full factorial within-subject repeated measures design was applied.

Independent Variables. (1) Six different *Working Postures (WP)* were designed to simulate the construction workers' frequently used working postures [14, 15], including standing upright, standing upright with arms raised forward 90°, full squatting, bending forward, bending forward with left turns and overhead carrying. (2) Two levels of *Lifting Load (LL),* 0 kg and 10 kg, were evaluated with the consideration of the participants' safety [16] and the real application in the construction industry. (3) The effect of *Standing Surface (SS)* was evaluated at two levels: flat (0°) and inclined (18°). The 18° incline angle was designed to represent a low slope type roof.

Dependent Variable. The dependent variable, postural instability, was measured by both subjective and objective measures. The subjective measure was the PPI. And, four categories of objective measures were estimated based on the COP, base of support (BOS) and kinematics data with reference to previous studies [6–9]. Twenty-four COP based, eight COP-BOS integrated measures (Table 1) were calculated based on COP only, COP-BOS interaction, respectively. Accelerations of eight main body segments were also estimated based on the raw data from eight IMUs, which were attached on pelvis (IAcc1), T8 (IAcc2), right shoulder (IAcc3), left shoulder (IAcc4), right upper leg (IAcc5), right lower leg (IAcc6), left upper leg (IAcc7), left lower leg (IAcc8). The variation range of eleven main joints' angles (Table 2) was also calculated.

Table 1. Center of pressure (COP) based, Center of pressure and base of support (COP-BOS) integrated postural instability measures.

Category	ID	Abbreviation	Explanations
COP Based	C1	Range_AP	Range of COP trajectory in AP direction (mm)
	C2	Range_ML	Range of COP trajectory in ML direction (mm)
	C3	MDIST	Mean distance from mean COP (mm)
	C4	MDIST_AP	Mean distance from mean COP in AP direction (mm)
	C5	RDIST	Root mean squared (RMS) distance from mean COP (mm)
	C6	RDIST_AP	RMS distance from mean COP in AP direction (mm)
	C7	MVEL	Mean velocity (mm/s)
	C8	MVEL_AP	Mean velocity in AP direction (mm/s)
	C9	PVEL	Peak velocity (mm/s)
	C10	PVEL_AP	Peak velocity in AP direction (mm/s)
	C11	MACC	Mean acceleration (mm/s^2)
	C12	MACC_AP	Mean acceleration in AP direction (mm/s^2)
	C13	Area_CE	Area of 95% confidence ellipse (mm^2)
	C14	Area_CC	Area of 95% confidence circle (mm^2)
	C15	Area_SW	Area of body sway (mm^2)
	C16	Axis_Ma	Major axis length of 95% confidence ellipse (mm)
	C17	Axis_Mi	Minor axis length of 95% confidence ellipse (mm)
	C18	MFREQ	Mean frequency (Hz)
	C19	MFREQ_AP	Mean frequency in AP direction (Hz)
	C20	FD_CE	Fractal dimension based on 95% confidence ellipse
	C21	FD_CC	Fractal dimension based on 95% confidence circle
	C22	PPP	Phase plane parameter
	C23	PD_P	Planar deviation in position (mm)
	C24	PD_V	Planar deviation in velocity (mm/s)
COP-BOS Integrated	CB1	TtC_V	Time to contact BOS boundary at current velocity (s)
	CB2	TtC_VA	Time to contact BOS boundary at current acceleration (s)
	CB3	MSDIST_B	Mean distance to the closest BOS boundary (mm)
	CB4	Ratio_AP_B	Ratio of COP range to BOS range in AP direction
	CB5	Ratio_ML_B	Ratio of COP range to BOS range in ML direction
	CB6	Ratio_CE_B	Ratio of Area_CE to BOS area
	CB7	Ratio_CC_B	Ratio of Area_CC to BOS area
	CB8	Ratio_SW_B	Ratio of Area_SW to BOS area

Table 2. Postural instability measures: Variation range of joint angles.

ID	Joint	Angle	ID	Joint	Angle
JA1	L5-S1	Flexion/Extension	JA6	Right Hip	Internal/External Rotation
JA2	L1-T12	Flexion/Extension	JA7	Right Knee	Flexion/Extension
JA3	T1-C7	Flexion/Extension	JA8	Right Ankle	Flexion/Extension
JA4	Right Shoulder	Flexion/Extension	JA9	Left Hip	Internal/External Rotation
JA5	Left Shoulder	Flexion/Extension	JA10	Left Knee	Flexion/Extension
–	–	–	JA11	Left Ankle	Flexion/Extension

Experimental Apparatus. An 11-point Likert scale was used to assess the participants' sense of the difficulty level (0: very easy; 5: moderate; 10: extremely difficult) to keep the body in balance (i.e. PPI). Xsens MVN Link motion capture system (Xsens, Enschede, The Netherlands), composed of 17 inertial sensors placed over the full body [17], was used for recording the kinematics data (including the joint angle) at 240 Hz. Wii Balance Board (Nintendo, Kyoto, Japan), interfaced with a desktop using a custom-written software, was used for recording COP data, which was sampled at 40 Hz and filtered by using a 4th order zero-phase low pass Butterworth filter with a 12 Hz cut-off frequency. The subjects' footprints were also recorded for BOS estimation.

Experimental Tasks. The experiment was divided into flat and inclined standing surface sessions with randomized sequences. Each subject was asked to lift up a load box (0 kg & 10 kg) and keep for 10 s in six working postures while standing on the flat and inclined surfaces, two trials in total for each task. After each task, the PPI was rated. After one session was completed, each subject was required to repeat one randomly selected task in each condition and rate PPI again.

Statistical Analysis. Intra-class correlation coefficients (ICC) estimates, absolute difference (AD) between test-retest PPI were calculated for checking its reliability. The Pearson correlation coefficient (r) between PPI and each objective measure was computed to assess their linear correlation. Paired-samples t-test or ANOVAs on each measure were conducted to compare their abilities to detect factor effects.

3 Results

The results were summarized in Table 3 in the *Appendix*. It showed more than half (thirty-five) of objective measures, including nineteen COP based, seven COP-BOS integrated, eight body segments' accelerations and one joint angle's variation range measures had large correlations ($|r| \geq 0.5$) with the subjective measure-PPI. Sixteen of them had relatively larger correlations ($|r| \geq 0.6$), in which *MVEL_AP* (C8) and *TtC_VA* (CB2) showed the first ($r = 0.718$) and second ($r = -0.710$) strongest correlations, respectively. There were higher correlations in 10 kg lifting load or inclined standing surface condition than in 0 kg lifting load or flat standing surface condition for most of the objective measures. The *Variation range of joint angles* correlated weakly with PPI in overall, compared with the other measures.

T-test and ANOVAs results (Table 3) showed all the measures could detect ($p < 0.05$) the main effects of WP and LL. PPI, fourteen COP based, five COP-BOS integrated measures successfully detected the main effects of SS, but all the body segments' acceleration (except for IAcc8) or joint angles' variation ranges (except for JA8) failed. All the measures (except for C20) could detect ($p < 0.05$) the WP $\times$ LL interaction effects. However, most of the objective measures failed in detecting SS $\times$ LL interaction. PPI, most of COP based and COP-BOS integrated measures had the capacity to identify SS $\times$ WP and SS $\times$ LL $\times$ WP interaction effects, but for the other measures, the opposite applies. In addition, eleven measures (PPI, eight COP based and two COP-BOS integrated) successfully detected both the main and interaction effects of all the factors.

4 Discussion

This study compared one subjective and fifty-one objective measures in the abilities to detect effects on postural instability of work-related factors, and studied their linear correlations. The subjective measure-PPI was given by the participant based on his judgment, which might be influenced by his experience or personality. However, results showed a high overall ICC (0.943) and a small mean AD value (0.545), and there were higher ICC and lower AD in with lifting load or inclined standing surface condition. This indicated the participants provided reliable and consistent PPI, especially when the instability level was high, which was partly supported by the findings of previous studies [4, 5]. And, it's important to highlight that the PPI measure was capable to detect all the investigated factors' main and interaction effects (Table 3).

Our results (Table 3) showed COP related (COP based and COP-BOS integrated) measures provided more adequate discriminating power for detecting the factors' effects than the other objective measures, and most of them correlated strongly with the PPI. Especially the COP movement-related (velocity, acceleration, time to contact, shortest distance to BOS: C7-C12, CB1-CB3), and PPP (C22), PD_V (C24) successfully detected all the effects and correlated strongly ($|r| \geq 0.6$, except for CB3) with PPI. This finding was partly in line with the previous study [8]. It should be specially explained that a Wii Balance Board, not a force plate, was used for COP data acquisition. Since it was low cost, easily setup and portable. More importantly, its validity and reliability in COP recording were demonstrated by many previous studies [18–20].

Compared with the COP related measures, the variation range of joint angles and accelerations of body segments performed poorly in detecting the effects of SS. Almost all of them failed in detecting the main effect of SS, or its interaction with the other factors. One possible reason could be the postural instability caused by the different levels of SS was too smaller to be detected by those measures. Another reason might be the six experimental postures were static, the participants consciously tried to keep the main body segments still for exactly maintaining the required postures, which caused a small amplitude of the body segments' sway. Unlike the dynamic motions, the static postural instability was mainly caused by the whole body's sway, which could be well reflected in the COP movement. Even so, the IMU was still a good device that could acquire the body kinematics data for human balance metrics calculation, which has been demonstrated [10, 11]. Possibly, more advanced or complicated calculation is needed, e.g. IMU-based Lyapunov exponents [11], IMU-based COP velocity [10].

5 Conclusions

The PPI is convenient, cost-effective, reliable, and sensitive to detect the effects on postural instability; however, caution should be taken when using it if the investigated instability level is very low. Significant correlations were found between the subjective PPI and most of the objective COP related measures. COP related measures have stronger abilities for assessing postural instability than the other objective measures. Especially, velocity, acceleration, phase plane parameter, planar deviation in velocity, time to contact and mean distance to the closest BOS boundary are recommended objective COP-related measures for assessing postural instability. However, the most appropriate method may depend on the specific situation.

Acknowledgments. This work was partially supported by the KAIST Startup Fund (G04160006) and the Basic Science Research Program through the National Research Foundation of Korea (NRF2017R1C1B2006811).

Appendix

Table 3. Results summary: Results of Pearson Correlation, T-test and Analysis of variance.

Measures	P-values (sig. +: $p < 0.05$, *: $p > 0.05$)							Pearson Correlation Coefficient				
	Main Effects			Interaction Effects								
	WP	LL	SS	SS × LL	SS × WP	LL × WP	SS × LL × WP	Overall	0 kg	10 kg	Flat	Inclined
PPI	+	+	+	+	+	+	+	1.00	1.00	1.00	1.00	1.00
C1	+	+	+	*	+	+	+	0.59	0.22	0.46	0.53	0.64
C2	+	+	*	*	+	+	+	0.59	0.36	0.46	0.56	0.62
C3	+	+	*	*	+	+	+	0.57	0.28	0.44	0.52	0.63
C4	+	+	*	*	*	+	+	0.52	0.18	0.39	0.45	0.60
C5	+	+	*	*	+	+	+	0.58	0.27	0.44	0.52	0.63
C6	+	+	*	*	*	+	+	0.53	0.18	0.40	0.46	0.61
C7	+	+	+	+	+	+	+	0.69	0.42	0.57	0.67	0.70
C8	+	+	+	+	+	+	+	0.72	0.43	0.61	0.70	0.73
C9	+	+	+	+	+	+	+	0.64	0.33	0.53	0.59	0.68
C10	+	+	+	+	+	+	+	0.67	0.36	0.55	0.62	0.70
C11	+	+	+	+	+	+	+	0.66	0.42	0.52	0.63	0.69
C12	+	+	+	+	+	+	+	0.68	0.40	0.54	0.66	0.69
C13	+	+	*	*	*	+	*	0.52	0.29	0.37	0.48	0.57
C14	+	+	*	*	*	+	+	0.49	0.23	0.34	0.44	0.56
C15	+	+	+	*	*	+	*	0.57	0.35	0.43	0.51	0.62
C16	+	+	*	*	+	+	+	0.55	0.24	0.41	0.49	0.61
C17	+	+	*	*	+	+	+	0.61	0.35	0.49	0.59	0.64
C18	+	+	+	*	+	+	+	0.30	0.12	0.30	0.37	0.22
C19	+	+	+	*	+	+	*	0.36	0.23	0.27	0.46	0.25
C20	+	+	+	*	+	*	*	0.12	0.02	0.04	0.16	0.06
C21	+	+	+	*	+	+	*	0.31	0.17	0.30	0.38	0.23
C22	+	+	+	+	+	+	+	0.68	0.39	0.57	0.65	0.71
C23	+	+	*	*	+	+	+	0.58	0.27	0.44	0.52	0.63
C24	+	+	+	+	+	+	+	0.69	0.40	0.58	0.66	0.71
CB1	+	+	+	+	+	+	+	−0.66	−0.42	−0.62	−0.66	−0.66
CB2	+	+	+	*	+	+	+	−0.71	−0.44	−0.61	−0.71	−0.71
CB3	+	+	+	+	+	+	+	−0.40	−0.10	−0.42	−0.36	−0.50
CB4	+	+	+	*	+	+	+	0.58	0.21	0.46	0.53	0.64
CB5	+	+	*	*	+	+	+	0.60	0.36	0.47	0.57	0.63
CB6	+	+	*	*	*	+	*	0.53	0.29	0.38	0.48	0.58
CB7	+	+	*	*	*	+	+	0.50	0.24	0.35	0.44	0.57
CB8	+	+	+	*	+	+	*	0.58	0.36	0.44	0.52	0.62
IAcc1	+	+	*	*	+	+	*	0.57	0.26	0.41	0.53	0.63
IAcc2	+	+	*	*	*	+	*	0.61	0.33	0.41	0.57	0.66
IAcc3	+	+	*	*	*	+	*	0.61	0.37	0.43	0.56	0.66
IAcc4	+	+	*	*	*	+	*	0.60	0.37	0.41	0.56	0.64
IAcc5	+	+	*	*	*	+	*	0.62	0.39	0.41	0.58	0.66
IAcc6	+	+	*	*	*	+	*	0.59	0.42	0.39	0.54	0.63
IAcc7	+	+	*	*	*	+	*	0.57	0.41	0.34	0.53	0.61
IAcc8	+	+	+	+	*	+	*	0.52	0.42	0.32	0.50	0.54
JA1	+	+	*	*	*	+	*	0.42	0.23	0.29	0.42	0.43
JA2	+	+	*	*	*	+	*	0.42	0.22	0.28	0.42	0.43
JA3	+	+	*	*	*	+	*	0.45	0.28	0.18	0.41	0.51

(*continued*)

Table 3. (*continued*)

Measures	*P*-values (sig. +: $p < 0.05$, *: $p > 0.05$)							Pearson Correlation Coefficient				
	Main Effects			Interaction Effects								
	WP	LL	SS	SS × LL	SS × WP	LL × WP	SS × LL × WP	Overall	0 kg	10 kg	Flat	Inclined
JA4	+	+	*	*	+	+	*	0.41	0.35	0.30	0.42	0.41
JA5	+	+	*	*	*	+	*	0.44	0.35	0.32	0.44	0.45
JA6	+	+	*	*	*	+	*	0.24	0.18	0.27	0.16	0.32
JA7	+	+	*	*	*	+	*	0.20	0.28	−0.01	0.30	0.08
JA8	+	+	+	*	*	+	*	0.52	0.33	0.40	0.54	0.52
JA9	+	+	*	*	*	+	*	0.27	0.15	0.29	0.24	0.30
JA10	+	+	*	*	*	+	*	0.19	0.30	−0.02	0.27	0.10
JA11	+	+	*	*	+	+	+	0.47	0.28	0.32	0.46	0.48

WP: Working Posture, LL: Lifting Load, SS: Standing Surface.

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Modeling the Joint Stiffness Change by Pelvic Tightening Based on Alignment of Lumbar and Pelvis

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Abstract. This study investigated the feature quantity related to the stiffness of the lumbar joints in 19 subjects for the construction of a dynamic tightening force control system for Active Corset. We investigate the change of the alignment of pelvis and lumbosacral vertebrae from X ray image, which are expected to change due to pelvic tightening. As a result, we confirm the tendency that joint stiffness increases as the sacrum tilt forward due to pelvic tightening.

Keywords: Active Corset · Joint stiffness · Pelvis · Lumbosacral alignment

1 Introduction

This study has developed the "Active Corset" (AC), an assist tool aimed at preventing low back pain (Fig. 1) [1]. AC is a pelvic belt type assist tool that reduces the lumbar load by tightening the pelvis. AC estimates the lumbar load using the built-in sensor suit, and dynamically changes the tightening force depending on the magnitude of the lumbar load (Dynamic tightening control).

Lumbar support by tightening has also been used in conventional pelvic belts and corsets, but it has not yet been clarified how much tightening force should be applied to how lumbar load. It seems that the higher the tightening force, the higher the assisting effect, but it is reported that the assisting effect of tightening is saturated at a certain tightening force [2, 3]. In addition, excessive tightening force may cause problems such as interruption in blood flow or atrophy of target muscles [4, 5]. Therefore, the purpose of this study is to design a dynamic tightening control, and to model the response of the lumbar part to the pelvic tightening force. We have verified the effect of reducing the burden of AC tightening. It was shown that the lumbar burden reduction due to tightening is related to the increase in joint stiffness of the lumbar joint [1, 6].

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Fig. 1. Active Corset

Although changes in stiffness of the lumbar joint due to the tightening force have been reported, it is unclear how the increase in lumbar joint stiffness is caused by the tightening of pelvis. Stefan et al.'s report confirms that tightening the pelvis changes the alignment of the pelvis and sacrum [7]. Therefore, we expect the relationship between the change in alignment due to tightening and the change in lumbar joint stiffness.

This study investigates the relationship between pelvic and sacral alignment and lumbar joint stiffness in subjects whose pelvic tightening has reduced the lumbar load associated with increased lumbar joint stiffness.

2 Changes in Pelvic and Lumbar Alignment

This section proposes the parameters used for modeling the change of lumbar joint stiffness.

Tightening the pelvis reduces the lumbar load by correcting the posture of the hip and lumbar spine in anteflexion. The factors that cause posture correction are considered to be the increase in lumbar joint stiffness and the change in muscle exertion. The increase in joint stiffness is caused by the increase in friction of the joint surface due to pelvic tightening, which increases the passive resistance of the joint. On the other hand, it is considered that the change in muscle exertion is due to the brain giving signals to muscles based on somatosensory information changed by tightening. This research targets subjects whose lumbar load is reduced due to change in joint stiffness accompanying the change in alignment as in the former case. We attach to the following three factors to express the increase of lumbar joint stiffness caused by tightening.

(1) Sacral inclination relative to the pelvis on the sagittal plane (Fig. 2(a))
(2) Distance between the left and right hip bones on the coronal plane (Fig. 2(b))
(3) Lumbar flexure on the sagittal plane (Fig. 2(c))

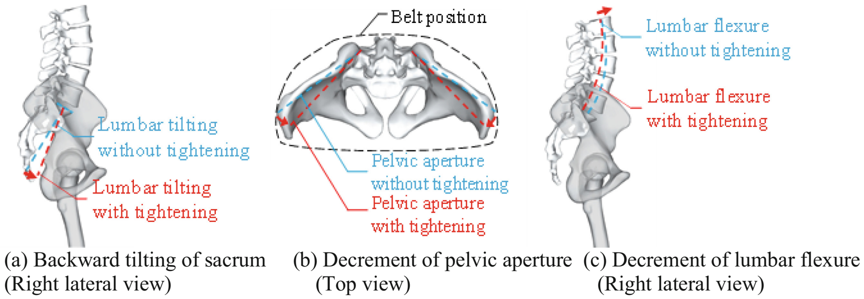

Fig. 2. Change of the lumbosacral and pelvic alignment due to pelvic tightening [8]

First, as for (1), when the tightening force is applied, the pelvic belt presses the skeleton from the front and back of the human body as shown in Fig. 3 (a). The lower part of the sacrum is pressed by the belt, and the sacrum tilts backward with respect to the pelvis around the lumbar joint [7]. When the sacrum is pressed against the pelvis from the back of the human body, the sacroiliac joints that joins the sacrum and hipbone are compressed, increasing friction and increasing joint stiffness. Therefore, the sacral inclination relative to the pelvis is considered as one of the parameters related to the increase in lumbar joint stiffness.

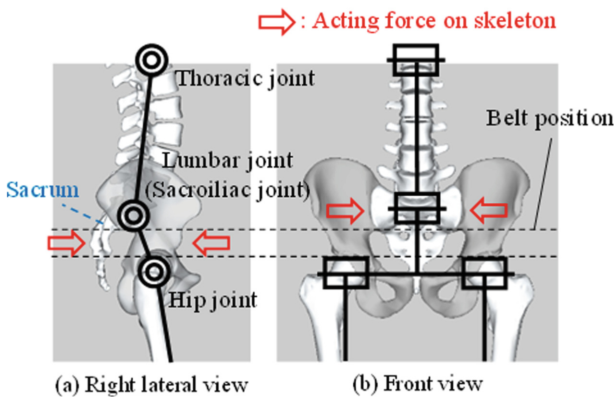

Fig. 3. Change in pelvic and sacral postures due to Active Corset tightening force change lumbar joint stiffness [8]

Next, regarding (2), on the coronal plane, the belt tension exerts a force on the hipbone from the left and right direction of the human body (Fig. 3(b)). Compression of the sacroiliac joint surface is expected to increase joint stiffness. Then, the pelvis will deform in the direction in which the distance between the left and right iliac crests decreases. Consequently, the distance between the left and right hip bones is considered to be a parameter related to the increase in joint stiffness.

In (3), when the inclination of the sacrum changes due to tightening, it is expected that the alignment of the lumbar spine connected to the upper part of the sacrum will also change. The lumbar spine curves toward the front of the human body. When the sacrum is tilted backward by tightening, the lumbar flexure angle decreases when same postures are compared [9]. Moreover, it is known that the lumbar spine has a non-linear elastic characteristic with respect to the bending due to muscles and ligaments attached between the vertebral bodies. Namely, changing the lumbar spine alignment means moving the elastic equilibrium point of the lumbar joint. Since the flexion of the lumbar vertebrae is included in the second link (lumbar joint) in Fig. 3(a), it is expected that there is a relationship between the change in lumbar joint stiffness and the lumbar flexure.

An attempt is made to express the change in the joint stiffness due to the tightening with a regression model using the features of (1) to (3).

3 Experiment and Analysis

This chapter describes experiments and analysis methods for measuring the lumbar joint stiffness and (1) to (3) of alignment features. Target subjects are 19 males whose lumbar load decreased with increasing in lumbar joint stiffness due to the dynamic tightening force of AC.

3.1 Measurement of the Lumbar Joint Stiffness

In order to measure the joint stiffness, the motion of the subject is obtained by inputting data measured by optical motion capture (Motion Analysis) into a mechanical model. The extension of the upper body from the forward flexion was measured. The subject extends the upper body for 3 s from the forward bending posture to the standing posture. The measurement was performed 10 times for each of the two conditions: when subject don't wear AC (Unbelted condition) and when subject is assisted by AC (Tightened condition).

Consider the mechanical model shown in Fig. 4 for calculating the joint stiffness. The model in Fig. 4 simulates the movement of the human sagittal plane and the hip and lumbar joints are elastic joint. The link length and link mass of the model were determined based on measurement by Ae et al. [10].

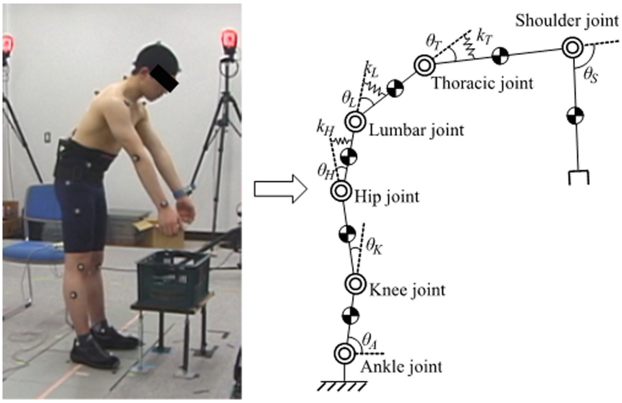

Fig. 4. Mechanical model for calculating joint stiffness

The joint stiffness is identified based on the equation of motion Eq. 1 of the model. Equation 1 is the inertia term $M(\theta_x)\ddot{\theta}_x$, centrifugal and Coriolis force term $c\left(\theta_x, \dot{\theta}_x\right)$, gravity term $g(\theta_x)$, elastic force term $k_x\theta_x$, muscle exertion torque τ_{mx}, and external force τ_{sx} described using θ_x, which represents the bending angle of each link, and θ_{x0}, which represents the elastic equilibrium point of each joint. Note that x in the equation is the symbol H (Hip joint), L (Lumbar joint), or T (Thoracic joint) that represents each joint,

$$\begin{aligned} M\left(\theta_{x(i)}\right)\ddot{\theta}_{x(i)} + c\left(\theta_{x(i)}, \dot{\theta}_{x(i)}\right) + g\left(\theta_{x(i)}\right) + k_x\left(\theta_{x(i)} - \theta_{xo}\right) \\ = \tau_{mx(i)} + \tau_{xs(i)} \quad (i = 1, 2, 3, \ldots s) \end{aligned} \tag{1}$$

In subjects reduced the lumbar load with tightening, lumbar joint stiffness is expected to become more higher relative to the hip joint stiffness. Then, the joint stiffness ratio R shown in Eq. 2 is calculated from the obtained stiffness values of the lumbar and hip joint. An increase in the joint stiffness ratio R due to tightening is expected.

$$R = \frac{k_L}{k_H} \tag{2}$$

Fig. 5. Measurement of θ_ST

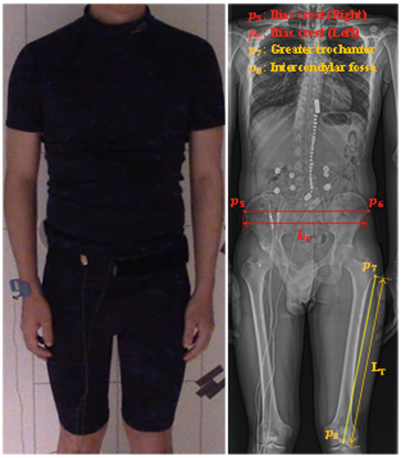

Fig. 6. Measurement of L_PA

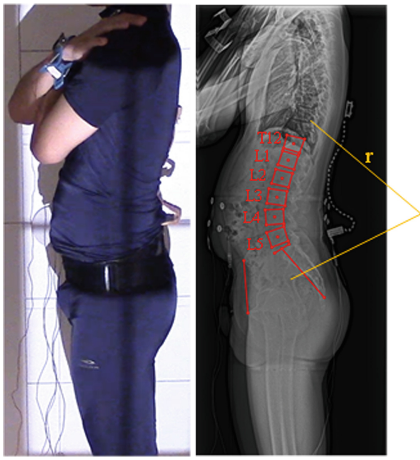

Fig. 7. Measurement of R_LF

From the joint stiffness in each condition, the increment in joint stiffness due to tightening is obtained from the following equation Eq. 3. The suffixes *(unbelted)* and *(Tightened)* in the Eq. 3 indicate the experimental conditions.

$$\Delta R = R_{(Tightened)} - R_{(Unbelted)} \tag{3}$$

3.2 Measurement of the Alignment of Pelvis and Lumbar

This section describes experiments and analysis methods for measuring the each of (1) to (3) of alignment features. For the measurement of these alignment features, we used X-ray images taken from the torso to the legs when the subject was standing posture.

The measurement of the backward tilting angle of sacrum relative to the pelvis θ_{ST} used the image taken from the side of the standing posture as shown in Fig. 5. From the inclination angles relative to the horizontal line of the pelvis θ_P and sacrum θ_S, θ_{ST} is calculated by the following formula Eq. 4. θ_P is the angle between the horizontal line and the line that connecting the two points, which are clearly imaged, among the three points of the pelvic anatomical features: superior anterior iliac spine, superior posterior iliac spine, and pubic symphysis θ_S is the angle between the line connecting the center of the sacral floor and the coccyx and the horizontal line.

$$\theta_{ST} = \theta_S - \theta_P \tag{4}$$

For the measurement of the distance between the left and right hip bones L_{PA}, the image taken from the front of the human body shown in Fig. 6 was used. In order to compensate for the difference in the scale of the image, Eq. 5 normalize by calculating the ratio of the distance between the right and left iliac crests L_P, to the length of femur L_T.

$$L_{PA} = \frac{L_P}{L_T} \times 100 \tag{5}$$

The lumbar flexure is measured using the image as shown in Fig. 7. Approximate the five points of the center of gravity from the first to the fifth lumbar vertebrae with an arc and calculate the curvature of it. For each of the measured θ_{ST}, L_{PA}, and R_{LF}, determine the amount of change due to the tightening using Eq. 6 to Eq. 8.

$$\Delta\theta_{ST} = \theta_{ST(Tightened)} - \theta_{ST(Unbelted)} \tag{6}$$

$$\Delta L_{PA} = \frac{L_{PA(Tightened)} - L_{PA(Unbelted)}}{L_{PA(Unbelted)}} \times 100 \tag{7}$$

$$\Delta R_{LF} = \frac{R_{LF(Tightened)} - R_{LF(Unbelted)}}{R_{LF(Unbelted)}} \times 100 \tag{8}$$

4 Relation Between Joint Stiffness and the Alignment Change

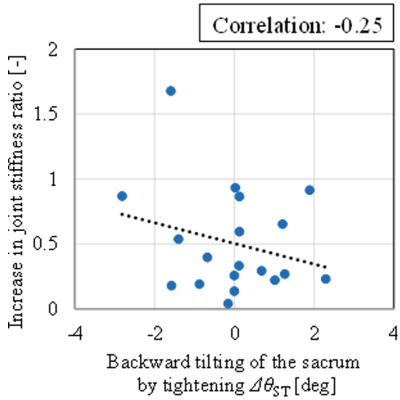

Fig. 8. Relation between ΔR and Δθ_ST

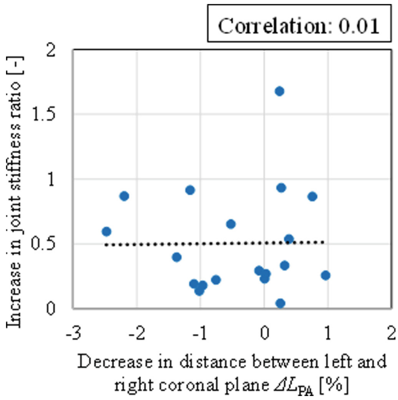

Fig. 9. Relation between ΔR and ΔL_PA

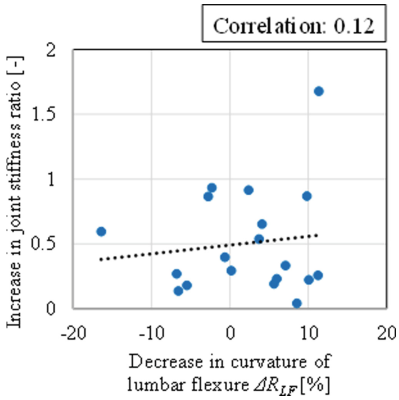

Fig. 10. Relation between ΔR and Δθ_LF

Figure 8, 9 and 10 show the correlation between the increase in joint stiffness ratio ΔR due to tightening and the three alignment changes obtained by Eq. 6 to Eq. 8: the angle change in the posterior direction of the sacrum $\Delta\theta_{ST}$, the decreasing rate in the pelvic width ΔR_{LF}, the decreasing rate in the curvature of the lumbar flexure ΔR_{LF}.

The change of the sacrum inclination $\Delta\theta_{ST}$ is correlated with the increase in joint stiffness ratio ΔR, and the correlation coefficient is -0.25. The joint stiffness ratio tended to increase as the sacrum tilts forward with respect to the pelvis. On the other hand, the decreasing rate of the pelvic width L_{PA} and the decreasing rate of the curvature of the lumbar flexure ΔR_{LF} didn't correlate with the increase of the joint stiffness ratio ΔR.

5 Conclusion

In this study, we investigated the relationship between the change in lumbar joint stiffness and the pelvic alignment due to tightening of the pelvis in order to construct a response model of the lumbar region due to pelvic tightening. Alignment measurement based on X-ray images was performed on subjects whose lumbar load was reduced due to increase of the joint stiffness by AC tightening. As a result, joint stiffness tends to increase as the sacrum tilt forward due to pelvic tightening. In the future, we will continue to investigate how the change in sacral posture contributes to the increase in the joint stiffness.

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Analysis of Moisture and Sebum of the Skin for Monitoring Wound Healing in Older Nursing Home Residents

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Abstract. Pressure ulcers are a common problem among older nursing home residents. Wound healing monitoring in these older residents causes intensive significant workload for nurses. Moisture and sebum of the skin are critical factors during wound healing which can observations for nurses quick and handy. The purpose of this study was to investigate the relation between moisture and sebum of the skin during wound healing in older people. The data of moisture and sebum was observed for four times in sequence biweekly from the sacrum region of eighteen subjects. Based on the wound healing status, the subjects were grouped into the wound healing, wound non-healing, and non-wound groups. The wound area was calculated by manually tracing the wound area in captured images using the Image-J. Ulcer area were median correlation with moisture ($r = .61$) and sebum ($r = -.60$) in the wound healing group. The moisture was also significantly correlated with sebum ($r = .89$, $p < .05$) in the wound non-healing group. Increasing moisture and decreasing sebum may be associated with wound healing among older nursing home residents. Our findings showed that moisture and sebum of human skin can be used to predict wound healing status.

Keywords: Pressure ulcers · Bedsores · Soft tissue · Sacrum region

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1 Introduction

As a global problem, the incidence of pressure ulcers in different types of bedridden patients ranges from 0.4% to 66% [1]. Among bedridden patients, pressure ulcers are listed as the most common and disturbing symptoms [2]. The relative position of the soft tissue between the bone and the skin is unlikely to move, and the pressure under the same gravity is higher than the surrounding soft tissue due to the protrusion of the bone, so bony prominences is a place where pressure ulcers often occur [3]. A pressure ulcer is usually caused by excessive interface pressure [4] or pressure gradient [5] on the skin. Changes in interface pressure or pressure gradient may provide a transient to increase in microcirculation to prevent the risk of pressure ulcers [6].

The others of chronic diseases in bedsore patients during rehabilitation will affect the speed of intervening [7], changes in microcirculation nutrient transport during wound healing can affect the balance of skin moisture and sebum [8, 9]. Although examination of the microcirculation could assessment predict wound healing status, the skin moisture and sebum as the non-invasive method can reflect soft tissue of skin property [10]. The intervention rate of wound healing in patients may relate to skin moisture and sebum.

This study hypothesized that the wound healing and wound non-healing of patients with pressure ulcers would show a correlation with skin moisture and sebum. The purpose of the study was to establish that the skin moisture and sebum relation to wound healing of pressure ulcers.

2 Methods

2.1 Subjects

Eighteen volunteers were recruited, including ten without pressure ulcers (seven males) and eight pressure ulcers (four males). Subjects stayed in bed for more than six months and patients with hypertension and diabetes over 20 years of age. The research protocol was explained to the volunteers who signed an informed consent form. The study has been approved by the Ethics Committee at the university.

2.2 Experimental Procedures and Data Analysis

The main tools of this research were two measurements as below. The first measurement was general physiological measurement: calculation of ulcer area: Image-J (US National Institutes of Health, Bethesda, Maryland, USA, https://imagej.nih.gov/ij/). The wound area of the ulcer was firstly measured to obtain an actual area, and then photographed by a photographic device and uploaded to the Image-J program for reading (Fig. 1A). The second measurement was physiological value measurement: skin moisture meter was used to measure the moisture and sebum of healthy skin around ulcers in the sacrum region (Fig. 1B).

The values were presented as the mean ± SD. A one-way ANOVA with Fisher's LSD post hoc test was used to examine two efficacy of repeated measures. The first was between the wound healing, wound non-healing, and non-wound condition. The second was week 3, week 5, and week 7. Correlations between the ulcer area, skin moisture, and skin sebum were determined using a Pearson product-moment correlation analysis. All statistical analyses were performed using SPSS 22 (IBM, Somers, NY) at the significance level of 0.05 (Fig. 1).

(A) (B)

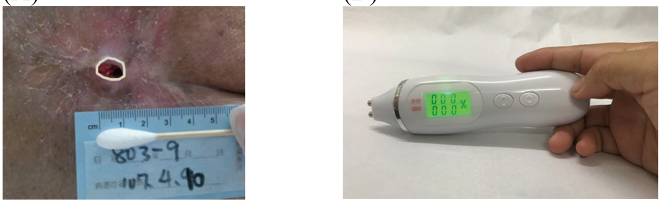

Fig. 1. An illustrator for the presentation and visualization of experimental procedures. (A) Example of scale and ulcer area. (B) Skin moisture and sebum meter.

3 Results

3.1 The Time Effect in Moisture and Sebum

According to the wound healing of pressure ulcers, the subjects were separated into three groups: wound healing, wound non-healing, and non-wound. A summary of the anthropometry data collected was shown in Table 1. The data of ulcer area, moisture, and sebum in first, third, and fifth, the seventh week were obtained in Table 2. The ratio results of ulcer area were not a significant difference between different weeks (Fig. 2).

3.2 Correlation Between Ulcer and Skin Parameters

The correlations between moisture, sebum parameters, and ulcer area were compared shown in Table 3. Although in the wound healing group, the ulcer area showed a high correlation for moisture (r = 0.61) and sebum (r = −0.60), there was no significant difference. However, significant correlations were found between moisture and sebum in the wound non-healing group (r = 0.89, p < .05) and the non-wound group (r = 0.75, p < .05) (Fig. 2).

Table 1. Basic information for people who were bedridden.

	Group		
	Wound healing	Wound non-healing	Non-wound
Sex M/F (people)	2/2	2/2	7/3
Age (years)	57.7 ± 16.9	60.3 ± 4.2	71.5 ± 14.4
Height (cm)	163.3 ± 6.7	163 ± 15.1	151.7 ± 47.8
Weight (kg)	59.9 ± 6.0	54.8 ± 15.0	60.2 ± 4.8
BMI (kg/cm^2)	22.4 ± 0.8	20.3 ± 2.3	21.7 ± 2.2

Table 2. Three consecutive biweekly comparisons of moisture and sebum

Group	Parameter	Group			One-way ANOVA	Fisher LSD Post hoc		
		Week 3	Week 5	Week 7	*p* value	Week 3 vs. Week 5	Week 3 vs. Week 7	Week 5 vs. Week 7
Wound healing	Ulcer area ratio (%)	40.1 ± 32.6	24.2 ± 30.9	12.2 ± 17.2	0.63	0.59	0.38	0.69
	Moisture (%)	19.0 ± 3.7	29.4 ± 19.9	14.2 ± 1.7	0.49	0.44	0.7	0.28
	Sebum (%)	21.5 ± 0.3	22.0 ± 1.6	22.5 ± 3.1	0.89	0.82	0.65	0.82
Wound non-healing	Ulcer area ratio (%)	84.2 ± 64.8	123.7 ± 116.9	125.9 ± 110.2	0.21	0.14	0.06	0.47
	Moisture (%)	16.2 ± 2.3	16.5 ± 0.5	16.8 ± 8.0	0.99	0.94	0.9	0.96
	Sebum (%)	24.0 ± 3.9	24.8 ± 0.7	21.7 ± 6.7	0.78	0.86	0.65	0.54
Non-wound	Ulcer area ratio (%)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Moisture (%)	18.7 ± 2.5	19.8 ± 8.2	27.4 ± 8.6	0.14	0.81	0.07	0.11
	Sebum (%)	23.5 ± 1.9	26.6 ± 6.1	30.5 ± 7.7	0.21	0.43	0.08	0.31

Note: The ulcer area ratio (%) was based on the first week. The values of moisture (%) and sebum (%) were recorded by skin moisture and sebum meter.

Table 3. Correlation between ulcer area, moisture, and sebum in three group

	Group		
	Wound healing	Wound non-healing	Non-wound
Ulcer area vs. Moisture	0.61	0.37	n/a
Ulcer area vs. Sebum	−0.60	0.66	n/a
Moisture vs. Sebum	−0.43	0.89*	0.75*

Note: *significant correlations ($p < .05$).

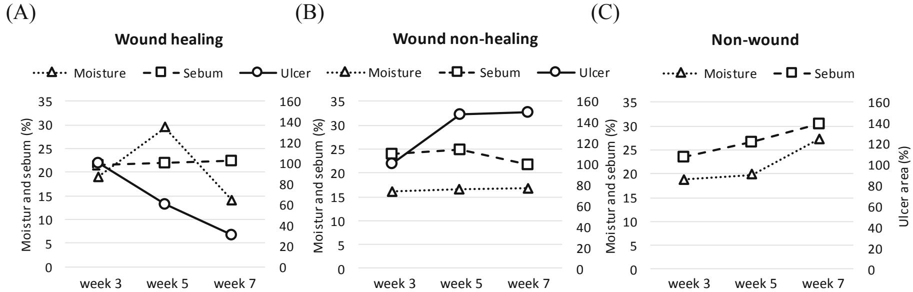

Fig. 2. The skin parameters result of ulcer area, moisture, and sebum in third week, fifth week, and seventh week. (A) Wound healing group. (B) Wound non-healing group. (C) Non-wound group.

4 Discussion

The significant correlations were found between moisture and sebum in the wound non-healing group and the non-wound group. The results can provide a foundation to understand the effect of moisture and sebum in skin wound healing of pressure ulcers.

In the wound healing group, the ulcer area showed a high positive correlation with moisture ($r = 0.61$), but a high negative correlation with sebum ($r = -0.60$). The skin moisture increased may relate to the microcirculation increased during the wound healing stage [11].

Meanwhile, the skin of wounding healing may increase microcirculation and decrease sebum in the fifth week. The fifth week was a more critical period of wound healing. As the study of Marrakchi and Maibach showed that the young people in the nose skin area had a higher microcirculation and lower sebum. Still, otherwise, the older people in the nose skin area had a higher microcirculation and higher sebum [12]. The wound healing skin may be similar to young people, and wound non-healing skin was related to older people.

5 Conclusion

The significant correlations were found between moisture and sebum in the wound non-healing group and the non-wound group. Our results provide the relation between skin moisture and sebum that may affect the wound non-healing of pressure ulcers. Increasing moisture and decreasing sebum may accelerate wound healing among older nursing home residents. The sequence observation of moisture and sebum of human skin can monitor the condition of the skin in each stage of the wound healing of pressure ulcers.

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Ergonomics in Product Design

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Estimation of Forearm, Deltoid, and Trapezius Muscle Activities Due to Overuse of Smartphone with and Without Armrest

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Abstract. Recent boom of smartphone technology and attractive new features with affordable price are continuously convincing new users to upgrade their phone and eventually they spend far more screen-time than ever before. Recent studies have shown that deltoid, trapezius, and forearm muscles mostly get affected among other muscular regions. But previous studies have some research gap in measuring combined effect of these three muscles due to smartphone use and they did not consider armrest conditions while measuring the combined muscular effect. Eight participants were recruited and EMG of six muscles (Upper Trapezius (UT), Anterior Deltoid (AD), Abductor Pollicis Longus (APL), Flexor Carpi Ulnaris (FCU), Extensor Pollicis Longus (EPL), and Abductor Pollicis Brevis (APB)) was recorded. Results found difference of UT MVC% when using cellphone on the chair with or without armrest. Gender had influence on part of muscles activity.

Keywords: Smartphone · EMG · Muscles activity · Gender · Fatigue

1 Introduction

With the fast-developed technology, the smartphone updated with the boom rate. Because of the attractive new features, more and more users spent a longer time on the smartphone daily. Based on the data from eMarketer, smartphone users spent 3 h, 10 min on their devices per day [1]. One study has reported a significant increase of neck-shoulder pain among young people aged between 20 to 29 years [2]. Researchers have discussed "the most probable explanation", they thought "the increased use of computers and Mobil phone" among young people would be the main reason [2]. Previous study has shown anterior deltoid has an important role in forearm support during keyboard use [3]. Therefore, the anterior deltoid would be an ideal muscle to measure during smartphone use. However, there's no related research in cellphone use. Compared with using smartwatch while sitting, using smartphone showed lower activation in upper trapezius, medial trapezius, and deltoid muscles [4]. In their research, all participants held the smartphone without armrest. With armrest, the muscular activities in trapezius and deltoid could be different. This study focused on the relationship between posture and muscle activities. Muscles most affected by excessive use of smartphones were identified.

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2 Literature Review

Studies in conventional computer settings with keyboards and mouse have shown that postures related musculoskeletal pain in the upper extremities and neck can be reduced significantly by adjusting the display location and providing adequate arm and wrist supports [5]. For example, having a screen at eye level reduces neck flexion, but at the expense of increased muscular loading in the shoulder/upper extremity regions [6]. To avoid this trade-off, armrests would be useful to alleviate physical demands on the shoulders/upper extremities. Such ergonomic interventions used in conventional computer settings can reduce awkward head/neck postures and associated musculoskeletal pain during prolonged mobile phone use effectively. Research has evaluated systematically the efficacy of adequate ergonomic controls to reduce biomechanical exposures. Armrests and back support reduced biomechanical loading experiment has been done [7] to investigate the relationship between mobile phone use and upper muscles activity and determine how much the armrest and the back support can relax muscles.

A comparison of biomechanical workload between smartphone and smartwatch while sitting and standing [4], showed that smart phone using while sitting would cause musculoskeletal disorders and cannot be ignored. The study of smart phone gaming duration on muscle activity and spinal posture [8] showed similar results. Moreover, it found out that neck muscle and spine also take a huge pressure from long standing while using smart phone. The lower trapezius and upper trapezius were measured and compared in the research. The research of sex-specific effects of sitting versus standing on upper body muscle activity during text typing [9] pointed out that pressure for different muscles associated with posture.

Based on the literature review, little research has been conducted to evaluate the muscle activity of upper body during smartphone gaming when being seated with armrest. Therefore, the goals of this study were twofold: 1) to quantify the kinematics of Upper Trapezius, Abductor Pollicis Brevis, Extensor Pollicis Longus, Abductor Pollicis Longus, Flexor Carpi Ulnaris and Anterior Deltoid during smartphone gaming, and 2) evaluate the effect of gender and armrest on muscle activities during smartphone gaming.

3 Research Methodology

3.1 Participants

Eight participants with equal sex distribution were recruited on campus. All participants have used smartphone for at least 3 years. All participants had no musculoskeletal pain one month before the experiment or disorder history in the deltoid and trapezius muscle regions.

3.2 Experiment Design

The experimental design included two independent variables: gender (male/female), armrest conditions (with/without armrest). Muscle activities of Upper Trapezius (UT), Anterior Deltoid (AD), Abductor Pollicis Longus (APL), Flexor Carpi Ulnaris (FCU) Extensor Pollicis Longus (EPL) and Abductor Pollicis Brevis (APB) were measured.

3.3 Equipment

Surface electromyography (EMG) were recorded using EMG machine to measure muscle activity levels (MVC%) for six selected muscles. Apple iPhone 6 Plus was chosen for the study.

3.4 Task

All participants have used two chairs, one with armrest and one without armrest. Game Fruit Ninja 2 with the same difficulty level was played by the participants by their dominant hand. All participants performed a gaming task for 10 min with armrest and 10 min without armrest and a 5 min break in between.

3.5 Procedure

Before the experiment, MVC was collected separately. Pinch gauge was used for 5 s to collect MVC data for APB and APL. Hand dynamometer was used for 5 s to collect MVC data for FCU and EPL as shown in Fig. 1 (a) and (b). For AD, a pulling task was performed for 5 s as shown in Fig. 1 (c) [10]. For UT, participants' shoulder abducted 90°, elbow flexed 90°, resisted abduction of upper arms in the frontal plane for 5 s. After measuring the MVC of each muscle, each participant should complete two 10-min experiment individually. The order of two experiments was randomized (Fig. 2).

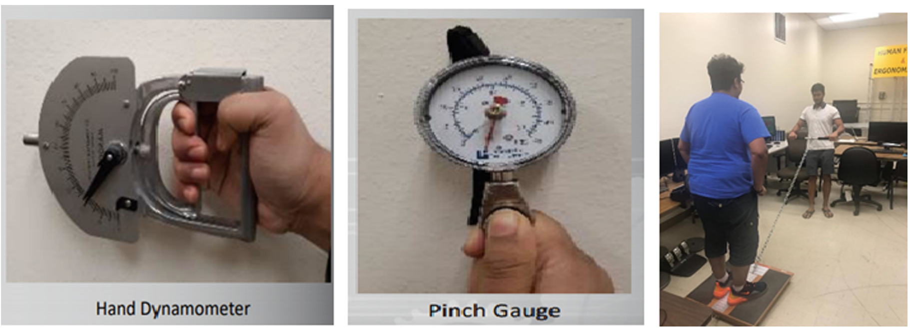

Fig. 1. Hand dynamometer (L), pinch gauge (M), and pulling mechanism (R)

Fig. 2. Experimental task

3.6 Data Collection

Muscle activities were measured at a sampling rate of 2000 Hz using Ag/AgCl surface electrodes and a wireless logger. Skin preparation, muscle identification, and electrode placement were conducted based on the European Recommendation for Surface Electromyography. Raw EMG data were processed initially with a band pass filter of 10–350 Hz, and the data was collected for entire 10 min of each operation.

4 Results and Discussion

4.1 Muscle Activity

According to the data collected by the Biometrics EMG machine, the MVC% of each muscle was shown as following (Fig. 3, 4, 5, 6 and 7). In figures, blue lines represent MVC% of muscles activity with armrest, red lines represent MVC% of muscles activity without armrest, and gray lines represent the ratio of MVC% of muscle activity with armrest to MVC% of muscle activity without armrest. Since the sensor that measured APB muscle activity was not in close contact, it was not analyzed in the study. The first purpose of this study is to find out whether armrest would affect muscles activity. From the data collected, muscles activity of AD, APL, EPL, FCU showed no difference between with or without armrest. However, the MVC% of UT with armrest is bigger than without armrest, which means that people playing mobile phones on chairs with armrests involved more shoulders activity than without armrest. While playing smartphone games with armrest, participants propped on their elbow to support movements, which may increase the pressure of shoulder and resulted in the higher muscle activity of UT.

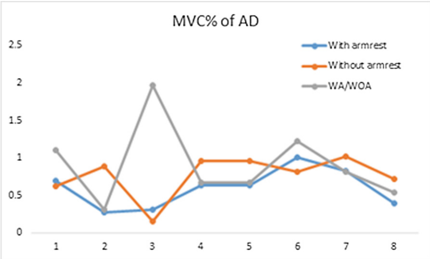

Fig. 3. MVC% of AD

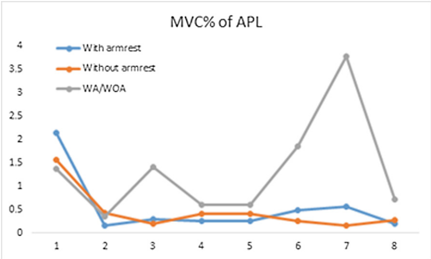

Fig. 4. MVC% of APL

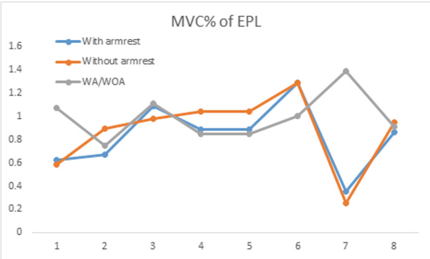

Fig. 5. MVC% of EPL

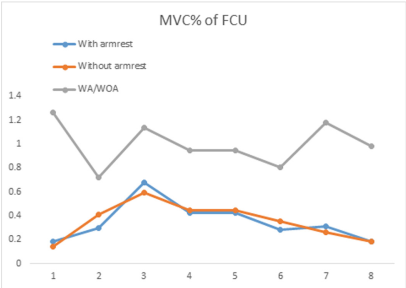

Fig. 6. MVC% of FCU

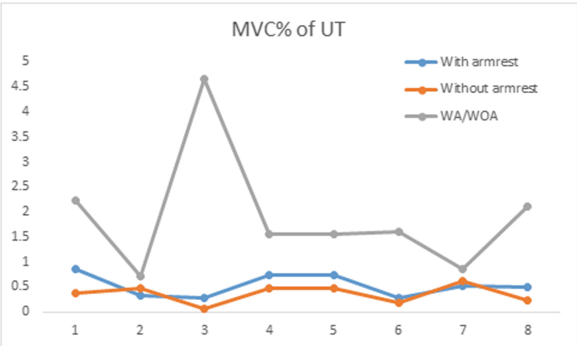

Fig. 7. MVC% of UT

4.2 Gender

This study has explored the relationship between gender and muscles activity (Fig. 8 and 9). Comparing muscles activity with different gender, no differences were found in EPL, FCU and UT. For APL, however, male participants constrained more than female participants in both with armrest and without armrest. For AD, female participants did more contraction than male participants. Male participants may perform more thumb movements than female participants, which caused more APL muscle activity or male participants preferred to use forearm unintentionally while playing smartphone games. On the contrary, Female participants may preferred to use shoulder to drive forearm, which caused the higher muscle activity of AD.

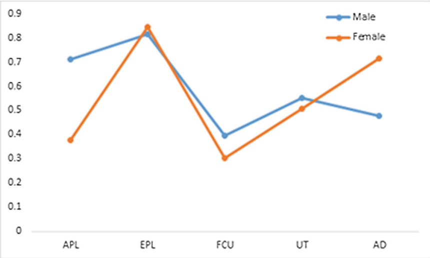

Fig. 8. Different gender MVC% of each muscle with armrest

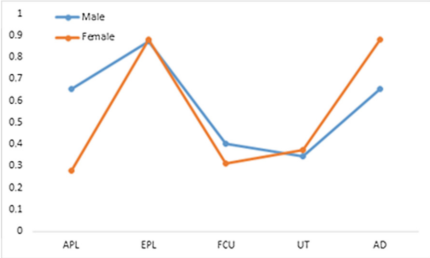

Fig. 9. Different gender MVC% of each muscle without armrest

5 Conclusion

The study found there are no difference of forearm muscles while playing cellphone on chair with or without armrest. What was unexpected is gaming with smartphone with armrest chair may involve more shoulder activity. In addition, the difference of muscle activity caused by gender should be considered in future study. However, the sample size in the study is not enough to make a statistical analysis. Ten-minute task in each section may not be sufficient to fully explore real-life situations. Additionally, the static postures of gaming task may not be actual postures in real life. These limitations should be taken into consideration when planning future studies.

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Women's Footwear Sole for the Elderly Produced with Sustainable Material: Friction Coefficient Analysis

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Abstract. One possibility to intervene in falls due to slipping is to use shoes with soles that can resist possible slips. The objective of this research is to evaluate the friction coefficient of the female footwear for the elderly produced with sustainable material (castor oil and bamboo composite). Slip tests on ceramic floors with a detergent solution and steel floors with glycerol solution (ABNT NBR ISO 20344: 2015, 5.11 and ISO 13287: 2012) were carried out at the Technological Research Institute of São Paulo (Brazil) - IPT. The results of the study showed that the sole developed with castor oil and bamboo is indicated for ceramic floors, but it is not advisable to use this kind of sole on steel floors with a glycerol solution.

Keywords: Elderly footwear · Slip · Friction coefficient · Biodegradable material · Sustainability

1 Introduction

One of the causes of accidental falls is slipping. Slipping is the loss of balance caused by an unforeseen action beyond the control of the individual or by a decrease in the friction coefficient between the footwear and the floor (SACHER, 1993). The most prevalent environmental risks are irregular surfaces such as bumpy sidewalks, slippery/wet floors, stairs without handrails, rugs in circulation areas and inappropriate shoes [1].

According to Lockhart et al. [2] the causes of falls due to slipping, both in terms of extrinsic and intrinsic factors and their associations, are not yet fully understood.

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Considering this, it is essential to examine the chain of events in an accident, including exposure to hazards, the starter events and the result that could leads to injuries and disabilities. In this sense, the physical analysis of the footwear and the biomechanics of the elderly using footwear, can facilitate the broader understanding of the fall predictive factors related to footwear used by the elderly.

The sole is the part of the shoe that interfaces with the ground, and because of this, it is the component that must guarantee traction and stability, in addition to absorbing impacts [3]. Currently, the main materials used for making soles are thermoplastic rubber (TR), polyurethane (PU) and mainly ethylene vinyl acetate (EVA) [4]. however, no studies evaluated the effects of soles produced with biodegradable materials. The objective of this study is to analyze the performance of soles constructed with castor oil and bamboo composite in footwear designed for elderly.

2 Materials and Methods

The sole developed for this work was developed with biodegradable materials composed of castor oil and bamboo fiber. The sole is 1 cm thick in the entire sole area (forefoot, midfoot and rearfoot). One of the soles is shown and detailed Fig. 1.

Fig. 1. The right sole developed with biodegradable material with outsole pattern designed with 2 mm square shapes and dashed diagonal lines.

Two physical tests were performed following the standards in (ABNT NBR ISO 20344: 2015, 5.11 and ISO 13287: 2012):

- Determination of slip resistance on ceramic floors with a detergent solution [5];
- Determination of slip resistance on steel floors with glycerol solution [6].

These tests were performed in 3 situations simulating the human movement: Heel strike (with support of the sole in the calcaneal region, simulating the initial phase of gait support); Foot flat or mid-stance position (with fully supported sole on the ground, simulating the intermediate phase of gait support) and Push-off (with sole support in the anterior region of the foot, simulating the final phase of propulsion gait).

Before performing each test, the following procedures are respected: the footwear remains 48 h in an environment at 23° and with 50% humidity; the ceramic floor is calibrated, showing friction coefficient results between 0.18 and 0.22; Then the lubricant solution of the respective test is added. After this initial configuration, the footwear is placed in a footwear mold that is fixed on the specimens' support.

During the tests the following is ensured: a maximum 7-degree contact angle at the rear of the shoe in heel strike (only the front is supported on the plate); a maximum 7 degree contact angle at the rear of the shoe (only the rear is supported on the plate); in midstance there is no inclination between the floor and the footwear. In all situations, the footwear is secured with a shoe-shaped fastener lowered on the 7-degree wedge by the action of its weight.

After preparing the test conditions, a force of 500 N is applied, then, the friction coefficient is determined. The tests were performed six times for each situation in each foot.

According to the standards [5, 6] the friction coefficient must not be less than 0.32 when measured in the plant and plane region and not less than 0.28 when measured only in the heel region when determining the resistance to slipping on ceramic floors with detergent solution, and must not be less than 0.18 when measured in the plant region and flat and not less than 0.13 when measured only in the heel region when determining the slip resistance in steel floors with glycerol solution.

3 Results and Discussion

For the tests with ceramic floor (Table 1), it was observed that in the situations of heel strike and foot-flat the sole presented the coefficient of friction within the standards in all situations on the left foot and in heel strike and foot-flat for the right foot. The values in the heel strike varied between 0.29 and 0.31 on the right foot and 0.28 and 0.30 on the left foot, therefore, in this situation the average is within the Standard for both feet (standard parameter value not lower to 0.28).

In the foot-flat situation, the averages are between 0.30 and 0.33 on the right foot and 0.34 and 0.35 on the left foot. In the Push-off situation, the values ranged between 0.27 and 0.30 on the right foot and 0.32 and 0.33 on the left foot (within the standard).

For the test with steel floor, the results of the friction coefficient in the heel strike situation are 0.10 on the right foot and 0.14 and 0.15 on the left foot, only the left foot presented the coefficient of friction within the Standard (values higher than 0.13). In the foot-flat situation, the friction coefficients were between 0.16 and 0.17 on the left foot and 0.13 on the right foot (the values should be higher or equal to 0.18), therefore, both feet are outside the Standard, and in the midstance situation, the right foot had coefficient values of 0.09 in all evaluations and the left foot had values between 0.13 and 0.15 (outside the standard). The results for these tests are shown in Table 2.

Table 1. Test results of the test with ceramic floor with detergent solution.

	Friction coefficient analysis situations simulating the human movement																	
Foot	Heel strike						|Foot-flat						Push-off					
Right	0.28	0.28	0.29	0.29	0.30	0.30	0.34	0.33	0.34	0.34	0.35	0.35	0.33	0.33	0.33	0.32	0.32	0.32
Left	0.29	0.29	0.30	0.30	0.31	0.31	0.30	0.30	0.32	0.31	0.31	0.33	0.27	0.27	0.28	0.29	0.30	0.30

Table 2. Test results of the test with steel floor with glycerol solution.

	Friction coefficient analysis situations simulating the human movement																	
Foot	Heel strike						|Foot-flat						Push-off					
Right	0.10	0.10	0.10	0.10	0.10	0.10	0.13	0.13	0.13	0.13	0.13	0.13	0.09	0.09	0.09	0.10	0.09	0.09
Left	0.14	0.14	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.13	0.15	0.15

4 Conclusion

The present research had the purpose of analyzing the performance of women's footwear soles designed for elderly developed with castor oil and bamboo concerning the friction coefficient in ceramic floors with a detergent solution and steel floor with glycerol solution. It was observed in the physical tests of slips that there is a difference in the friction coefficient in relation to the type of floor and lubricant.

The results of the study showed that the sole developed with castor oil and bamboo showed results within the norm on the ceramic floor with the feet (right and left) only in the heel strike situation and in the foot-flat and push-off situations with only the left foot. On the steel floor with glycerol solution, the sole presented parameters within the norm for the situation of heel strike only for the left foot. In the foot-flat and push-off situations the friction coefficient was below the parameters established by the standard. In short, the sole with a composite of castor oil and bamboo is suitable for ceramic floors, but it is not advisable to use the sole on steel floors with a glycerol solution.

The analysis of the friction coefficient is important to analyze the slip event, however, several other physical tests should be performed, such as analyzing the shape of the sole, thickness and characteristics of the ridges. In addition to the physical tests, it is also interesting to study the biomechanical tests in relation to the frictional force, impact and impulse when walking.

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Design and Analysis of Chest of Drawers from the Perspective of Child Safety

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Abstract. By analyzing the fuse of the IKEA "Malm" chest of drawers event, the human factor dimensions of children, behavioral differences between children and adults, and drawer material density changes were taken as design factors for the new chest of drawer, and a model was established. Four design points were proposed: i) multiple anti-dumping structure design to prevent children from being crushed to death; ii) design of drawer safety lock; iii) drawer volume gradually decreased from bottom to top, material density also gradually decreased from bottom to top, the overall center of gravity of the chest of drawers moves down; iv) the arc-shaped structure with the center of gravity moved backwards and reduces the contact area at the bottom. The Creo modeling software was used to perform a stability virtual test. The analysis results show that the designed chest of drawer is relatively stable and meets national standards. This study can provide new design ideas for improving the safety of chest of drawers in the future.

Keywords: Chest of drawer · Child safety · Ergonomics · Stability test

1 Introduction

In recent years, with the rapid development of the economy and real estate, people's living conditions have continued to improve [1]. With the implementation of the second child policy, the number of children is increasing [2]. This means that more and more children will have independent living and entertainment spaces. Children's groups will receive high attention from governments, businesses and society. The real development opportunities of the furniture industry concerned about child safety will also come. Preschool children are in the physiological period of rapid bone growth and development, and their curiosity for knowledge and their desire to explore the unknown have increased. Therefore, their healthy growth requires environmentally friendly, safe, and human-machine compatible drawers. The current chest of drawers are of a single style and of poor quality. Basically it is a plate structure, mainly composed of fiberboard and particleboard. Because fiberboard and particleboard are filled with plant residues and bonded with glue, the formaldehyde content is relatively high, which is very harmful to children in development. In addition, consumers' use habits and installation and removal tools are also limited. This assemblable design does not have sufficient robustness, and most drawers are easy to loose in use, and the safety and

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stability are not high. These unenvironmental and unsafe factors require our chest of drawers designers to rethink, reposition, design and produce a batch of chest of drawers that are easy for families to use, ensure the safety of children, and prevent dangers from happening [3].

The purpose of this research is to explore the reasonable design of chest of drawers based on children's human factors engineering and user habits, to design a chest of drawer that is more suitable for the family environment and to prevent children from accidents caused by the falling of the drawer. In addition, the stability test and mechanical analysis research are designed. The stability virtual test is performed by Creo modeling software to verify the stability of the chest of drawer.

2 Related Research

As an immature group, children have unique personality and behavioral characteristics at each age [4]. Structural safety is an important component of children's furniture that is different from adult furniture. Children's furniture must not only consider its normal use function, but also consider the liveliness and mobility of children, and also consider factors that may cause physical harm to children [5]. Structural safety includes requirements for edges and tips, protrusions, holes and gaps, folding mechanisms, closed furniture, mechanical properties, etc. With the rapid development of children's furniture products, more and more adjustable mechanisms, locking devices and new materials are used in children's furniture products. Although this improves the functions of children's furniture products, it also brings many hidden safety hazards. In recent years, due to substandard quality and safety of children's furniture, children's furniture recalls have occurred many times at home and abroad, and the safety of children's furniture has become a topic [6].

According to relevant investigations [7], from 1990 to 2007, there were 264,200 child injury accidents caused by the dumping of furniture in the United States, with an average of 14,700 accidents each year. That is to say, nearly 21 people per 100,000 people are injured every year due to furniture overturning. Among them, children under 6 years old account for 3/4, and the number of people injured due to furniture overturning is increasing year by year at a rate of 40%. IKEA's "deadly chest of drawers" incident has experienced twists and turns in China. The cause of the incident was the end of June 2016 when IKEA announced a recall of 29 million chests of drawers in the United States, including the malm series. The recall was due to the fact that chests of drawers have caused many child injuries in the United States since 1989, including 6 child deaths and 36 child injuries [8]. Therefore, the malm series chest of drawers are also known as the "life-threatening chest of drawers".

With the substantial increase in the number of children, the acceleration of the urbanization process, the improvement of living conditions and the increase in consumption capacity, the healthy development of the children's furniture industry is untenable.

3 Research Methods

3.1 Ergonomics

In the design of furniture products, factors such as human size, people's habits of storing items, and people's sight should be fully considered, so that the drawer not only has the practicality of simple storage function, but also has the comfort, convenience and efficiency of use. Compared with traditional furniture, the design of children's furniture has higher requirements for use, viewing and safety [9]. In order to make the design of children's furniture more in line with children's psychological and physical development requirements, the design of children's furniture based on ergonomic principles can well meet the market demand.

The design of children's furniture under the principle of ergonomics needs to consider multiple aspects of design elements, which are mainly divided into three aspects: children's own factors, furniture products themselves, and the use of environmental factors. To achieve effective coordination among children, furniture and the environment.

1. Children's factors. According to relevant literature research and questionnaire surveys, children of different ages and their corresponding characteristics are classified as shown in Table 1 [10]. According to Table 1, children's own factors can be divided into psychological factors and physiological factors. Preschool children (3–6 years old) develop faster than other stages. They began to have their own unique ideas and behaviors in terms of physiology, psychology, behavior, etc., and their different needs for furniture gradually became apparent. This subject is mainly to consider the dangerous situation that children will have when operating chest of drawers individually, and to improve the structure, size, and shape of the drawer according to the analysis of children's height, size, and behavioral habits to ensure the safety of children. Pre-school children (3 to 6 years old) were used as the target users of the research. Through the deep exploration of the target users, the corresponding human furniture engineering positioning of the corresponding children's furniture was carried out, and the design practice was carried out.

Table 1. Children's age classification and corresponding characteristics table

Childhood period	Age division	Physiology	Psychology	Behavior
Infancy	0–12 months	Perceptual sensitivity	Strong dependence	Sleepiness and crying
Early childhood	1–3 years old	Faster response	Cognitive enhancement	Active communication
Preschool age	3–6 years old	Rapid growth and development of bone	Increased curiosity, creativity and exploration	Lively and active
School age	6–12 years old	Increased ability to think	Character tends to mature	Sustainability work
Juvenile period	12–18 years old	Basically mature limbs	Personality gradually formed	Clear purpose

2. Product factors. Children's furniture and adult furniture are different. Children's lively and active characteristics are most likely to cause some dangers. Therefore, the biggest principle of children's furniture design is to focus on safety, which mainly involves the following aspects [11]. (i) Structural safety. The furniture has sufficient strength and stability after installation, and the installation of each component does not loosen or break. The nails and sharp corners of the furniture installation will not be exposed, and the drawers must be fixed outside, handrails shall be installed, etc., and write the corresponding precautions. (ii) Modeling safety. The design of the edges and corners of the furniture is rounded. Some shapes should also be designed on the premise of safe use. The shape should conform to the size of the child's body. Or equip furniture with corresponding cushioning materials, such as rubber table corners. The gaps in the furniture should be properly filled to prevent the child from being pinched. At the same time, the furniture should not be too high, so as not to increase the risk of children's use. (iii) Color matching is safe. The color of the furniture should not be too bright. The child's eyes are in the stage of continuous development. Long-term color stimulation will also damage the child's vision. Try to choose some fresh and bright color matching. You can fill it with specific things, such as animals, flowers and trees for color filling.
3. Environmental factors. Environmental factors include both natural and family environmental factors. (i) Natural environmental factors. Ergonomics-based children's furniture needs to be effectively coordinated with environmental factors, and it is best to consider light, heat, and dust protection measures in the environment. For example, the noise and environmental pollution around children's rooms can be improved by corresponding children's furniture, so that the environment in which children live can meet their physical health, safety, and comfort development needs. (ii) Family environmental factors. The living space of the child is mainly the family environment. Many pollution factors will appear during the decoration of the house. In order to meet the needs of the family environment, the design of children's furniture must also consider the purification of children's rooms. The corresponding potted plant function can be designed in the furniture design to purify the child's living space.

3.2 Mechanical Analysis

Cabinet stability is an important index related to the safety performance of cabinet furniture products. In China, it is not uncommon for children to be injured due to substandard mechanical properties such as the stability of furniture. With the continuous development of China's furniture industry, furniture products continue to innovate, especially in terms of raw materials, structure, and style. The introduction of the national standard GB/T 10357.4-2013 "Furniture Mechanical Performance Test: Part 4 Cabinet Stability" conforms to this trend of domestic and foreign furniture market development [12]. The verification of the design practice of the chest of drawer is the stability test based on the mechanical property test of the furniture.

4 Design of Chest of Drawers

4.1 Design Concept

Based on the usability principle, the existing design defects of the Malm series chest of drawers are analyzed to provide a basis for the next improvement design.

(i) Consider the limits of people: The differences between children and adults in terms of physical, psychological, and behavior are huge. A chest of drawer that is safe for adults may be the killer of children's lives. (ii) Form a natural match: A chest of drawer that may be dangerous for children due to misuse do not provide certain limitations, making the operation impossible. (iii) Fault tolerance: there is no clear possible danger statement before installation; there is no countermeasure design for wrong operation.

4.2 Results Presented

Design points for chest of drawer: (i) Multiple anti-dumping structure design to prevent children from being crushed to death; (ii) Design of drawer lock safety lock, the drawer safety lock is a tubular structure that is inserted in the drawer and adopts an overall design. The two sides of the lock are locked at the same time; if it needs to be opened, both hands must be swung at the same time to turn the switch. Taking into account the naughty nature of children, they will climb to the drawer, so the difference between the arm length of adults and children, the distance between the two sections of the buckle is far longer than the arm length of the child, to prevent children from opening the drawer without permission, trampling on it and causing the chest of drawer to fall (As shown in Fig. 2); (iii) Drawer volume gradually decreases from bottom to top, material density also gradually decreases from bottom to top, the overall center of gravity of the chest of drawer moves downwards; (iv) The arc structure with the center of gravity moved backwards and reduces the contact area at the bottom (As shown in Fig. 1).

Fig. 1. Render of a chest of drawers

Fig. 2. Chest of drawer safety lock details

5 Study on Drawer Stability

5.1 Creo Stability Virtual Test

Product modeling in Creo. In order to increase the stability of the chest of drawer, a different density material is selected for each layer, and then the density value is set in Creo. The specific operation steps are: open the file drop-down menu, select the model attribute, and then select the mass attribute. The density value can be set in the mass attribute menu (as shown in Fig. 3). The drawer on the upper level of the chest of drawer are made of less dense materials, and the density of the materials gradually increases from the upper level to the lower level. The lowest density of the drawer is the highest. This can reduce the center of gravity of the chest of drawer, make the chest of drawer more stable and difficult to fall.

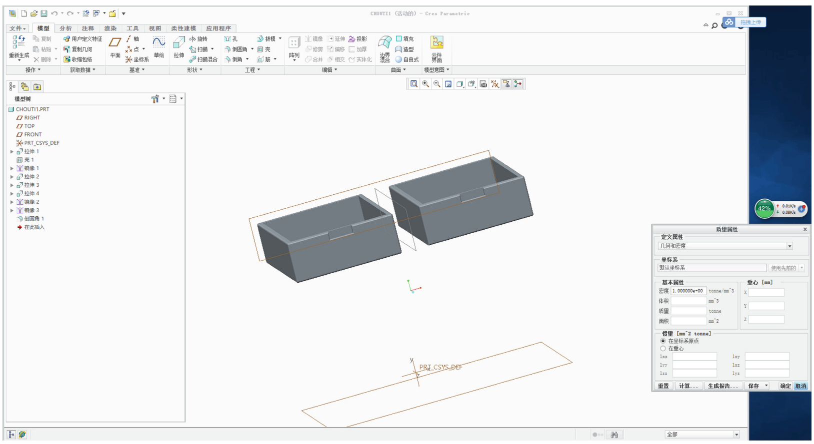

Fig. 3. Set material density in Creo

With the powerful analysis function of Creo, you can automatically calculate the quality of the chest of drawer and find the center of gravity of the chest of drawer. The operation method is to find the mass attribute in the analysis menu of the toolbar, select the feature, and click preview. At this time, the volume, mass, and average density of the model are automatically calculated. Then click the feature, check the centroid point, and click Finish. The center of gravity of the model is now displayed. The analysis results show that the center of gravity of the designed chest of drawer is lower. This result is exactly what we expected, because the lower the center of gravity, the better the stability of the chest of drawer and the more difficult it will fall.

5.2 Mechanical Calculation of the Chest of Drawer Stability

The national standard specifies the inspection method for vertical load stability of moving parts of cabinet furniture as outlined below.

Lean the block on the outside of the front foot of the test piece, and open the sliding test parts such as sliding door, drawer, and flip door in order according to the following rules, and apply the force vertically to these parts, and then gradually increase to the point where at least one foot of the opposite two feet is raised off the ground, and record the actual applied force in Newton.

The open states and afterburner positions of sliding doors, drawers, flip doors and shelves are: (1) Sliding doors: open to 90°, the middle part of the upper edge of the door 50 mm away from the side edge of the door handle. (2) Drawers: Pull out two-thirds, the middle part of the drawer panel; (3) Flip doors and shelves: in a horizontal or near-horizontal state, 50 mm from the front of the door or shelf. During the test, the moving parts that are not tested shall be closed (as shown in Fig. 4).

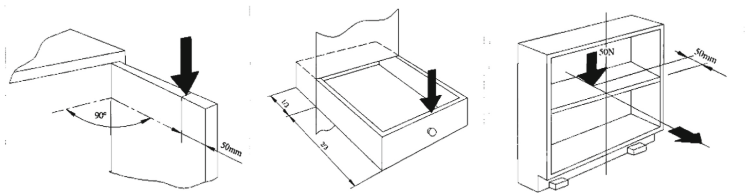

Fig. 4. Sliding door, drawer, shelf vertical loading stability

According to the national standard, when the force applied to the drawer is 150 N or the force on the sliding door is 100 N, the furniture does not tip over, the product is qualified. The chest of drawer designed in this article only has a drawer and no other structure such as a sliding door, so it only needs to detect the force applied to the drawer.

According to the detection method specified by the national standard, two thirds of a drawer is opened, and the other drawers are kept closed. A force F is applied along the middle part of the opened drawer panel, and the critical point is used for force analysis. When just overturning, the two front feet of the chest of drawer are supported by the ground at this time, and the two rear feet are just away from the ground without force. At the same time, the chest of drawer is subjected to gravity. Take the front feet of the chest of drawer as the origin of coordinates and establish a spatial coordinate system. The coordinate system and force analysis diagram are shown in Fig. 5.

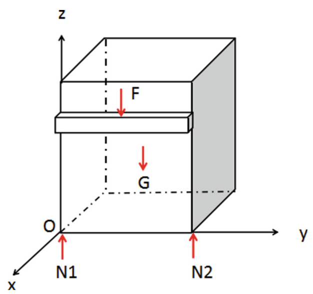

Fig. 5. Coordinate system and force analysis

The force analysis of the designed drawer is performed, and the equilibrium equation of the space force system is shown in Eq. 1.

$$\begin{cases} \sum F_{xi} = 0 \\ \sum F_{yi} = 0 \\ \sum F_{zi} = 0 \\ \sum m_x(F_i) = 0 \\ \sum m_y(F_i) = 0 \\ \sum m_z(F_i) = 0 \end{cases} \tag{1}$$

Calculate according to the equilibrium equation of the space force system, then the magnitude of the force F at the critical point can be obtained. If the obtained force F is more than 150 N, it means that the designed chest of drawer complies with national standards. The calculation process is as follows:

$$\sum F_{zi} = N_1 + N_2 - G - F = 0 \tag{2}$$

$$\sum m_y(F_i) = Fl_1 - Gl_2 = 0 \tag{3}$$

$$\sum m_x(F_i) = N_2 l_3 - F\frac{l_3}{2} - G\frac{l_3}{2} = 0 \tag{4}$$

Among them, L1 and L2 are the distances of F and G from the y axis, and L3 is the length of the chest of drawer. The value can be determined by the size of the designed drawer and the position of the center of gravity obtained by Creo analysis. The calculated result is F = 208.80 N, which is greater than 150 N, which proves that the designed chest of drawer meets national standards. Check the other drawers in turn as above, and found that they meet the requirements.

6 Summary

The chest of drawer should be different from ordinary adult furniture in terms of shape and structure. The dimensions of the furniture should be designed strictly according to the size of children at different ages, the appearance design should meet the psychological and physiological characteristics of children [13]. By analyzing the development of the chest of drawers and the current market situation, it is concluded that there are still many problems in the chest of drawers market. The most important problem is the threat of falling easily similar to the IKEA Malm chest of drawer. In order to prevent this wardrobe defect from causing disasters Based on design concepts such as ergonomics and mechanical analysis, this article proposes to use Creo to build a 3D model, and to determine the center of gravity through a software stability virtual test. Finally, the stability of the model under the use of the scene is verified by mechanical calculations to optimize the design of the chest of drawer more scientifically.

It is hoped that the research on this subject will have a positive impact on the development and growth of the chest of drawer industry. At the same time, I hope that in the future, we can provide new design ideas for improving the safety of chest of drawer and incorporate more scientific basis into the design.

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Improved Design of Household Kitchen Waste Composting Machine Based on Human Factors Engineering

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Abstract. As an unavoidable part of family life, kitchen waste contains high moisture and organic matter, which is easy to rot and produce a bad smell. The use of household kitchen waste machine can be properly handled, into new resources, such as organic fertilizer. In consideration of the comfort of operation, the deodorization performance of composting, and the guarantee of efficiency, the modeling and structural design of household kitchen waste composting machine are improved to make the product more in line with the physiological and psychological characteristics of people.

Keywords: Kitchen waste · Composting · Human factors engineering

1 Introduction

The policy of household waste classification has been implemented in major cities [1], which is of great significance for reducing greenhouse gas emissions, slowing down the process of global warming, coping with national energy shortage and improving urban ecological environment. Different kinds of garbage have different characteristics and corresponding treatment methods. Therefore, after garbage classification, garbage can be classified for treatment, which can save resources and make energy reuse at the same time.

Among them, kitchen waste is an important part of household waste. Kitchen waste is the family. restaurants, canteens and other food units abandoned the residual food collectively. At present, about 40% of the municipal garbage in most countries in the world is kitchen waste [2]. With the improvement of people's living standards, the production of kitchen waste is on the rise year by year. Compared with developed countries, the proportion of kitchen waste in urban household garbage in China is too high [3]. The contents of organic matter in kitchen waste are higher, and the development and utilization value is higher, but it is perishable and produces odor. At the same time, high moisture content, inconvenient to collect and transport, improper treatment is easy to produce secondary pollutants; Moreover, the oil content is higher

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than other domestic wastes, which has a greater impact on the quality of resource-based products and needs to be properly handled [2].

Therefore, the research on the disposal of kitchen waste is extremely important.

2 The Principle and Present Situation of Kitchen Waste Composting Machine

The existing treatment technology is mainly harmless treatment technology, fertilizer treatment technology, feed treatment technology and energy treatment technology four categories of treatment methods [2]. Fertilizer treatment technology is a relatively mature treatment technology at present, and feed treatment technology has gradually started engineering application, while energy treatment technology is the future development direction, the latter two need to invest more cost. Innocuous treatment is mainly pulverized straight discharge and bury, to the environment pollution is larger. Fertilizer treatment includes aerobic composting, anaerobic fermentation, earthworm composting, container composting and other methods. Because of simple treatment method and ability to make fertilizer and feed, Aerobic composting has attracted more attention.

Aerobic composting is to decompose organic solids in the raw material into soluble organic matter by secreting extracellular enzymes and then penetrate into microbial cells to participate in metabolism under aerobic conditions, so as to realize the transformation of raw material into humus and finally achieve maturity and stability and become organic fertilizer [4]. In the aerobic composting of kitchen waste, the added kitchen waste should be screened and pretreated, and the ventilation and agitation should be controlled at the same time. At present, aerobic composting of kitchen waste is developing towards miniaturization, mobility and specialization [2].

Here is a practical case of kitchen waste composting processor. Based on the principle of DANO roller, Guangdong Modern Agricultural Equipment Research institute independently developed the non-power composting tank for kitchen waste, and then improved it into the air-box composting machine for kitchen waste [5]. The main structure includes horizontal stirring shaft, heat preservation and heating device, aeration box for aerated ventilation, deodorization system, single chip microcomputer, universal wheel with tightening mechanism and fuselage shell. Now, the air-box type kitchen waste composting machine has been tried out in institute community of Guangdong province Modern Agricultural Equipment and Shengshi village, Zhongshan.

3 The Deficiency of Household Kitchen Waste Composting Machine

The main shortcomings of the existing kitchen waste composting machine are as follows: 1) from the perspective of aesthetics, the fuselage is bulky and not beautiful, the material is single, the screen printing is simple, without sense of science and technology; 2) from the perspective of economy, there is no systematic industrial design, and the airframe cost is relatively high, leading to the difficulty in promotion; 3) from the perspective of practical functions, there are odors and intractable stains in the use process.

Therefore, clean and beautiful, deodorization and cost reduction are the key points in improving the design, which can help build users' good impression on the compost machine (Fig. 1).

Fig. 1. The picture shows the design before improvement.

4 Improved Design of Household Kitchen Waste Composting Machine Based on Human Factors

4.1 Size

The composting machine for household kitchen waste is 560 mm wide, 380 mm deep, 635 mm high and no more than 1010 mm high after opening the cover. According to <Human Dimensions of Chinese Adults> [6], the 1th percentile of the functional hand height (axis of grip) and the shoulder height of 18 to 60 years old male is 656 mm and 1244 mm respectively, the 1th percentile of the functional hand height (axis of grip) and the shoulder height of 18 to 60 years old female is 630 mm and 1166 mm respectively. so man can be easily open and close the cover of the machine operation, young or old, there will be no discomfort with hands above shoulders, effectively prevent injuries [6].

This form is flat, effectively distinguishing it from other bulky square garbage processors, giving a new feel to the form and making it easier to use. And also conveniently placed in the corner of the space. The cover is made of frosted plastic and the body is made of stainless-steel plate, which can effectively reduce the cost and increase the durability.

4.2 Interactive Panel

The size of the panel is 160 mm*80 mm, and the size of the keys is 20 mm*20 mm. The median of the index finger width of male adults is 19 mm, which is convenient for users to operate and not easy to press by mistake. The design of the interaction should pay attention to fault tolerance, and minimize the user's thinking, can be simple operation, so the interface design only three keys, "switch" "dehumidification" "deodorization".

Because most of the user of the family composting machine isn't professional, it provides the rational humidity, temperature numerical reference on the screen, at the same time, with "too wet", "too smelly" two indicator lights to remind the user to carry out the corresponding operation.

4.3 The Human-Computer Interaction

The man-machine interaction between the user and the machine is mainly embodied in the process of handling the machine, opening and closing the cover, replacing the deodorizer and so on.

Plastic accessory handles are designed on both sides of the fuselage to reduce costs by using manufactured standard parts. With the universal wheel at the bottom, it is convenient for users to place the composting machine.

The product semantics of the cover arc can guide the user to lift the cover up, because the user is mostly right-handed, the common situation is the right hand to carry out the garbage, the left hand to open the cover, the operation panel is placed on the left side of the machine, so as not to dirty the table.

The deodorization system is mainly composed of devices containing water and wood chips, which need to be replaced regularly. Then the corresponding disassembly device is designed for the fuselage, which can be easily removed by using the buckle, without affecting the durability of the whole machine. The length of the disassembly part is 300 mm, the height is 600 mm, and the steel plate is 3 mm thick. The weight of a single plate is acceptable. The opening hole width of the plastic clip for disassembly is 26.5 mm and the length is 39.5 mm, which conforms to the design of human factors engineering.

4.4 Practical Function

The thickness of the cover is 20 mm, which can play an effective insulation effect. But the arc design makes the whole machine not too heavy and rigid.

4.5 Decoration Design

Fuselage cover integral design, color selection household appliances commonly used light gray, the whole machine more integration, home appliances, science and technology, in the white household appliances do not appear abrupt. It is also beneficial for subsequent update iterations.

The cover is made of matte plastic and covered with silk-screen printing to remind the user which kitchen waste can be put in and which kitchen waste cannot. It is more solid, beautiful and neat than the previous sticker, and can also improve the sense of quality.

The use of stainless steel stamping body texture, do not increase too much cost at the same time, improve the sense of quality, sense of science and technology (Fig. 2).

Fig. 2. The picture shows the shape after the design

5 Conclusion

This paper introduces the development status and principle of kitchen waste composting, and USES the knowledge of human factors engineering to improve the design of the family kitchen waste composting machine, making up for the shortcomings of the previous design. This design focuses on the design of the body and cover, making the composting machine easier to use, more beautiful appearance, lower cost. This design meets the market demand for garbage classification

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The Evaluation on Visual Fatigue and Comfort Between the VR HMD and the iPad

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Abstract. In the same indoor lighting conditions, we compared the differences on visual fatigue, comfort and visual function between before and after viewing the same video on VR and iPad display. The test task is to watch the same cartoon, and the test time for each condition is 40 min. The main measures indexes include critical fusion frequency, contrast sensitivity, diopter, accommodation response and visual fatigue and comfort perception scale, etc. The subjects are students aged 9–15. The results show that there is significant difference on critical fusion frequency index between the VR HMD and the iPad, which the decline range of CFF by viewing the video on the VR HMD is more than that of viewing it on the iPad, indicating that the use of VR HMD has a greater impact on users' ability to identify critical fusion frequency than that of iPad. However, there are no significant differences on objective visual fatigue, comfort, diopter and accommodation response, contrast sensitivity and so on, which are compared between the two samples and before and after viewing the cartoon. The results demonstrate that there are a lot of developments in the technology of VR devices, and their effects on users' visual fatigue and visual function are getting less and less, but there is still a certain distance between the VR HMD and tablet computer in some aspects.

Keywords: VR HMD · iPad · CFF · Visual fatigue · Comfort · EEG

1 Introduction

With the development of technology, electronic Display terminals(Video Display Terminal) including mobile phones, tablets, televisions, VR glasses, tutor machines have been widely used in study and life of teenagers, the electronic Display Terminal have brought convenience and efficiency for teachers, parents and students, but also produced some of the students eye-using healthy problems. Teenagers are in the critical period of the growth and development of each organ of the body, and the extension of the eye ball wall is large, which is easily affected by eye hygiene habits and external environmental factors. In particular, parents are very worried about the impact of watching mobile phones and Pad products on children's myopia for a long time in China. However, some people speculate that VR products have remote vision function

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according to VR principle, which may have certain effect on reducing myopia of teenagers.

Some researchers used the visual perception training platform based on virtual reality to train the patients with myopic anisometropia amblyopia for one year, the patients' visual acuity improved significantly and the fine stereoscopic vision defect was improved. Although the fine stereoscopic vision of the sighted people is still different from that of the normal population, it can be proved that the visual perception training platform based on virtual reality has clinical application value in the treatment of patients with myopic anisometropia amblyopia [1]. Some researchers also watch outdoor scenes simulated by VR technology, which can effectively mobilize the stretching and relaxation of the ciliary muscle of the children under test and improve the ciliary muscle regulation. The results show that the technique has the function of ciliary muscle exercise, the function of modulating and relieving ciliary muscle spasm, and the function of preventing the development of myopia [2].

In recent years, many companies have also been thinking about whether VR products can be used for vision training to correct myopia, or VR tools can be used for education or learning, to make up for the shortage of mobile phones, pads and other devices that are mainly used for close viewing and lack of the adjustment of far sighting. However, there is no clear research conclusion on whether the effects of learning or entertainment using VR products on vision and visual function are consistent with the effects of looking at mobile phones or tablets on vision and visual function.

In this study, it was tested if the mobile head display devices have advantages in reducing visual fatigue by comparing VR mobile head display device with iPad under the same environment. It will not only provide experimental data support for the promotion and application of VR device, but also provide data support and reference for setting their single-use time.

2 Methods

2.1 Experimental Design

In this study, two different types of display samples are selected, one of which is a VR HMD produced by Chinese company; the other is compared with the iPad 6 manufactured by Apple Inc, the information of the two samples is as follows. And the evaluation indicators included in accommodation response, diopter, visual fatigue, critical fusion frequency, contrast sensitivity and so on (Table 1).

Table 1. Model and conditions of experimental samples

	Screen intensity	Contrast ratio	Remarks
VR HMD		>1000:1	Field angle: 53°
Tablet	39.52(3.21–84.55)	26.27	

2.2 Subjects

15 students with normal vision or corrected vision aged 9–15 participated in the experiment, including 11 boys and 4 girls, with an average age of 11.2 years old which its standard deviation is 1.26.

2.3 Apparatus

Critical Fusion Frequency Meter: The test rang of the critical fusion frequency meter is 4.0 Hz–60.0 Hz, adjustable in 0.1 Hz, and its error is less than 0.1 Hz. The blue and yellow color light was selected.

Visual Function Tester: The Bayesian threshold measurement theory was used to evaluate the contrast sensitivity in the visual function tester with the measurement accuracy of $\pm$ 2DB.

Refractometer: The accommodation response and diopter data were collected by the NIDEK ARK-1S refractometer.

2.4 Procedure

The experiment was the conducted in the daily environment with 300 lux illumination. Firstly, the subjects were selected by means of visual acuity chart and stereopsis, and the subjects who were not suitable for the experiment were excluded. Secondly, the subjects were introduced to the purpose and content of the experiment. The subjects filled in the informed consent and the pre-test visual fatigue questionnaire, and conducted the critical fusion frequency, optometry and the contrast sensitivity testing. Then, the subjects entered the formal experimental procedure, and watched the 40-min 2D video played on the mobile head display and iPad, which the play sequence was balanced between different conditions. The 2D video named Crazy Animal City. During viewing the video, the CFF was checked every 10 min. After watching the video, the critical fusion frequency, contrast sensitivity, optometry and visual fatigue were tested again. At the end of the test, the subjects were paid a certain reward for his/her participation.

2.5 Data Analysis

The changes value of visual fatigue and comfort data was analyzed by IBM SPSS 20 Statistics software (IBM-SPSS Inc. Chicago, IL). The method of repeated-measure ANOVA analysis and t test were applied to the experiment data.

3 Results and Analysis

3.1 Critical Fusion Frequency Results

The critical fusion frequency difference of two different devices during watching video was shown in Fig. 1. The results showed that the decrease of critical fusion frequency of VR HMD was significantly greater than that of iPad both in the blue and yellow light, which indicated that watching the video on VR HMD will cause easily visual fatigue. As time went on, the critical fusion frequency of watching VR HMD generally showed a downward trend both in the blue and yellow light, which was reversed in after about 30 min in the blue light, and continued to decrease after 40 min. The critical fusion frequency of watching iPad also showed an overall downward trend, with a large reversal about 20 min after watching in blue light, and a further downward trend about after watching 30 min. The critical fusion frequency after 40-min viewing task on the two samples, the subjects produced a certain degree of visual fatigue. During the test, both samples were reversed to a certain extent both in blue light index, which may indicate that the users showed increased brain arousal during the process of watching by the blue light. On the whole, the reduction of critical fusion of VR HMD is slightly greater than that of iPad, indicating that the fatigue degree of VR HMD is slightly greater than that of iPad.

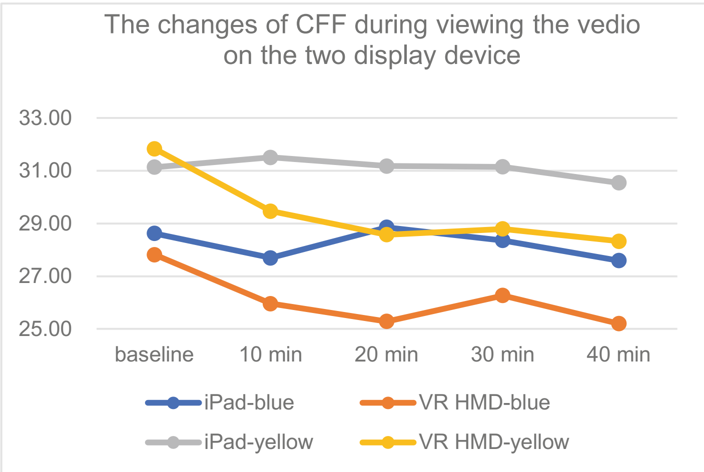

Fig. 1. The changes of the critical fusion frequency during viewing the video on the two display device (the blue light and the yellow light)

With regard to the CFF of the blue light, a repeated-measure ANOVA was applied on the CFF data of the blue light of the different viewing time periods, a significant main effect of the two samples was found ($F\ (1,2) = 123.60$, $p < 0.001$), the main effect of viewing time was significant($F(1,4) = 5.42$, < 0.01, and there was significant interaction, $F(1,10) = 3.50$, $p < 0.05$. The post-hoc test results showed that the measured value of CFF every 10 min was significantly different from the baseline (*p*s < 0.05), and the difference among the CFF data after watching 10, 20, 30 and 40 min was not significantly different, indicating that watching the animation for 10 min may cause visual fatigue. The matching T test results about the CFF data of two samples showed that the difference of the two samples in the baseline period was not significant, but after viewing10 min, 20 min, 30 min and 40 min, the CFF data of the two samples produced the significant differences (*p*s < 0.01), which indicated the CFF baseline data of the two samples was similar, but after viewing 10 min the significant difference has showed between the two samples, and watching on the VR HMD led to a more serious visual fatigue.

With regard to the CFF of the yellow light, a same repeated-measure ANOVA was applied on the CFF data of the yellow light of the different viewing time periods, a significant main effect of the two samples was found ($F\ (1{,}2) = 15.27$, $p < 0.01$), the main effect of viewing time was significant ($F(1{,}4) = 4.58$, $p < 0.01$), and the interaction of samples and the time was significant, $F(1{,}10) = 3.91$,$p < 0.05$. The post-hoc test results showed that the CFF data after 10-min viewing was not significantly different from the baseline (*p*s < 0.05), but the differences between the CFF data of baseline and that of after viewing 20, 30 and 40 min were obvious (*p*s < 0.05), and the difference among the CFF data after watching 10, 20, 30 and 40 min was not significantly different, indicating that watching the animation for more than 20 min may cause visual yellow light fatigue. The matching T test results about the CFF data of two samples showed that the difference of the two samples in the baseline period was not significant, but after viewing10 min, 20 min, 30 min and 40 min, the CFF data of the two samples produced the significant differences (*p*s < 0.01), which indicated the CFF baseline data of the two samples was similar, but after viewing 10 min the significant difference has showed between the two samples, and watching on the VR HMD led to a more serious visual fatigue.

According the above results, the same decreases of CFF have showed by viewing the blue and yellow lights, and the CFF decrease time of the blue light was 10 min late, but the CFF decrease time of the yellow light was 20 min late. The results showed that the visual fatigue of the two samples was obvious, and the CFF decrease of viewing on the VR HMD was greater than that of viewing on the iPad.

3.2 Contrast Sensitivity Results

A repeated-measure ANOVA was conducted on the contrast sensitivity data of the baseline and the two samples with spatial frequencies of 1.5C/D,3C/D,6C/D,12C/D and 18C/D. a significant main effect of the two samples and the baseline was found ($F\ (1{,}3) = 29.78$, $p < 0.001$), the main effect of viewing time was significant ($F\ (1{,}2) = 6.54$, $p < 0.01$), and the interaction of test conditions and the time was significant, $F(1{,}6) = 1.90$, $p = 0.051$. The post-hoc test results of the two samples showed that there was no significant difference between the contrast sensitivity data of the two samples.

3.3 Diopter

The results of descriptive statistics of left eye diopter showed that subjects using VR HMD ($M = -0.51$, $SD = 0.92$) and using iPad ($M = -0.53$, $SD = 0.97$) had little difference. The results of paired sample t-test of subjects' diopters after completing the task on VR HMD and iPad showed that there was no significant difference between the diopter data of the two samples.

3.4 Accommodation Response

The results of descriptive statistics of left and right accommodation responses showed that there was no significant difference in the accommodation response of subjects using VR HMD (M = 8.01, SD = 2.12) and using iPad (M = 8.09, SD = 1.48). The results of paired sample t test of the accommodation response after using VR HMD and iPad to complete the task showed that there was no significant difference between them.

3.5 Visual Fatigue

Statistical results showed that both samples produced a certain degree of eye strain and headache after viewing 40 min. The results of visual fatigue before and after using two samples to watch videos showed that watching VR HMD would affect more about the eye strain and headache, and watching the iPad would affect more about eye dryness. The results of Wilcoxon's sign rank test showed that there was no significant difference in fatigue degree between the two devices, indicating that there was no difference between the two devices in the primary perception of visual fatigue.

3.6 Visual Comfort

The statistical results show that the subjective feeling of comfort had produced slight change after viewing the two samples. The Wilcoxon sign rank test result show that the change of comfort perception between the two devices is not significant, only the comfort of the brightness-contrast perception has a significant edge difference ($p = 0.066 < 0.1$), the brightness-contrast perception of VR HMD decreases slightly (M = −3.75, SD = 7.18), and the brightness-contrast perception of iPad has little change (M = −3.75, SD = 0.27).

4 Conclusion

In this study, after viewing the video for 40 min on the two samples, some visual fatigue performance, such as eye strain and headache symptom had produced on the subjects, and the CFF had declined in the two samples, but in the indexes of the contrast sensitivity, comfort, visual fatigue, diopter and accommodation response there was no significant differences. However, as far as critical fusion frequency is concerned, the same decreases of CFF of viewing the video have showed by viewing the blue and yellow lights, and the CFF decrease time of the blue light was 10 min late, but the CFF decrease time of the yellow light was 20 min late. The visual fatigue of the two samples was obvious, which the CFF decrease of viewing on the VR HMD was greater than that of viewing on the iPad, indicating that the visual fatigue caused by watching VR HMD is more serious than that of iPad. And it has not been verified that viewing the video on the VR HMD had better function on reducing the visual fatigue and enhancing the visual function than viewing the video on the iPad. In general, although the effect of watching VR HMD on the visual fatigue is not as serious as expected, its effect is far from achieving the improvement of vision and visual function, which may be related to the technical development of VR HMD. VR technology is currently in the process of continuous development, and we hope to see more better and comfortable VR HMD products in the near future.

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Risk Assessment and Injury Prevention

The Indoor Thermal Environment in Fencing Halls: Assessment of the Environmental Conditions Through an Objective and Subjective Approach

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Abstract. As the importance of sport practice is currently growing, the evaluation of the environmental parameters and especially of the thermal conditions in sport halls is particularly relevant, since they can affect the health and performance of the athletes. In particular, as a lack of studies has been detected and current standards are missing a scientific base for the determination of the environmental parameters, a methodology for assessing the indoor thermal environment in fencing halls has been provided, starting from a case study. This research leads also to preliminary results obtained through objective and subjective measurements and lays the groundwork for future studies.

Keywords: Indoor environmental quality · Thermal environment · Thermal comfort · Sport facilities · Fencing halls

1 Introduction

In recent times, sport participation is increasingly growing, thus providing sport facilities with high environmental quality is getting more and more relevant. In particular, the thermal environment can play a key role in these spaces, as during sport practice the heat production of the body can reach high values, rising the body temperature [1]. Moreover, the increase of the heat storage affects the athletic performance due to heat exhaustion and overheating. The dissipation of the exceeding heat can be obtained through the thermoregulatory system, which includes mechanisms such as vasodilation and sweat [2]. Even if training can improve the thermoregulatory system, in some environments it may not be sufficient to dissipate heat [3], thus health and performance problems can occur.

For these reasons, the scientific community is focusing on ensuring comfort in these spaces. However, only few studies have been carried out on the determination of thermal comfort in sport facilities. In particular, most studies were applying Fanger's indices Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD), obtained through field measurements [4–8] or were studying the perception of the

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thermal environment through a subjective approach [7, 9–11]. Considering the existing regulations, it can be noticed that they are very heterogeneous and they are not usually completed by a solid scientific base providing the methods used for the determination of the environmental conditions. In fact, only few indications are given by the International Olympic Committee (IOC) and by Sports Federations. In particular, the International Fencing Federation (FIE) does not specify information regarding the environmental conditions that can ensure comfort and health of the athletes [12].

The aim of this paper is to provide a scientific base for the evaluation of thermal conditions in fencing halls, which is currently lacking, using a methodology developed comparing objective and subjective approaches in a case study. Preliminary results based on objective and subjective measurements show the environmental parameters that should be maintained in fencing halls. These results are fundamental, as environmental conditions have great influence on athletes' health, also considering that fencers cannot adapt their conditions by removing or picking appropriate garments, as they wear a standardized uniform according to FIE's regulations.

2 Methods

The methodology applied consists of a comparison between objective and subjective measurements, as showed in the following sections.

2.1 The Case Study

The case study considered for this investigation was the fencing hall "Club Scherma Pisa Antonio di Ciolo" located in Pisa, Italy. In this case, it was possible to work with professional fencers, as this Club can be considered a pillar of the national and international fencing, which gave birth to champions such as Alessandro Puccini, Salvatore Sanzo and Simone Vanni. This is particularly important, since at professional competitive level the environmental factors may play a key role in the performance of the athletes.

The fencing hall presents a rectangular area of 390 m^2, with a ridge height of 5.90 m, while the changing rooms and all the technical rooms are located outside the structure (Fig. 1). The building envelope is characterized by a structure composed by laminated wood beams and steel columns, covered with a single membrane PVC on the walls and a double membrane on the roof.

The investigation was carried out during spring 2019 and included both objective and subjective measurements. After a primary characterization of the thermal environment, which consisted of air temperature and relative humidity measurements in different parts of the fencing hall, all the environmental parameters (air temperature, relative humidity, mean radiant temperature and air velocity) have been detected and the individual parameters (clothing insulation and metabolic rate) evaluated. The monitoring duration was 8 days, divided in three different weeks, from 19:00 to 21:00, when adult athletes were fencing. At the end of the trainings (21:00), the questionnaires were submitted. During the campaign, 200 questionnaires have been provided to the athletes.

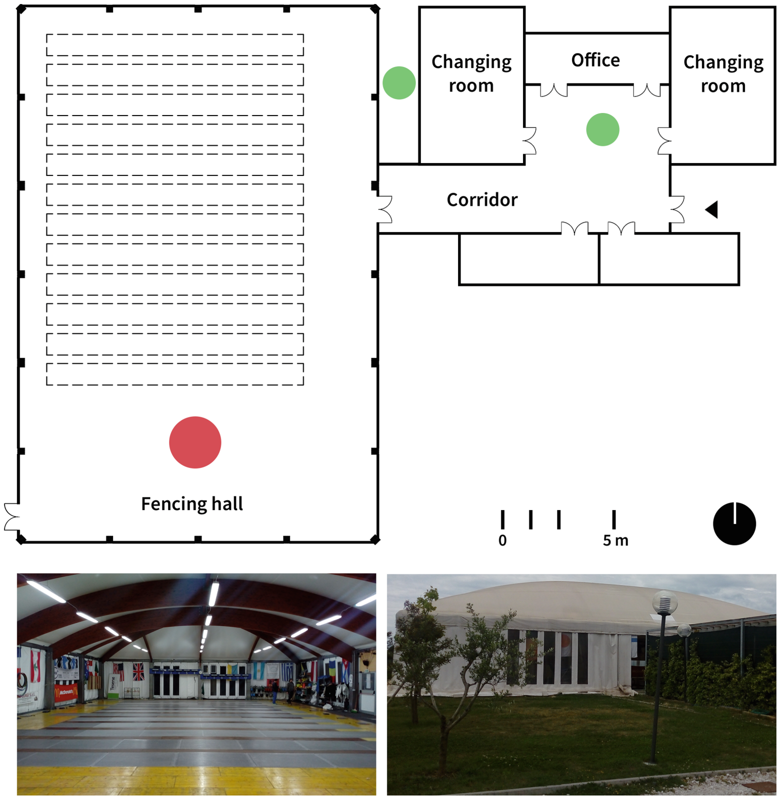

Fig. 1. Position of the probes in the fencing hall (above): in red, the microclimate data logger, while in green the air temperature and relative humidity data loggers. Internal (below, left) and external (below, right) view of the fencing hall.

2.2 Objective Measurements

The thermal environment can be determined through an objective approach according to different methodologies, corresponding to three Classes [13]. In this case, a Class II field study has been carried out and a Microclimate Data Logger DeltaOhm HD 32.3 was used to record simultaneously the four environmental parameters (air temperature t_a, relative humidity RH, mean radiant temperature t_r and air velocity v_a) [14]. Furthermore, values of air temperature and relative humidity have been detected in the corridor and outdoors with PCE – HT110 probe [15]. The position of the probes measuring environmental parameters is shown in Fig. 1. In general, dataloggers measuring environmental parameters are located close to the positions occupied by people, or in the center of the hall. However, there is to notice that in sport facilities locating the probes is more difficult as they may interfere with the activities carried out. In the case of fencing halls, we recommend to place the probes as close as possible to the fencing pistes and in any case far from walls, windows, etc. Values of temperature and relative humidity were also recorded in the corridor and outdoors (Fig. 1). For the evaluation of the individual parameters (I_{cl}, M), the thermal insulation of the fencing uniform was provided by specific studies [16], while the metabolic rate was estimated specifically for the sport of fencing [17].

2.3 Subjective Measurements

The questionnaires were submitted at the end of the trainings (21:00) to all the adult athletes. Adults were asked to answer the following questions:

1. General information (age, gender, date, time);
2. Thermal sensation on ASHRAE's 7-points scale, from −3 (cold) to +3 (hot);
3. Thermal comfort expressed on the evaluative scale from 0 (comfort) to 4 (much discomfort);
4. Thermal preference expressed on a 7-points scale from −3 (much colder) to +3 (much warmer).

Questionnaires were validated observing the congruence between the answers. The subjective response was evaluated through the Thermal Sensation Vote (TSV), which can be deduced from the thermal sensation scale and through the Percentage of Dissatisfied (PD) that can be obtained from the evaluative scale. Athletes were considered dissatisfied when they were expressing 3 or 4 on the thermal comfort scale.

3 Results

Considering the thermal environment as a function of the six basic parameters (air temperature, relative humidity, air velocity, mean radiant temperature, clothing insulation and metabolic rate) measured through an objective approach, these parameters and the response of the questionnaires (TSV and PD) have to be compared.

Table 1 reports the mean value of the parameters measured from 19:00 to 21:00, when athletes were training and the subjective response obtained through questionnaires.

Table 1. Mean values of environmental parameters recorded during the measurement campaign, individual parameters evaluated for fencers and subjective response obtained through questionnaires.

Environmental parameters				Individual parameters		Subjective response	
t_a (°C)	RH (%)	t_r (°C)	v_a (°C)	I_{cl} (clo)	M (met)	TSV	PD
15.7	77	15.7	0.01	0.82	6	0.48	11%
17.5	75	17.5	0.01	0.82	6	0.60	30%
18.6	55	18.6	0.01	0.82	6	0.80	20%
13.7	62	13.7	0.01	0.82	6	−0.75	38%
15.4	60	15.4	0.01	0.82	6	−0.42	15%
14.3	52	14.3	0.01	0.82	6	−0.50	21%
16.5	57	16.5	0.01	0.82	6	−0.11	17%
14.9	47	14.9	0.01	0.82	6	−0.43	39%

4 Discussion

Sport facilities can be very heterogeneous, therefore specific standards identifying the environmental parameters that should be maintained in these buildings are often provided. However, it lacks a scientific base concerning these issues, especially for the sport of fencing [2].

Preliminary results can be obtained considering fixed the values of metabolic rate (6 Met), clothing insulation (0.82 Clo), air velocity (0.01 m/s) and the mean radiant temperature equal to the air temperature (no radiant asymmetry). It results that the only environmental parameters changing are: air temperature (t_a) and relative humidity (RH). Figure 2 shows the relationship between the Thermal Sensation Vote (TSV) and these two parameters. A good correlation ($R^2 = 0.80$) between TSV and air temperature can be noticed and expressed with the following equation:

$$TSV = 0.32 \cdot ta - 5.10 \tag{1}$$

There is instead no evident correlation between relative humidity and TSV ($R^2 = 0.25$), therefore a range of relative humidity between 40–60% was considered acceptable.

Then, supposing admissible a range of TSV between −0.5 and +0.5, according to ISO 7730 [18], Eq. (1) gives the values of temperature that should be maintained in fencing halls:

$t_{a,min}$ = 14.4 °C corresponding to a TSV = − 0.5

$t_{a,max}$ = 17.5 °C corresponding to a TSV = + 0.5

It is evident that the temperatures considered acceptable by athletes are much lower if compared with people in steady state conditions (M = 1 Met), due to the high metabolic rate of the fencers (M = 6 Met). Furthermore, it is important to notice that the campaign was carried out in the early spring, thus these temperatures can be considered valid for the colder seasons (autumn-winter-spring), while in summer acclimatization may occur and athletes could feel more comfortable with higher temperatures. These aspects should be further investigated.

Considering the relation between the thermal sensation vote (TSV) and the Percentage of Dissatisfied (PD) shown in Fig. 3, it can be noticed that the minimum Percentage of Dissatisfied is attested on sensations of warmth, showing that athletes accept better warm rather than cold sensations. Qualitatively, this fact can be contemplated considering the range of temperatures between 15 °C and 18 °C, which is more in accordance with the existing Italian National Olympic Committee (CONI) guidelines [19].

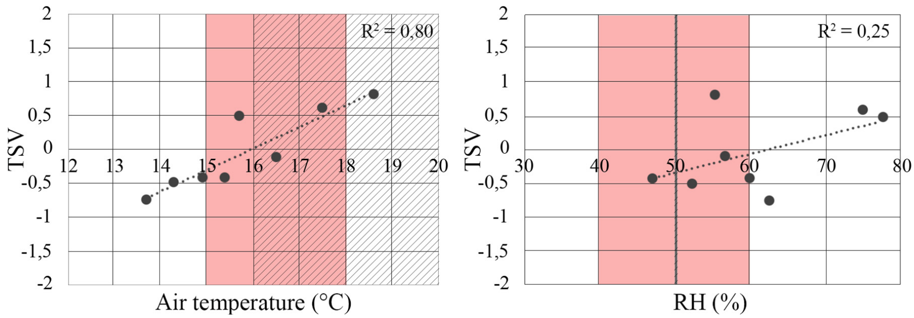

Fig. 2. Relationship between air temperature (t_a), relative humidity (RH) and thermal sensation vote (TSV). In red, the optimal range of air temperature (15–18°C) and relative humidity (40–60%) found for fencing halls. In grey lines, the range of air temperature (16–20°C) and the value of relative humidity (50%) recommended by the Italian National Olympic Committee (CONI) guidelines for sport facilities [19].

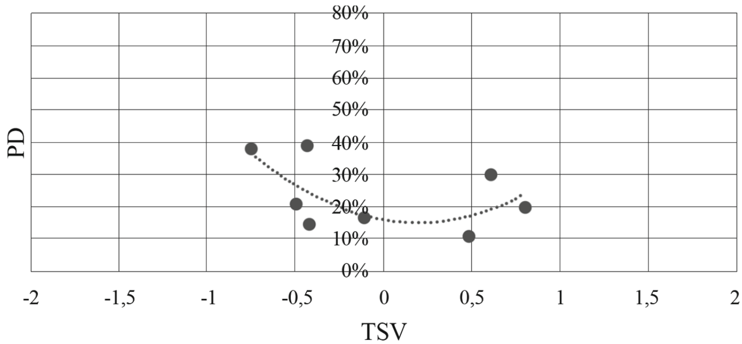

Fig. 3. Relationship between Thermal Sensation Vote (TSV) and Percentage of Dissatisfied (PD) of the fencers.

5 Conclusive Remarks

As the thermal conditions are particularly relevant in sport facilities, the evaluation of the environmental parameters that should be maintained in fencing halls is specifically important, also considering the lack of the existing standards. The methodology developed in this research is fundamental as it can be applied not only to the case study, but to all the fencing halls. This research also provides a scientific base for the definition of standards that could be adopted by the Fencing Federation and presents preliminary results showing the environmental parameters that should be maintained in fencing halls. Further studies to determine the four basic parameters (air temperature, relative humidity, mean radiant temperature and air velocity) ensuring thermal comfort in fencing should be developed in order to implement the guidelines of National and International Fencing Federations, regardless the kind of building in which this sport is performed.

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The Effects of Chemical Protective Clothing on Manual Dexterity

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Abstract. This study evaluated the effects of wearing chemical protective clothing on manual dexterity. In addition, this study tested whether the manual dexterity measured from the protective glove only can represent the manual dexterity for the full protective clothing. The results indicated that the completing time required for the bare hand, glove only, and full protective clothing settings were 45.97 ± 5.87, 127.36 ± 45.45, and 129.44 ± 48.77 s, respectively. Wearing protective device (glove only and full protective clothing) decrease the manual dexterity, however, no significant differences were found between these two settings. Therefore, the traditional way which uses the glove only to establish the dexterity data can be used for selection of the full chemical protective clothing to meet the dexterity requirements.

Keywords: Manual dexterity · Glove · Chemical protective clothing · Hand protection

1 Introduction

Chemical protective clothing is used to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered during hazardous materials operations [1]. One issue related to the physical limitations imposed by using protective clothing is the selection of gloves with appropriate manual dexterity when tasks require repetitive motions. Wearing protective clothing with gloves may impair hand performances such as manual dexterity, tactile sensitivity, range of motions and strength capabilities [2, 3]. Manual dexterity is defined as the ability to make coordinated hand and finger movements in handling objects such as grasp and manipulate objects [4]. In most ergonomics studies, manual dexterity is quantified and measured based on the time or the error rates it takes to complete a task [2]. Less time and fewer errors imply better manual dexterity. The tests used to assessed manual dexterity including Pegboard test [5–7], O'Conner finger dexterity test [8, 9], Bennet hand-tool dexterity test [10, 11], and Minnesota rate of manipulation-turning test [12], etc. Published results indicate that gloved hands decrease manual dexterity by increasing the time needed to complete the task or number of errors [2]. When performing a nut-bolt-washer assembly-disassembly task, three types of gloves increased the average completion

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time by 15 to 37% compared to bare hand [11]. The manual dexterity was also found decreased nearly linearly with increase in the glove thickness [13, 14]. The reduced performance on manual dexterity may be due to reduced inter-digital movements, range of motion and tactile sensitivity [15], poor contact and poor fit [2], etc. This study evaluated the effects of wearing chemical protective clothing on manual dexterity. The purpose is to test whether the manual dexterity measured for "protective glove only" condition can represent the manual dexterity measured for "full protective clothing" condition. Then, the time required to test manual dexterity for the full protective clothing could be reduced since it will not be necessary to wear full protective clothing for testing the manual dexterity.

2 Methods

2.1 Subjects

Twelve male volunteers free of musculoskeletal disorders/injuries (MSDs) in the upper extremities comprised the subject pool. The subject's free of MSDs status in the upper extremities was identified through interviewing during the recruiting process. All these subjects are right handed. The mean values of age, height, hand length and maximum breadth of hand for the subjects are 24.3 ± 1.4 years, 172.1 ± 7.4 cm, 108.2 ± 6.2 mm, and 99.0 ± 4.2 mm, respectively. Thirty-four hand and forearm dimensions [16] were recorded for each subject. The dimensions measured at the thumb included fingertip to knuckle, 1st joint to root, breadth at first joint, and depth at tip. The dimensions measured at the digits included fingertip to root, 1st joint to root, 2nd joint to root, depth at tip, breadth at first joint, and breadth at second joint. In addition, maximum breadth of hand, length of hand, breadth at knuckles, depth at knuckles, circumference of hand, and circumference of forearm were measured for each subject.

2.2 Pegboard Test and Protective Clothing

Manual dexterity was measured as the time to complete 25 pins pegboard test (Fig. 1). The pins were first placed in the groove, then, the subjects picked up the pin and placed the pin into the pinholes. The placing order is from left to right and up to down. The experiments were repeated three times for each level. Level C chemical protective clothing (size L) made of plastic fabric coated with neoprene material on both sides was adopted for simulation. Figure 2 shows a subject performing the pegboard test when wearing full chemical protective clothing.

2.3 Experimental Design and Statistical Analysis

The independent variable in this experiment is protective clothing with three levels including bare hand (no protective clothing), wearing protective glove only, and wearing full chemical protective clothing (with glove). The dependent variable is manual dexterity measured as the time to complete the 25 pins pegboard test.

Analyses of variance (ANOVA) with repeated measures were used to evaluate the effects protective clothing on hand dexterity. Stepwise regression with "forward selection" and "backward elimination" approaches were also used to formulate functions to predict manual dexterity from 34 hand and forearm anthropometric dimensions and age, weight, and height of the subjects. All data were analyzed for statistical significance at $p \leq 0.05$ using the SPSS 12 (SPSS Inc., Chicago, Illinois) statistical software.

Fig. 1. 25 pins pegboard

Fig. 2. Pegboard test with full chemical protective clothing

3 Results

The average completion time for the 12 male subjects under bare hand, protective glove and full protective clothing conditions are 45.97 ± 5.87, 127.36 ± 45.45 and 129.44 ± 48.77 s, respectively (Table 1). The repeated-measured ANOVA results (Table 2) indicate that there is a statistically significant “protective clothing” effect on manual dexterity ($F = 84.88$, $p < 0.001$). The LSD post hoc analysis results (Table 3) show that the completion time for the bare hand is shorter than the other two conditions. No completion time differences were found between “wearing protective glove only” and “wearing full chemical protective clothing (with glove)” conditions.

Table 1. Completion time (in seconds) for performing pegboard test for 12 male subjects

Protective clothing	Completion time (s)
Bare hand	45.97 ± 5.87
Protective glove	127.36 ± 45.45
Full chemical protective clothing	129.44 ± 48.77

Table 2. Repeated measures ANOVA results for the effects of protective clothing on manual dexterity

Source of Variation	SS	d.f.	MS	F ratio	Sig.
Protective Clothing	163153.241	2	81576.620	84.884	0.000
Error	67272.759	70	961.039		

Table 3. LSD post hoc analysis results for the effects of protective clothing on manual dexterity

(I) Dexterity	(J) Dexterity	Mean Difference (I-J)	Std. error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	−81.389	8.459	0.000	−98.635	−64.143
	3	−83.472	8.434	0.000	−100.595	−66.35
2	1	81.389	8.459	0.000	64.143	98.635
	3	−2.083	4.107	0.615	−10.421	6.255
3	1	83.472	8.434	0.000	66.35	100.595
	2	2.083	4.107	0.615	−6.255	10.421

1: bare hand; 2: protective glove; 3: liill chemical protective clothing

Stepwise regression with “forward selection” and “backward elimination” approaches were used to formulate functions to estimate manual dexterity from 34 hand and forearm anthropometric dimensions. For the barehanded condition, ten fitted final models were created by both approaches. Table 4 shows the final model selected by this study with the highest adjusted R^2 value (0.708). The predicting variables included in this selected model are depth at knuckles, forearm length and circumference, wrist circumference, 2nd joint to root of 2nd and 3rd digits, and depth at tip and breast at 1st joint of thumb. For the protective glove only condition, sixteen fitted final models were created by both approaches. Table 4 shows the final model selected by this study with the highest adjusted R^2 value (0.834). The predicting variables included in this selected model are breadth and depth at knuckles, forearm length, wrist circumference, 2nd joint to root of 2nd and 3rd digits, and depth at tip, breast at 1st joint, and 1st joint to root of thumb. For the full chemical protective clothing condition, eight fitted final models were created by both approaches. Table 4 shows the final model selected by this study with the highest adjusted R^2 value (0.929). The predicting variables included in this selected model are breadth and depth at knuckles, forearm length and circumference, wrist circumference, 2nd joint to root of 2nd digits, breadth at 2nd joint of 3rd digits, and depth at tip, breast at 1st joint, and 1st joint to root of thumb.

Table 4. Parameters and anthropometric variables of manual dexterity predicting models

Protective clothing	**Manual dextery predicting model**												**Adjusted R^2**
	constant	Breadth at knuckles	Depth at knuckles	Forearm length	Forearm circumfe rence	Wrist circumfe rence	2nd digit: 2nd joint to root	3rd digit: 2nd joint to root	3rd digit: Breadth at 2nd joint	Thumb: Depth at tip	Thumb: Breadth at1st joint	Thumb: 1st joint to root	
1	-47.870	—	1.780	-0.360	-0.069	0.558	-0.549	0.667	—	1.650	1.762	—	0.708
2	-8.343	6.467	-15.393	4.908	—	7.054	8.512	-2.728	—	-19.158	-17.305	-8.261	0.834
3	-370.322	-6.135	-10.469	4.213	-0.15	11.142	-16.572	—	-4.549	-26.432	-14.045	-10.751	0.929

1: bare hand; 2: protective glove; 3: full chemical protective clothing

4 Discussions and Conclusions

This study found that the completing time of pegboard tests for bare hand, protective glove only, and full protective clothing settings were 45.97 ± 5.87, 127.36 ± 45.5, and 129.44 ± 48.77 s, respectively. The bare hand performs significantly better in manual dexterity than the other two settings. The results are in agreement with previous studies listed in Dianat et al.'s [2] review articles. Wearing protective clothing (glove only and full protective clothing) decrease manual dexterity, however, no significant differences were found between these two settings. Therefore, the traditional way which uses the protective glove only to establish the manual dexterity data can be used for selection of the full chemical protective clothing to meet the manual dexterity requirements. For future study, other factors such as glove material characteristics, glove thickness, and type and of protective clothing which were not evaluated in this study could be included to test their effects on manual dexterity.

The forward selection and backward elimination stepwise regression were used to select the model to predict manual dexterity using 37 anthropometric variables including 34 hand and forearm anthropometric variables and age, weight, and height of the subjects. The adjusted R^2 for the best models to predict the manual dexterity for the bare hand, protective glove only, and full protective clothing settings were 0.708, 0.834, and 0.929, respectively. It is interesting to find that both the models formulated for wearing protective clothing predict manual dexterity better than the bare hand model. In the future, the glove characteristics could also been added to test whether the predicting capabilities could be increased. The subjects use only the thumb and the 1st and 2nd digits to pick up the pins during the pegboard tests, therefore, the anthropometric dimensions measured of the 4th and 5th digits were not appeared in the models. The weight and height variables were also not seen in the final models since the pegboard tests could be categorized as light manual operation. In the future, the subject size could be expanded to include wider range of the hand and forearm dimensions. In addition, female subjects could also been recruited to evaluate the effects of gender on manual dexterity.

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Back and Shoulder Biomechanical Load in Curbside Waste Workers

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Abstract. Data from various countries (USA, Great Britain, Brazil, Italy, India, etc.) shows a significant prevalence and incidence of musculoskeletal disorders in kerbside waste collection workers. We investigated some biomechanical parameters of the task of pouring bins in collection kerb through 3DSSPP software. (v 7.0.6). Bins manual handling was investigated in four different operating modes: through 1) a lorry side window; 2) at the back of the lorry; 3) in a certified container; 4) in a non-certified container. 3DSSPP risk assessment showed that bin pouring implies a high level of biomechanical load in each of the four modes. The most dangerous mode was that in which the worker empties the bin directly into the back of the van (mode 2). 3DSSPP showed significant values of percentage of maximum voluntary contraction (%MVC) for trunk flexion (67% MVC), left shoulder abduction (30% MVC) and left wrist ulnar deviation (50% MVC). These values imply a low level of the maximum recommended exertion duty cycle (1% for trunk flexion, 3.2% for left wrist ulnar deviation). Also the balance was unacceptable. Emptying technique that showed the lowest level of risk was mode 3 (certified container) that reported 29% of MVC for trunk flexion and a maximum recommended exertion duty cycle of 13.6%. 3DSSPP showed no relevant values of orthogonal and shear forces at L4/L5 and L5/S1 levels. Finally, this technique was the only one that showed an acceptable balance. It would be desirable to design the vehicles for collection with easier access, as the operator is continuously getting on and off.

Keywords: Ergonomics · Musculoskeletal disorders · Muscle fatigue · 3DSSPP

1 Introduction

Data reported by INAIL President in the 2019 Annual Report [1] shows that musculoskeletal disorders (MSDs) are on the rise. They represent the majority of complaints made to Italian Workers' Compensation Authority both as absolute values and as percentage (38,777 and 65.16% of the total in 2018).

Evidence of biomechanical overload of kerbside waste collection workers has been found all over the world: Brazil [2], Denmark [3], Netherlands [4], USA [5, 6], India [7], Great Britain [8, 9], Italy [10].

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Poulsen [3] in his review investigated all types of risks that waste collection workers are exposed to; he identifies as the greatest hazards, in addition to biological ones, those related to manual material handling (MMH). Guercio [10] showed similar findings. In his study, he shows that biomechanical overload is the most important apart of biohazard. According to Guercio, different factors can increase that risk: loads too heavy and uncomfortable to grasp, awkward postures and bad techniques to speed up the collection round (e.g. throwing the garbage in the collection truck).

In a laboratory research, De Looze [11] examined the load at L5/S1 level while pushing a four-wheeled container. His results show compression forces exceeding the 3400 N threshold recommended by NIOSH [12]. Similar findings were also observed in the lifting of bags and bins.

The biomechanical overload in kerbside waste workers was analyzed as metabolic and compressive force at L5/S1 by Pinder [8]. The results are consistent with the other abovementioned studies. Pinder, for biomechanical load reduction, suggests to use wheeled bins.

In 2002 an [6] conducted an epidemiological study in Florida in which he identified two main categories of health risks for waste collection workers: skin infections and MSDs. He reported that MSDs and skin infections account for about 90% of all cases of compensation by American insurance companies.

The biomechanical risk in kerbside waste workers has also been studied by Oxley [9]. Oxley found an adequate height and width of the bins used for collection whereas the bins depth was excessive. The compression force threshold at L5/S1 recommended by NIOSH [12] was always exceeded during the handling of 13 kg bins even though the lifting was performed with proper lifting techniques. Based on these data, the study proposed a lifting weight threshold, with a frequency of twice a minute for eight consecutive working hours, of 11.38 kg. This threshold is recommended also according to the MMH risk assessment guidelines of Liberty Mutual [13]. The threshold would protect 90% of the male and 20% of the female working population.

From the reported bibliography it is clear that MSDs represent a remarkable and widespread problem in kerbside waste workers.

The present paper aims to provide a biomechanical risk assessment in kerbside waste workers in a scenario that strongly differs from those of the above-mentioned research in terms of the landscape where the collection is done, trucks used and timelines.

2 Materials and Methods

The studied task was the handling of a bin containing 10 kg of glass. This task was investigated in four different modes:

1. handling directly in the lorry by a side window (WIN);
2. handling directly in the lorry from the back (POST);
3. handling in a certified container to be mechanically unloaded in the lorry (HOM);
4. handling in a non-certified container to be mechanically unloaded in the lorry (NHOM).

Video recordings were made during task simulations. From video recordings, were sampled six frames each every two seconds. The most significant frame was analyzed by 3DSSPP software (v 7.0.6) [14, 15]. Tables 1 to V show, for each handling technique, the results from 3DSSPP regarding the following parameters: orthogonal forces (ORT) and shear forces (SHE) at L4/L5 and L5/S1 level, balance, percent of maximum voluntary contraction (%MVC), Strength Percent Capable (SPC), the maximum static (continuous) allowed exertion time (Static) and the maximum duty cycle time as a percent of the exertion (%DC). The latter parameter refers to the thresholds proposed by ACGIH [16] based on the Potvin research [17] regarding muscle fatigue.

3 Results

3.1 Orthogonal Forces – Shear Forces – Balance

Table 1 resumes, for each of the four handling techniques, orthogonal (ORT) and shear (SHE) forces at L4/L5 and L5/S1 level values and balance conditions. Figures 1, 2, 3 and 4 show 3DSSPP reconstructions.

Orthogonal forces at L4/L5 level were between 882 N (NHOM) and 2025 N (POST), the ones at L5/S1 level were between 571 N (NHOM) and 1692 N (WIN). Shear forces at L5/S1 level were between 59 N (NHOM) e 177 N (WIN), the ones at L5/S1 level were between 120 N (POST) e 292 N (WIN). All the results were below the threshold values proposed by NIOSH (3400 N) [12] and by Gallagher (700 N) [18].

Worker's balance was acceptable for WIN technique, critical in HOM and NHOM techniques and unacceptable in POST technique.

Table 1. Table shows for each of the four handling techniques the results of orthogonal and shear forces at L4/L5 e L5/S1 level and workers balance.

Handling technique	Ort L4/L5	She L4/L5	Ort L5/S1	She L5/S1	Balance
WIN	1595 N	177 N	1692 N	292 N	Acceptable
POST	2025 N	125 N	1367 N	120 N	Unacceptable
HOM	1878 N	116 N	1590 N	227 N	Critical
NHOM	882 N	59 N	571 N	215 N	Critical

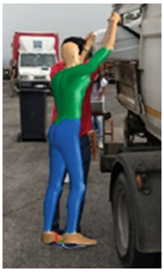

Fig. 1. Handling directly in the lorry by a side window (WIN)

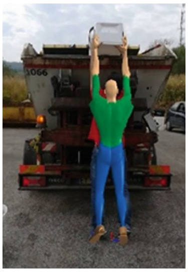

Fig. 2. Handling directly in the lorry from the backside (POST)

Fig. 3. Handling in a certified container (HOM)

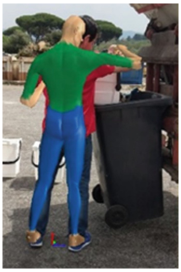

Fig. 4. Handling in a non-certified container (NHOM)

3.2 %MVC – SPC – Static - %DC

Tables 2, 3, 4 and 5 summarize the most relevant 3DSSPP results regarding percent of maximum voluntary contraction (%MVC), Strenght Percent Capable (SPC), maximum static (continuous) allowed exertion time (Static) and the maximum duty cycle time as percent of the exertion (%DC).

Handling Directly in the Lorry by a Side Window (WIN). In this handling technique the results of %MVC were relevant for: wrist flexion (37% both hands) and ulnar deviation (25% right), elbow flexion (38% right), shoulders abduction (31% left, 26% right) and trunk flexion (38%).

The lowest SPC value found was relative to trunk (95%). The lowest values of maximum static exertion were those of shoulder rotation (64s left) and abduction (63s left).

The lowest values of maximum duty cycle time (%DC) were those of wrist flexion (7.9% for both limbs), elbow flexion (7.5% right) and trunk flexion (7.4%).

Table 2. Table shows the most relevant 3DSSPP results from Fig. 1 of %MVC, SPC, Static and %DC. L stands for left side, R stands for right side.

%MVC	SPC	Static	%DC
wrist flex L 37% R 37% wrist ul R 25% elb flex R 38% shou rot L 31% shou abd L 31% R 26% tor flex 38%	wrist 98% torso 95%	wrist flex L 82s R 82s wrist ul R 154s elb flex R 76s shou rot L 64s shou abd L 63s R 88s	wrist flex L 7.9% R 7.9% wrist ul R 18.3% elb flex R 7.5% shou rot L 12.4% shou abd L 12.2% R 17.4% tor flex 7.4%

Handling Directly in the Lorry from the Back (POST). In this handling technique, the results of %MVC were relevant for wrist ulnar deviation (50% left), elbow flexion (73% left), left shoulder abduction (30% left), trunk flexion (38%).

The lowest SPC values found were relative to trunk (87%), elbow and knee (91%).

The lowest values of maximum static exertion were those of wrist (51s left), elbow flexion (18s left) and shoulder abduction (65s left).

The lowest values of maximum duty cycle time (%DC) were those of wrist ulnar deviation (3.2% left), elbow flexion (0.6% left), shoulder abduction (12.7% left) and trunk flexion (1%).

Table 3. Table shows the most relevant 3DSSPP results from Fig. 2 of %MVC, SPC, Static and %DC. L stands for left side, R stands for right side

%MVC	SPC	Static	%DC
wrist ul L 50% elb flex L 73% shou abd L 30% tor flex 67% knee flex L 51% R 53% ankle flex L 38% R 42%	wrist 94% elbow 91% torso 87% knee 91%	wrist ul L 51s elb flex L 18s shou abd L 65s	wrist ul L 3.2% elb flex L 0.6% shou abd L 12.7% tor flex 1%

Handling in a Certified Container to be Routinely Unloaded in the Lorry (HOM). With this handling technique results of %MVC were relevant for: wrist flexion (35% left; 51% right), shoulder rotation (66% left; 40% right) and trunk flexion (29%).

The lowest SPC value found was that of shoulder (93%).

The lowest values of maximum static exertion were from wrist flexion (50s right) and shoulder rotation (16s left; 39s right). The lowest values of maximum duty cycle time (%DC) were from wrist flexion (9.1% left; 3% right), shoulder rotation (1.1% left; 6.4% right) and trunk flexion (13.6%).

Table 4. Table shows the most relevant 3DSSPP results from Fig. 3 of %MVC, SPC, Static and %DC. L stands for left side, R stands for right side

%MVC	SPC	Static	%DC
wrist flex L 35% R 51% shou rot L 66% R 40% shou abd R 22% tor flex 29%	wrist 94% shoulder 93%	wrist flex L 90s R 50s shou rot L 16s R 39s shou abd R 117s	wrist flex L 9.1% R 3% shou rot L 1.1% R 6.4% shou abd R 22.7% tor flex 13.6%

Handling in a Non-certified Container to be Mechanically Unloaded in the Lorry (NHOM). With this handling technique results of %MVC were relevant for: wrist flexion (29% left; 45% right) and ulnar deviation (32% left), shoulder rotation (35% left; 63% right) and abduction (25% right).

The lowest SPC value was that of shoulder (95%). The lowest values of maximum static exertion were from wrist flexion (61s right) and shoulder rotation (52s left; 17s right).

The lowest values of maximum duty cycle time (%DC) were those of wrist flexion (14.4% left; 4.7% right), ulnar deviation (11.4% left; 24.5% right) and rotation (22.7% right). Noteworthy were also values of shoulder rotation (9.6% left; 1.3% right) and abduction (18% right).

Table 5. Table shows the most relevant 3DSSPP results from Fig. 4 of %MVC, SPC, Static and %DC. L stands for left side, R stands for right side.

%MVC	SPC	Static	%DC
wrist flex L 29% R 45% wrist ul L 32% R 21% shou rot L 35% R 63% shou abd R 25% tro flex 7%	wrist 96% shoulder 95%	wrist flex L 125s R 61 s wrist ul L 105s R 206 s shou rot L 52s R 17 s shou abd R 91s	wrist flex L 14.4% R 4.7% wrist ul L 11.4% R 24.5% wrist rot R 22.7% shou rot L 9.6% R 1.3% shou abd R 18%

4 Discussion

Scientific literature has shown that in kerbside waste collection biomechanical load is high and widespread.

The various workplaces and working techniques make it hard to use standardized protocols for manual material handling risk assessment. For these reasons we investigated bin handling using biomechanical parameters of 3DSSPP software.

3DSSPP results software did not show values exceeding the thresholds proposed by NIOSH [12] and Gallagher [18] for orthogonal and shear forces at L4/L5 and L5/S1 level in each of four handling technique we studied. However, our study was aimed to investigate the handling of a bin and not all the tasks as to go up and down from the collection truck and carrying wheeled bins. The weight we choosen (10 kg) was below the threshold of 11.38 kg recommended by Oxley [9] in a eight-hour shift.

SPC values were all over 90% but trunk value in POST handling technique was 87%. MVC percentages in POST handling were: 73% (left elbow flexion), 67% (trunk flexion), 53% right and 51% left (knee flexions) and 42% right and 38% left (ankle flexions). The POST handling technique, among the four investigated, had the highest values of %MVC. As for trunk flexion, the technique with the lowest %MVC was NHOM. HOM handling technique had a higher %MVC of trunk flexion (29%) than NHOM (7%) due to the narrow size of the certified container, resulting in a higher worker's trunk flexion.

Results for the maximum %DC are related to %MVC and postures adopted from the different body districts. Also for this parameter the lowest values, indicating an increased risk of biomechanical load, are all in the POST handling technique: left elbow flexion (0.6% of DC) and trunk flexion (1% of DC). In WIN handling technique the noticeable %DC were those concerning the shoulders: rotation (12.4% of DC left) and abduction (12.2% of DC left; 17.4% of DC right). On the other hand NHOM handling technique was overloading, for both wrists, in flexion (4.7% right; 14.4% DC) and ulnar deviation (24.5% right; 11.4% left). In HOM handling technique %DC was notably low for shoulder rotation (6.4% right; 1.1% left).

Our research highlighted main biomechanical risk factors when handling waste bins. To reduce biomechanical risk in waste collection, it would be advisable to redesign the collection equipment to avoid workers to raise shoulders near to physiological limits and to reduce trunk flexion.

Based on this data, POST handling technique, followed by WIN and NHOM techniques, is considered to be more risky overall. The least stressful technique is the HOM one, but it also presents problems concerning trunk flexion. Furthermore HOM handling technique presents organizational problems. The reduced capacity of the container would lead to a considerable increase of the collection round duration as already showed in two studies by Ziaei and by Camada [19, 20]. To solve this problem, it would be useful to replace the certified container with a larger one, manufactured with a durable component to allow to be mechanically emptied in the truck.

Further investigations are needed to investigate biomechanical load and energetic cost of whole task with surface electromyography and heart rate monitor to study net and relative cardiac cost.

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Ergonomic Approaches to Reduce the Risk of a Manual Material Handling Task in a Brazilian Poultry Slaughterhouse

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Abstract. This case study aimed to analyze the ergonomic risk of a manual material handling task and the effects of simulated interventions to reduce risks. The task of picking up boxes on the conveyor belt and putting them on the trolley of the freezing tunnel sector was selected intentionally. Two Brazilian poultry slaughterhouse workers positioned four boxes (7–18 kg) on each of the 11 shelves for 453 min daily. The vertical (0.25–1.75 m) and horizontal distances (0.45 m) and grip quality (poor) were collected. International Standards and the Variable Lift Index (VLI) software were employed. The average mass handled per worker was 11.7 kg (<25 kg), however, the results recommended weight limits of 2.1–5.5 kg for different heights. The cumulative mass lifted was 35,333 kg/worker/day (limit-10 tons), and 2,849 boxes/worker/day, consequently, the lifting frequency was 6.3/min, and VLI was 4.99 (very high). Performing job rotation with eight workers, ideal vertical area and box weights of 7–8 kg, VLI was 0.80.

Keywords: Manual handling · Slaughterhouse · Ergonomics · Job rotation

1 Introduction

Brazil is the largest exporter and the second producer of poultry in the world [1]. According to OSHA [2], poultry processing jobs have many ergonomic-related risk factors, including forceful exertion. A systematic review identified that a heavy workload and the load accumulation or lift frequency were moderate to strong risk factors for low back pain (LBP) in workers [3]. As stated by the U.S. Department of Labor, the amount of physical effort to perform a demanding task as heavy lifting may lead to the development of musculoskeletal disorders in poultry slaughterhouse workers [2].

Overall, studies have shown that slaughterhouse workers experienced musculoskeletal symptoms in the lower back, 66.7% [4] and 43.5% [5], as well as association between perception of bodily discomfort and performance of repetitive tasks [6]. Additionally, researchers consider the work in poultry slaughterhouses as a moderate risk for developing upper-limb work-related musculoskeletal disorders (UL-WMSDs) [7].

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Therefore, in order to guarantee the safety, health and quality of life in slaughterhouses, in 2013, the Brazilian Regulatory Standard 36 was established, setting general requirements for this economic sector, along with providing requisites for the manual transportation and lifting of products and loads [8]. However, statistical data showed that in 2017, the branch of slaughtering pigs, poultry, and other small animals was 3rd place among the sectors that most developed occupational diseases in Brazil [9].

In relation to manual material-handling, the risk-assessment model presented in ISO-11228 – "Part 1: Lifting and carrying" can allow the estimation of the risk associated with this task [10], furthermore affording an ergonomic approach to remove or reduce the risk of a manual handling injury.

This paper is justified because although manual material handling (MMH) is common in slaughterhouses, few studies were found that evaluated the risk of handling and lifting loads in slaughterhouses using the ISO 11228-1 method [11, 12]. Likewise, the objective of this study was to analyze the ergonomic risk of a MMH task in a Brazilian slaughterhouse and accomplish simulations to reduce risks.

2 Method

This cross-sectional observational study was conducted in a slaughterhouse in the Midwest of Brazil, with 326 workers in which 111,000 chickens were slaughtered per day in two work shifts. The research was approved by the local Committee of Ethics in Research with Human Beings, protocol nº 2098/201. Participants worked in the freezing tunnel sector with an artificially cold environment (0 to 9 °C) and the manipulated chilled products (<7 °C). Workers used personal protective equipment provided by the slaughterhouses. Work shift duration was 528 min, excluding 60 min for meal break. Workers performed 3 × 20 min of rest breaks and 15 min of uniform change, totaling 453 min of lifting and carrying in their daily work.

The task analyzed was selected intentionally because when workers put the boxes on the trolley, they adopted hazardous postures in a cold environment. In the real condition, two workers (18–45 years old) per work shift completed this task, and each box was lifted only once by the worker. The task was initiated when the worker picked up the boxes on the conveyor belt at a height of 0.95 m (Fig. 1A) and put them on the trolley (Fig. 1B) of the freezing tunnel sector. The worker positioned four boxes on each of the 11 shelves. The height of the first shelf was 0.25 m and the last was 1.75 m with 0.15 m intervals between them (Fig. 1A). The carrying distance was about 1 m, the horizontal distance was 0.45 m and the boxes weighed 7, 8, 9, 10, 11, 12, 13, 14, 15 and 18 kg.

In this study, the variable-task manual lifting was analyzed, it is defined as a lifting task in which both the geometry and load mass vary in different lifts performed by the worker(s) in the same period (Fig. 1A) [13].

To evaluate the risk associated with a MMH task, the ISO 11228 - Ergonomics - Manual handling - Part 1: Lifting and carrying [10] was employed. An initial screening of the task by following five steps (Table 1) and an evaluation of the ideal conditions for MMH were carried out, in order to verify if it is acceptable. The step model describes the following procedures [10]: Step 1 – mass of object to be lifted ≤ reference mass (population group) and ideal condition?; Step 2 – mass and frequency < limits?; Step 3 – mass of object < limits derived by the Equation 1?; Step 4 – cumulative mass <10000 kg?; Step 5 – cumulative mass and distance of carrying < limits?

The ideal conditions for MMH include ideal posture, a firm grip on the object and a favorable environmental condition [10]. As the participants were from the adult working population, the reference mass (m_{ref}) adopted was 25 kg [10]. To calculate the recommended limit for the mass (m_R) of the object, the NIOSH method was applied [10]. The object to be handled may constitute a hazard because of its mass or resistance to movement, its size, shape or rigidity or the absence of handgrips [10]. In this research, the grip quality for the handled boxes was considered poor (c_M = 0.90).

Fig. 1. Description of manual handling task (A – picking up the box on the conveyor belt; B – putting the box on the trolley).

Document ISO/TR 12295:2014 that guides users through the ISO 11228 series was employed in this study [13]. The analyzed task in this paper includes complex types of the lifting task, since it is advised to use the Variable Lifting Index (VLI). It is noteworthy that LI is equal to the ratio between the actual lifted mass (m_A) and the corresponding recommended limit for the mass (m_R) [13]. Additionally, the result is considered an acceptable condition when m_A is $\leq m_R$ and LI is ≤ 1, but >1 constitutes a risk. NIOSH method was used to determine the suggested weight limit (m_R) at the origin (picking up the boxes) and destination heights (putting down the boxes).

Simulated interventions (SI) were performed progressively to reduce the risk of VLI: SI.1 - increase the number of workers per shift to diminish the individual cumulative mass ($\leq$ 10 tons); SI.2 - eliminate 3 shelves of the trolley, 1 upper and 2 lower; SI.3 - allow lifting only in ideal area (vertical heights: 0.51–1.25 m) [13]; SI.4 - eliminate boxes of 18 kg by redistributing their total mass into 15 kg boxes; SI.5 - exclude boxes of 18 and 15 kg by redistributing their total mass into 14 kg boxes; and finally, SI.6 - perform job rotation with tasks without MMH (limit manual lifting time to 50% of work shift; 226 min; medium duration - 1 h < t $\leq$ 2 h of continuous lifting task) (Table 2).

A digital camcorder was used to film the workers performing the task. Researchers collected the measurements of vertical and horizontal distances of shelves and conveyor belt using a measuring tape. Documents regarding work organization, daily production of one week and environmental condition were provided by slaughterhouse management team. To evaluate the Variable Lifting Index (VLI), the free software NIOSH VLI High Precision was used [14], conforming to the ISO 12295:2014 [13].

The data were analyzed descriptively, the work conditions were qualitatively evaluated, and the results of simulated interventions were annotated for later comparisons.

3 Results

According to the production data, two workers per work shift handled 5346 ± 412 boxes daily, totaling 60858.8 ± 5648.2 kg. Analyzing each lift individually and considering the different heights at the origin and destination, the m_R was lower than the average m_A handled per worker (boxes) (11.7 kg). At the origin, the m_R was from 2.8 kg (0.25; 0.40; 1.6; 1.75 m) to 5.5 kg (1.0 m) and at the destinations were from 2.1 kg (1.75 m) to 5.4 kg (1.0 m). The screening of the task found that this manual handling was unacceptable and needed adaptation, since m_A was higher than m_R at different heights at the origin and destination of the boxes (step 3), in addition, the cumulative mass was higher than recommended (step 4) (Table 1).

Of the twelve criteria described as ideal conditions for MMH [10], six were unfulfilled and inappropriate: cold environment temperature, poor grip quality, floor was uneven and slippery, cold temperature of the products, vertical displacement of the loads in a non-ideal area, and the loads were not kept close to the body.

In order to evaluate possible solutions, ergonomic approaches were carried out through simulated interventions (Table 2). Results of the simulated interventions show that VLI in the real condition was 4.99, with very high risk, in which interventions of the redesign task and workplace should be performed immediately (Table 2). As the total cumulative mass of lifting and manual carrying should never exceed 10 tons/worker/day, whichever is the daily duration of work [10], it took eight workers per shift performing this lift to meet this requirement (step 4).

Comparing the values of VLI of the simulated interventions with the real condition, the interference that resulted on the smaller VLI was SI.5 with eight workers, risk reduction of 69.3%. Nonetheless, with the same number of workers, without reducing the box weights (SI.3), the diminution was 62.3% and performing job rotation (SI.6) was 67.3%. On the other hand, the intervention that had the lowest risk reduction (1.6%) was SI.2 with two workers per shift (Table 2). Alternatively, performing only job rotation with two workers (manual lifting up to 50% of work shift) the VLI was 3.01, a risk reduction of 39.7% in relation to the real condition.

Table 1. Multiplier factors that comprised the risk-assessment and step model fulfillments.

Multiplier factors/steps	References*	Study data	Met
m_{ref} - Reference mass (steps 1 and 2)	Men: 18–45 years; m_{ref} = 25 kg; f < 9 lifts/min	m_A = 11.7 ± 3.4 kg[a] f = 6.3 lifts/min	Yes Yes
m_{cum} - Cumulative mass (steps 4 and 5)	10,000 kg/day Distance ≤ 10 m	35333 kg/worker/day Distance < 1 m	No Yes
h_m - Horizontal distance multiplier	h ≤ 0.63 cm	h = 0.45 m; h_m = 0.55	Yes
v_m - Vertical location multiplier, Limits for the mass of objects (step 3)	0 < v ≤ 1.75 m $m_A \leq m_R$	Origin – v = 0.95 m; v_m = 0.94 Destination – v = 0.25–1.75 m; v_m = 0.93 – 0.70; m_R = 2.1–5.5 kg; m_A = 11.7 kg; $m_A > m_R$	Yes Yes No
d_m - Vertical-displacement multiplier	d ≤ 1.75 m	d = 0.05−0.80 m; d_m = 1.72−0.87	Yes
α_m - Asymmetry multiplier	$\alpha \leq 135°$	$\alpha = 0°$; $\alpha_m = 1$	Yes
f_m - Frequency multiplier of the lifting task	Long duration: 2 h < lifting task ≤ 8 h; $f_m > 0$	6.3 lifts/min; f_m = 0.27	Yes
c_m - Coupling multiplier	Poor; c_m = 0.90	Poor; c_m = 0.90	Yes

* Method [10, 13]; [a]box weight; m_A – actual lifted mass; m_R – recommended weight limit.

In order to reach the VLI ≤ 1, simulations with 8 workers carrying out the job rotation (with tasks without MMH), lifting at ideal heights and with the progressive weight reduction of the boxes were performed (Table 3). Only after redistributing the entire cumulative mass of the boxes from 9–18 kg to 7 and 8 kg, the VLI reached a score of 0.80 (acceptable condition without risk of musculoskeletal disorders) [13]. Though, a reduction of 80.6% has already been found for the borderline (yellow) condition. Although, in the acceptable condition, there was a 46.5% increase in the number of lift/min/worker in relation to the condition of the boxes with the original weights (Table 3).

4 Discussion

MMH is a risk factor for the development of low back pain (LBP) in workers [2–4, 12]. Brazilian data showed that 10.7% of all records for occupational diseases were related to back pain and other disorders in intervertebral discs [9]. Increase the number of workers was the first ergonomic approach adopted, however, it should be noted that there are often limitations in relation to the physical space to insert more workers.

Table 2. Simulated interventions (SI) for reducing the Variable Lift Index (VLI).

Workers	Cumulative mass/worker[A]	Lifts/ worker[B]	Lift/ min[#]	Variable Lift Index - VLI					
				SI.1	SI.2	SI.3	SI.4	SI.5	SI.6
2	35333	2849	6.29	4.99[*]	4.91	3.50	3.25	3.24	2.21
3	23555	1899	4.19	3.42	3.38	2.52	2.29	2.15	1.81
4	17666	1424	3.14	2.95	2.86	2.23	1.98	1.84	1.73
5	14133	1139	2.52	2.68	2.65	2.10	1.83	1.70	1.69
6	11778	950	2.10	2.57	2.52	2.02	1.74	1.62	1.67
7	10095	814	1.80	2.47	2.44	1.97	1.68	1.57	1.65
8	8833	712	1.57	2.40	2.39	1.88	1.65	1.53	1.63

SI.1 – cumulative mass reduction; SI.2 – cumulative mass reduction and three heights; SI.3 – cumulative mass reduction and lift at ideal heights; SI.4 – cumulative mass reduction, lift at ideal heights and 18kg box elimination; SI.5 – cumulative mass reduction, lift at ideal heights and 15 and 18kg box elimination; SI.6 – cumulative mass reduction, lift at ideal heights and manual lifting up to 50% of work shift; [*] Real condition – two workers/shift; [A] Refer to SI.1 - SI.5; [B] Refer to SI.1, SI.2 and SI.3; [#] Refer to SI.1, SI.2, SI.3 and SI.6; Purple – very high risk (VLI > 3), Red – high risk (2 < VLI ≤ 3), Red – moderate risk (1 < VLI ≤ 2) [14].

In agreement with quick assessments, the lift frequency per min was not a critical condition (<9) for work with long duration (>2 h), but it was a repetitive task (6.3 lift/min) and the risk was classified as very high. The job rotations in real condition can be an option to reduce the risk (VLI) without increasing the number of workers, accordingly, the work pace (lift/min) will remain the same. The effects of the applied interventions must be analyzed periodically, because only then, will the changes be verified as positive or not in reducing the risks. In the rotation simulation, the risks of the lifting task were minimized, however, the task without MMH should be evaluated and adequate, if necessary, to mitigate the total occupational risks.

Table 3. Simulated interventions with job rotation and reducing the weight of the boxes.

Simulated interventions with job rotations (MMH - 226 min; M_{cum} = 4417 kg/worker)	N lifted object /worker/shift	Lift/min	VLI	Reduction in relation to real condition (%)
Original weight of the boxes (7-18kg)[*]	356	1.57	1.63	67.3
Eliminated 15 and 18kg boxes	364	1.61	1.28	74.3
Eliminated 11 to 18kg boxes	424	1.88	0.97	80.6
Eliminated 10 to 18kg boxes	466	2.06	0.89	82.2
Eliminated 9 to 18kg boxes	520	2.30	0.80	84.0

[*] SI.6; Risk classification [14]: Purple – very high risk (VLI >3); Red – high risk (2 < VLI ≤ 3); Red – moderate risk (1 < VLI ≤ 2); Yellow - borderline (0.85 < VLI ≤ 1); Green - acceptable (VLI ≤ 0.85).

In this research, the workers were exposed to hazardous postures (extreme reaches). Notwithstanding, when performing the SI.2 (elimination of three shelves), the VLI decreased the risk by only 1.6% compared to the real condition. On the other hand, when the MMH was carried out at an ideal height (0.51–1.2 m), it reduced to 29.9%

(SI.3). Despite the SI.2 result, the SI.3 shows that excessive joint amplitudes should be avoided during the work [8, 10]. The use of excessive force during the performance of tasks should be refrained, as it increases the risk level of exposure of the worker [8]. A study analyzing repetitive tasks in slaughterhouses found that due to the high demand for required strength to perform certain tasks, the risk level of the activity could not be reduced by only decreasing the work pace [7]. To solve step 3, the masses of 18 and 15 kg were distributed in 14 kg boxes, but this intervention did not reduce the risk level (VLI > 3) (SI.5). This occurred because the average m_A of the boxes was 212 to 557% higher than the m_R at different heights when depositing the boxes. Therefore, in order to achieve a borderline VLI (≤ 1), it would also be necessary to reduce the box weights (force applied) in addition to correcting other inadequacies.

The very cold environmental temperature was a critical condition [13] verified in the work sector. Studies have found that even while using PPE, most of the slaughterhouse workers presented temperatures of <24 °C in the hands, as well as inadequate thermal insulation [15]. A study of 925 slaughterhouse workers established a significant association between perception of bodily discomfort and cold perceptions (OR = 2.05; 95% CI 1.44 to 2.91) [6]. The vertical displacement of the load was a critical condition, whereas occurred below the knees and above the shoulders [10]. For these two critical conditions, the recommended limits for cumulative mass for carrying (10 tons) should be substantially reduced at least by one-third [10]. Thus, the employer should provide technical means of reducing the risk, complemented with information and appropriate training with respect to work-related risks, nonetheless, it is emphasized that information and training alone will not ensure safe manual handling [10].

5 Conclusion

The task has been classified at an unacceptable level of risk and needs adaptation. Recommended weight limits were lower than actual limits and the handled individual cumulative mass was >10 tons. After carrying out all possible simulated interventions, acceptable MMH conditions were achieved. However, this only occurred in the job rotation intervention of eight workers, performing lifts in an ideal area and considerably reducing the weight of the boxes. It shows that as the risk of the task analyzed is very high, an ergonomic intervention must address several risk factors, as an action focusing on only one risk factor is insufficient to eliminate them. These ergonomic solutions often require physical space and human resources, often unavailable. Therefore, another alternative for the elimination of risks may be automation, in this case, the implementation of an automatic carton freezer.

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Ergonomic Assessment of the Lifting Tasks Performed by North Indian Workers in LPG Cylinder Distribution Supply Chain

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Abstract. Lifting is considered as the most stressful activity in manual material handling and leads to musculoskeletal disorders. The present work was performed to evaluate the lifting index and the risk of low back pain among workers involved in lifting of Liquefied Petroleum Gas (LPG) cylinder. 40 workers working in 3 modes of transportation of liquefied petroleum gas cylinders in north India were investigated with the help of the NIOSH lifting equation. The results revealed that 100% of the workers have performed under different levels of risk as their LI > 1. 22.5% were under low risk, 32.5% of workers were under medium risk and 45% of the workers were under high risk. The present work reveals that there is a need to redesign the lifting tasks by reducing the horizontal distance of lifting of cylinders and reducing the weight of the cylinder.

Keywords: Ergonomics · Supply chain · NIOSH Lifting index · ANOVA · LPG cylinder

1 Introduction

Handling is defined as holding, grasping, or working with the hands. In manual material handling the involvement of fingers is only to that level that they act as an extension of the hand: to change the gears of an automobile [1]. Handling according to ergonomic guidelines for manual material handling tells that the person's hands move individual load manually by either lifting or lowering. Workers are exposed to physical conditions (force, unwanted postures, and repetitive movements) that may cause injuries to workers and waste their energy and time. These problems can be avoided if the organization takes advantage of improving the fitness between the demands of worker job tasks and the capabilities of its workers [2]. Workers' performance may vary from task to task because of their demographics like age, physical health, physical strength, gender. Most industrial plants are not automated and material handling processes are carried out manually [3]. Physical demands for the workers are different for different tasks. By implementing, documenting and upholding proper procedures and policies workplaces can help workers to perform these tasks safely and with ease.

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The back is a complex structure of bone and muscle, supported by cartilage, tendons, and ligaments, and fed by a network of blood vessels and nerves. The back especially the lumbar, or lower back bears much of the body's weight during human activities like lifting, lowering, walking, and running. Muscles and bones of the back are involved in the disintegration of the lower back. Forty percent of people at any time in their lives are affected by lower back pain. Back injuries comprised 32% of all injuries reported but consumed more than 40% of all workers' compensation [4]. Generally, movements of lifting, twisting of the torso, or forward-bending cause lower back pain. The symptoms of lower back pain start soon after the repetitive movements or when getting up in the morning. Lower back problem is generally a complaint. Skeletal problems such as sprains are believed to be the cause of lower back pain. Abdominal fat, pregnancy weight gain, stress, bad physical health condition, awkward posture, and awkward sleeping position are also the reasons that may lead to low back pain. Low back pain is a universal fact and a general human experience as almost particularly everyone has low back pain at some time in their lives regardless of age and gender.

Liquefied Petroleum Gas (LPG) is an important consumable of the government. LPG usage has increased manifold since its inception in 1955. As per data available of 2011 Hindustan petroleum gas has over 3.3 crore LPG customers catered and taken care of by 2630 gas distributors [5]. HP Gas is the branded product of HPCL which is helping the consumers for cooking and industrial purposes. There are 44 LPG Bottling Plants in India with a total production capacity of about 3550 TMTPA [6]. To maintain the product quality the gas delivered to the end consumer after passing through a series of checks at each point starting from production and bottling to distribution. Safety is the first consideration of any oil marketing company [7].

2 Literature Review

Manual material handling and load lifting approaches were used for the review of the literature [8]. The various sources for the research include Google and yahoo search engine. The search was done using the terms manual lifting, NIOSH Lifting index. In 1981 when the NIOSH lifting equation was published for calculating the limits of recommended weights for manual lifting and lowering job tasks, numbers of companies and industries have applied the NIOSH equation to identify the risky tasks having a very high lifting index for the worker [8]. Psychophysical criteria and measured the rate of oxygen consumption, anthropometric parameters, and heart rate were reported [9]. Accepting criteria for the jobs for the RWL, the 1981 NIOSH equation was less restrictive as compared to the NIOSH lifting equation [10]. NIOSH played a critical role in interpreting the results of the equation [11]. The different criteria like physiological, psychophysical and biomechanical were cross-verified and validated for establishing the limits of manual lifting for NIOSH with the data of different researchers [12]. The validity of the load constant for the Korean population was evaluated using the psychophysical approach [13]. The modeling of human factors was done through biomechanical approach and software [14]. The large increase in risk with a large range of exposure parameters and measurement of the exposures was observed. The diagnostic system based on an artificial neural network that classified industry tasks according to lower back disorder risk was designed [15]. The system can be informative in the prevention of injury due to manual handling in the industry environment. Fuzzy set theory to distribute the load corresponding to the various levels of heaviness [16]. The results showed that inter-observer variability was very small for the horizontal distance and the least accuracy was observed for the measurement of asymmetric and coupling parameters. In 1999, an evaluation of four industrial sites was studied with the help of the NIOSH lifting equation [17]. Correlation between LI and lower back pain was done with regression analysis. It was reported the ability to lift loads is not dependent on the capability to perform the manual material handling task [18]. It was reported material handling tasks can be simulated by the biomechanical models and the prediction of the stresses on the back can be done while designing the tasks of manual materials handling in the industry [19]. The systematic review of the literature, in the field to identify problems, recommended practices and unresolved issues of cleaning problems [20]. The effectiveness of mechanical lifting aid in single task lifting of fire brick manufacturing company was investigated [21]. The relationship between low back injury risk and work factors in the casting industry was investigated [22]. Lifting index was used as a potential factor for the risk level of a low back injury.

2.1 Research Gaps

From the Literature survey above that most of the work done in advanced and economically developed countries and little work has been reported in the lifting of very heavy loads and across the supply chain of distribution of liquefied petroleum gas. Economically developed countries have gas pipelines for the supply of gas at home. Manual handling of cylinders which are very heavy in weight is done in India as compared to advanced countries where automation is there in the handling of LPG cylinders. The chapter reported the study by various researchers related to back pain, and biomechanical, physiological criteria for evaluation of workers.

3 Methodology

The work methodology adopted in the present work consists of six phases.

Step 1: Apprehend the employees about the methodology and the technique of the study.
Step 2: Visualize the cylinder lifting task and have a clear idea of that operation by videotaping and taking photographs.
Step 3: Interview the cylinder lifting workers on their task previous history and body part pain, ache.
Step 4: Analyzing the videotape and taking a snapshot of the task.
Step 5: A tape measure was used to measure the lifting height, horizontal distance, and distance. The weight of the cylinder was printed on the cylinder and was noted from the cylinder itself.
Step 6: NIOSH lifting equation was used for calculating the potential risk involved with the task.

NIOSH Lifting Equation:

$$\text{RWL} = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \tag{1}$$

3.1 Procedural Steps to Calculate the LI Using NIOSH Lifting Equation

Step 1: Measure and Record Task Variables

The first step is to gather the needed information and measurements for lifting task variables and record the data to be used later to calculate the RWL and LI for the tasks being evaluated.

Step 2: Calculate the Multipliers

Each multiplier should be computed from the appropriate formula from Table 1. The multipliers or penalties or reduction coefficients are calculated using the task variables in Table 1.

Table 1. Multiplier equations

		Metric	The US. customary
Load Constant	LC	23 kg	51 lbs.
Horizontal Multiplier	HM	(25/H)	(10/H)
Vertical Multiplier	VM	1−(0.003|V-75|)	1−(0.0075 |V-30|)
Distance Multiplier	DM	0.82 + (4.5/D)	0.82 + (1.8/D)
Asymmetric Multiplier	AM	1−(0.0032 A)	1−(0.0032 A)

Step 3: Calculate the RWL using the NIOSH lifting equation.

Step 4: Conduct the risk assessment by calculating the LI for the cylinder lifting/lowering task.

4 Results and Discussion

Table 3 presents descriptive demographic data and statistics regarding the workers and their historical exposure in their current cylinder distribution jobs (Tables 2 and 4).

Table 2. Statistics of worker

Worker profile parameters	Mean	S.D	Range
Age (years)	33.92	12.15	18–63
Body Height (cm)	171.42	4.0	163–180
Body Weight (kg)	77.95	7.37	62–95
Job experience (years)	7.67	5.44	2–25
Weight Lifted (kg)	25.815	7.47	16–30.2

Table 3. Risk associated with the lifting index

LI	Potential risk level	Action required	The physical stress of job task
0–1	No	No	Not stressful
1–2	Low	Yes	Moderately stressful
2–3	Medium	Yes	Highly stressful
>3	High	Yes	Very highly stressful. Ergonomic intervention and job redesign required

Table 4. Multiplier mean cylinder supply mode wise

Multipliers	HM mean	VM mean	DM mean	AM mean	FM mean	CM mean
Truck	0.63	0.90	0.88	0.90	0.68	0.99
3wheeler	0.63	0.84	0.89	0.85	1	0.99
Cycle rickshaw	0.58	0.841	0.94	0.93	1	0.99

4.1 Statistical Analysis of Data Using Analysis of Variance (ANOVA)

It is a collection of statistical models used to analyze the differences between group means and their associated procedures (such as "variation" among and between groups), developed by R.A. Fisher [23]. In the ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are equal [24] (Table 5).

Table 5. Statistic from the ANOVA test

Source of variation	Degrees of freedom	SS	MSS	F Ratio
Between groups	3 − 1 = 2	SSC = 5.99	5.99/2 = 2.995	F = 2.995/1.8475 = **1.621**
Within groups	40 − 3 = 37	SSE = 68.36	68.36/37 = 1.8465	
Total	39	74.36		

Value (Critical value): $F(2, 37) = 3.25$. Since $1.621 < 3.25$ we accepted the null hypothesis that there is no significant difference between the Lifting Index of Truck, 3 wheeler and Cycle rickshaw modes of cylinder supply workers.

5 Conclusion

Analysis of the results concludes that there is a need to redesign the job task. The workers of the cylinder distributors should lift the cylinder close to the body so that the horizontal distance is reduced. If possible automation should be provided for the lifting of cylinders. The weight of the cylinder should be reduced by using cylinders with less LPG gas or cylinders should be made of lighter material. The results also show that 100% of workers are at risk of developing low back pain with 45% of the workers having unsafe LI > 3. The overall mean LI of sample is 3.14 which suggests that cylinder lifting job is physically highly stressful. Hence ergonomic intervention is required. Around 52.5% of the workers reported lower back pain.

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Research on the Influence of Physical Environment in Civil Aircraft Cabin on Seat Comfort

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Abstract. The physical environment of the aircraft cabin is the basic factor influencing the comfort experience of air passengers. In order to clarify the influence path of the cabin physical environment factors on the passenger comfort experience. Exploratory factor analysis methods and structural equation models are used to explore the effects of environmental factors such as temperature, humidity, brightness, noise, vibration, and air pressure on seat comfort and cross-group analysis is used to explore whether the above paths are affected by passenger gender and Influence of body shape. The results show that the overall fitting indexes of the model meet the critical conditions and the routes described in the model have significant effects on passengers of different genders and shapes. The research results provide a reference for the study of the relationship between the factors affecting the comfort. Research are beneficial to the improvement of comfort experience of aircraft cabin.

Keywords: Aircraft cabin · Comfort · Structural equation model · Cross-Group analysis

1 Introduction

The global air passenger volume is increasing year by year, achieving an annual growth rate of 6.1% in 2018 with a total passenger volume of more than 4.3 billion [1]. Aircraft comfort has become not only an important manifestation of market differentiation between airlines and aircraft manufacturers, but also an important means of market competition [2]. Zhang et al. [3] find that discomfort is related to physical factors in the environment, and comfort is more related to additional and enjoyable experience. Bubb [4] proposes a pyramid of uncomfortable feeling, believing that comfort is seriously influenced by unpleasant smell, followed by physical factors such as luminance, noise and climate, and service factors are located at the top of the pyramid in business

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competition. Therefore, physical environment is the basic factor affecting the experience of cabin comfort.

It has been confirmed that environmental factors such as noise, temperature and humidity can affect the comfort of civil aviation passengers in many studies [5–8], but there is no study on how such factors affect the comfort of passengers. Seats are the facilities contacting with passengers in the longest time in the cabin. Richards and Jacobson [9] and Blok et al. [10] point out that seats are the most important factor affecting the comfort of passengers. Therefore, seat comfort is selected as the representative factor of passenger comfort in this paper, and exploratory factor analysis method and structural equation model are used to explore the impact of physical environment factors on seat comfort. In addition, cross-group analysis method is used to explore whether the above path is affected by the gender and body shape of passengers. In this way, it provides theoretical basis to improve seat comfort and passenger comfort.

2 Research on Aircraft Cabin Comfort Based on Structural Equation Model

2.1 Structural Equation Model

Structural equation model includes measurement model and structural model: the former describes how measurement variables express potential variables through confirmatory factor analysis; and the latter analyzes the relationship between measurement variables and potential variables through multiple regressions [11]. Chen [12] uses structural equation model to analyze the relationship among the service quality, perceived value, satisfaction and behavioral intention, so as to clarify the path and the importance of factors that affect the behavior choice of passengers. Lee et al. [13] use structural equation model to quantify the impact and value of comfort factors on high-speed train ride comfort. The structural equation model can be used to analyze the structural relationship among factors affecting cabin comfort.

2.2 Structural Equation Model for the Influence of Physical Environment Factors on Seat Comfort

The physical environment factors of the cabin mainly include vibration, temperature, humidity, luminance, noise, and air pressure. The factors that affect the comfort of cabin seats mainly include the geometric parameters of seats related to anthropometry, the operation performance of seat auxiliary facilities, and seat aesthetics. The structural relationship is analyzed between physical environment factors and seat comfort factors by the following steps:

Step 1: Constructing the structural relationship model between the physical environment factors and the seat comfort factors based on the relevant theoretical research;

Step 2: Drawing the hypothetical model in Amos Graphics™ software;

Step 3: Correlating the comfort survey data of the physical environment factors and seat factors of the aircraft cabin with the model map, and fitting the model with "*Calculate Estimates*" function;
Step 4: Verifying according to the fitting indicators, and modifying the model to improve the fitting degree.

3 Case Study

3.1 Data Acquisition

A questionnaire survey was conducted on the cabin comfort of narrow body aircraft in two flights of a traditional airline. The flight routes were the same, both being medium-distance trunk flights without obvious delay. Questionnaires were distributed after the plane had flown smoothly. Finally, 226 valid questionnaires were collected, with an effective rate of 72%. There were 6 items on physical environment factors and 28 items on seat factors.

3.2 Factor Analysis

Exploratory factor analysis was used to reduce the dimension of items in the questionnaires, which made preparations for the construction of structural equation model. Based on the standard that the total variance was greater than 70%, two factors of physical environment and five factors of seats were selected finally. The items and scores of such factors are shown below (Table 1):

Table 1. Summary of model factors

Factor category	Factor overview	Corresponding item	Factor score
Physical environment	Environmental factor 1 (N1)	Temperature	.874
		Humidity	.830
		Luminance	.813
	Environmental factor 2 (N2)	Noise	.884
		Vibration	.870
		Air pressure	.742
Seat	Comfort of skin contact (N3)	Backrest transverse concave surface	.731
		Sitting transverse concave surface	.706
		Hard or soft seat	.638
		Size of small table	.635
		Handrail size	.621
		Fabric breathability	.599
		Lumbar support	.591
		Touch and comfort of surface material	.575
		Head support	.503

(*continued*)

Table 1. (*continued*)

Factor category	Factor overview	Corresponding item	Factor score
	Comfort of body support (N4)	Seat width	.730
		Seat depth	.705
		Backrest width	.668
		Backrest height	.667
		Knee length	.635
		Seat height	.582
		Maximum backrest inclination	.538
	Perception of quality safety (N5)	Stable seat adjustment device	.796
		Stable seat support structure	.780
		Round seat corners	.761
		Safe seat gap	.631
		Seat belt	.594
	Assistant operation fluency (N6)	Armrest operation	.688
		Operation of small table	.671
		Setting of book and newspaper holders	.643
		Backrest adjustment degree	.539
	Aesthetics perception of seats (N7)	Delicacy of seats	.756
		Suitable color of seats	.684
		Harmonious overall shape of seats	.508

The results indicate that environmental factors and seat comfort can be represented by factors of different dimensions. Specifically, environmental factors can be divided into two categories: those without obvious changes inside and outside the cabin and those with obvious changes inside and outside the cabin. The former includes the perceived comfort of temperature, humidity and luminance, while the latter includes the perceived comfort of noise, vibration and air pressure. Seat comfort can be represented by five dimensions: comfort of skin contact, comfort of body support, perception of quality and safety, assistant operation fluency and aesthetics perception of seats.

3.3 Model Construction and Analysis

Based on the results of exploratory factor analysis, the structural equation can be constructed to explore how the environmental factors in different dimensions affect the seat comfort in different dimensions. After testing, the data are in the normal distribution, the VIF values are all less than 2, satisfying the requirement of being less than 5, indicating that there is no serious multicollinearity. Therefore, the experimental data satisfy the linear regression hypothesis, and the structural equation method can be used to explore the possible influence relationship between the above factors. The results show that the coefficients of each path are significant, and the fitting indicators of the whole model satisfy the critical conditions, as shown in Table 2. Finally, the model of the influence of physical environment on seat comfort is obtained (Fig. 1).

Table 2. Fitting indicators of model

Indicators	CMIN/DF	RMSEA	NFI	RFI	IFI
Index value	2.759	0.056	0.920	0.911	0.948
Critical value	1–3	<0.08	>0.9	>0.9	>0.9

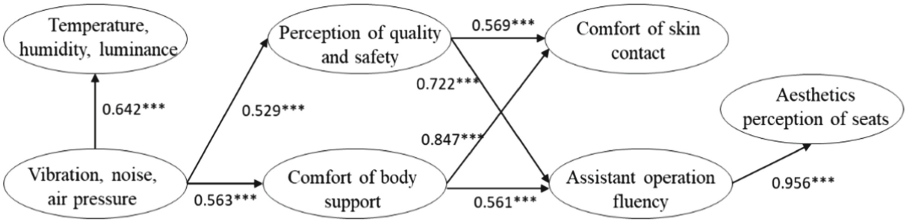

Fig. 1. The model of the influence of physical environment on seat

In order to further explore whether the characteristics of passengers will affect the above model, the cross-group analysis method is used for the model.

3.4 Cross-Group Analysis

When the cross-group analysis is conducted by genders, P value is 0.261, less than 0.5, indicating that gender has an impact on the above model. In addition, P values for path coefficients in each group are all less than 0.001, indicating that the path described by the model has a significant impact on passengers of different genders. Specifically, when the path coefficient is larger at male or female and the influence of the path on the gender is greater, as shown in Table 3.

Table 3. Summary of path coefficients by genders in cross-group analysis

Path			Male	Female	P
N2	→	N1	.660	.622	***
N2	→	N4	.531	.620	***
N2	→	N5	.514	.570	***
N5	→	N6	.691	.782	***
N4	→	N6	.607	.476	***
N6	→	N7	.951	.965	***
N5	→	N3	.525	.660	***
N4	→	N3	.866	.797	***

Note: * represents p < 0.05, ** represents p < 0.01, and *** represents p < 0.001

When the cross-group analysis is conducted by body shapes, P value is 0.009, less than 0.5, indicating that body shape has a significant impact on the above model. In addition, P values for path coefficients in each group are all less than 0.001, indicating that the path described by the model has a significant impact on passengers of different body types. Specifically, when the path coefficient is larger at thin, ordinary or fat, the influence of the path on the gender is greater, as shown in Table 4.

Table 4. Summary of path coefficients by body shapes in cross-group analysis

Path			Thin	Ordinary	Fat	P
N2	→	N1	.528	.675	.595	***
N2	→	N4	.687	.576	.418	***
N2	→	N5	.520	.507	.512	***
N5	→	N6	.772	.747	.474	***
N4	→	N6	.677	.565	.563	***
N6	→	N7	.860	.979	1.031	***
N5	→	N3	.775	.516	.430	***
N4	→	N3	.752	.835	1.116	***

Note: * represents $p < 0.05$, ** represents $p < 0.01$, and *** represents $p < 0.001$

4 Conclusion

The structural equation model is constructed to explore how physical environment of the cabin affects seat comfort, and the cross-group analysis is used to explore the influence of different genders and body shapes on the model. The results reveal that vibration, noise and air pressure affect the comfort of body support, which affects the comfort of seat assistant operation fluency and skin contact; vibration, noise and air pressure affect the perception of quality safety, which affects the fluency of assistant operation and skin comfort; and the assistant operation fluency affects the aesthetic perception of seat. The path described by the model has a significant influence on passengers of different genders and body shapes. The research results provide a theoretical basis for the improvement of cabin comfort.

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Ergonomic Methods Adaptation for Risk Evaluation Associated to Musculoskeletal Disorders in Elderly Indigenous Women of the Ecuadorian Highlands

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Abstract. In Ecuador, agriculture is an activity of social and economic relevance perform mainly by indigenous women. In previous studies ergonomic evaluations done to daily activities of these women yielded in all cases high physical workload. Elderly women of these communities show severe spinal deformations which are believed to be related to workload. Ergonomic methods are aimed for industrial and administrative environments, with limited application for unstructured labors. The evaluated activities are performed in poor environmental and safety conditions. The aim is to adapt an ergonomics method to enable the asassertively determination of risk level of the evaluated activities. The proposed method is based on REBA and assess forced postures and loads handling and transportation, calculating a unique ergonomic risk value and showing similar results when load is carried symmetrically and within the permissible weight limits; however, when these factors are not met the modified method allows to increase the risk factor.

Keywords: Ergonomic methods · Musculoskeletal disorders · Indigenous women · REBA

1 Introduction

At global scale, the musculoskeletal system damages due to work have been acknowledged as one of the main causes of work absenteeism; these damages include a set of conditions involving tendons, nerves, and muscles. Epidemiological studies establish that risk factors, such as repetitive tasks, overexertion, load handling and its frequency, transporting heavy objects, adopting forced postures for a prolonged time, disergonomic work stations, exposure to cold, static loads, among others, contribute to the development and occurrence of these type of damages [1].

Back pain is the musculoskeletal disorder that is most commonly associated to work absenteeism, with a global incidence of 51.9%, which is significantly higher in workers over the age of 50, women, and people who are exposed to greater domestic loads [2].

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There is also a greater incidence of this condition among workers involved in manual activities (54.9%). Suffering from back pains has shown to reduce the ability to perform personal and work activities, and they entail direct and indirect costs; therefore, studying them and their causes is considered of great importance [3].

In Ecuador, a population of indigenous women from the highlands was studied to relate severe spine deformations in elder women with workload; therefore, ergonomic assessments (REBA, GINSHT, JSI & LEST), were conducted in order to determine the risk level due to the exposure to forced postures and loads. As a result, it is stated that the applied methods focus on industrial and administrative tasks and that in unstructured jobs, such as the ones of indigenous women, they are unable to properly assess risks or to propose adequate solutions [4]. The AWBA (Agricultural Whole Body Assessment) [5] method is also applied in the study, it focuses on the ergonomic assessment of upper and lower limbs in agricultural work, which is the main activity of indigenous women. AWBA was also unable to accurately assess high risk levels [4].

The aim of this study is to adapt known ergonomic methods in order to more accurately assess and determine the risk level to which indigenous women are exposed and to use this information as a basis to propose recommendations that are adapted to the context and culture of the studied population.

2 Materials and Methods

This investigation is conducted using a non-probabilistic sample of 40 indigenous women over the age of 60 who belong to the communities that are located in the higher areas of Quisapincha parish, Tungurahua province, in the Ecuadorian highlands. All the assessed women wear a lumbar belt as part of their traditional clothes, which is called *chumbi*, and it consists of a series of woven ribbons that are firmly fastened around the waist. They carry out a wide variety of daily activities, mainly domestic work, sowing- and harvesting-related activities, and farm animals caring.

The studied women carry out all the activities without using any safety or protection equipment; they carry small children on their backs (see Fig. 1) and work out-doors, at an average altitude of 4,050 m.a.s.l., and an annual average temperature of 7 °C [7].

Eight activities were selected for the ergonomic assessment: (1) Kneeling washing clothes, (2) Handling fertilizers, (3) Harvesting potatoes, (4) Standing up washing clothes, (5) Tilling the soil while carrying her child on her back, (6) Washing radishes, (7) Carrying bulk of potatoes of approx. 100 lbs. on her back, (8) Fumigating with a tank on her back.

For assessing and determining the risk levels related to postural load, repetitiveness, trunk angles, upper and lower limbs, handled loads, transportation distances and grip type, several known methods (RULA, REBA, GINSHT y AWBA) were applied, focusing on their sensitivity for assessing the difficult analyzed tasks. It was determined that the assessment is unable to discriminate the risk level in most of the cases [6, 7].

In order to provide more sensitivity to risk determination in the uppermost area, the most suitable method, REBA, is modified [7]. The modified method is called MREBA, and it is applied to all the activities; then, the results are compared to the ones obtained with the known methods, in order to validate the modified method.

Fig. 1. Photos of indigenous women performing agricultural work while they carry children fastened to their backs with a blanket.

3 Results

In the selected tasks, we can see women performing repetitive movements while adopting inadequate postures, women performing domestic and agricultural tasks while carrying a child on their backs, frequent trunk rotations, and transportation of considerable loads, which are moved and pushed with a bent back, all of which make it difficult to assess activities with traditional ergonomic methods.

To propose the MREBA, the REBA is first applied, as this method was selected because it suits the study objectives better. Then the changes made to REBA are described and justified:

1. *Modification of the partial scores of Group A (trunk, neck, legs)*

It is considered necessary to include specific characteristics in load handling by indigenous women, as their usual activities consist of regularly handling heavy loads, such as sacks of agricultural products that range between 20 and 50 kg; also, they perform many of their activities with a child fastened to their backs.

When they perform the activities, we could see that they lift loads from the ground, with extended arms, in a standing, sitting or kneeling position. We could also see that the lifting is performed with a twisted and/or rotated trunk and asymmetrical load, and that the working period is over 8 h. All these remarks are detrimental in terms of ergonomics and health.

It is proposed to consider the body weight of the persons performing the activity, which is based on the studies conducted on load handling [8–11], where it is established that the recommended load must be approximately 10% of the body weight, and that the upper weight limit must be one eighth (12,5%) of the body weight, considering that the load may be carried on the upper or lower portion of the back, on one shoulder or on one hand.

Regarding the metabolic expense, the results show that carrying a load on one hand results in maximum metabolic expense increases [8] and that there is a relationship between the presence and intensity of pain and the weight of the load [11].

MSD, specially lower back pain, are associated to the transportation of loads and ground typology, as well as load grip or fastening characteristics; indigenous women generally carry loads on their backs and walk long distances with them along roads and harvest fields that are characterized by having a slope of up to 45º, as seen on Fig. 2. These tasks require a coactivation process to stabilize the spine while increasing muscle activity and, therefore, put compression and cutting loads on intervertebral discs [12]; the latter intensify according to the inclination and rotation angle of the trunk and load weight, size, and shape [13, 14]. Therefore, this is a risk factor in pathologies, such as back pain. When considering the metabolic expense, it is understood that the greater the land slope, load, or traveled distance, the greater the metabolic cost [15].

(a) (b) (c)

Fig. 2. Indigenous women of the Ecuadorian highlands carrying a load on their backs; 2a: sack of vegetables that weights approximately 100 lb; 2b: fumigation tank that weights approximately 50 lb; 2c: bulk of grass that weights approximately 30 lb.

Based on all these statements, the partial score of Group A is modified. The calculation of this score in REBA and how it is modified is shown below:

REBA: for a load or force below 5 kg. with a score of 0, the load or force between 5 and 10 kg. with a score of +1 and the load or force above 10 kg. with a score of +2. In addition, if the force is suddenly applied, one additional unit must be added to the score above.

MREBA: for a load or force below 10% of the body weight with a score of 0, the load or force between 10% and 12.5% of the body weight with a score of +1 and the load or force above 12.5% of the body weight with a score of +2. In addition, if the load is carried walking uphill, the score increases +1; if loads are carried asymmetrically, the score increases +1; if it is carried on the back, the score increases +1.

2. *Modification regarding daily transported load limits and distances*

In order to consider the total weight of the load handled on a daily basis, as well as the travelled distance, and on the basis of the GINSHT method, the Total Daily Transported Weight (PTTD), defined as the total kilos that the worker transports on a daily basis [11], is included, and it is calculated with the following Eq. (1):

$$\text{PTTD} = \text{Real weight} \times \text{Handling frequency} \times \text{Total task duration} \tag{1}$$

Then, the PTTD value is used to determine if the risk is Tolerable or Not Tolerable, as detailed in Table 1.

Table 1. Daily transported load limits for an 8-h shift, depending on the distance [16].

Transportation distance	Transported kilos/day (recommended maximum)	Risk
Up to 10 m	PTTD $\leq$ 10,000 kg	Tolerable
	PTTD > 10,000 kg.	Not Tolerable
More than 10 m	PTTD $\leq$ 6,000 kg	Tolerable
	PTTD > 6,000 kg	Not Tolerable

Once the modifications and adaptations are made to the method, it is applied to the 8 tasks and compared to traditional methods (Table 2), showing the comparison between the risk levels of the different assessment instruments, including MREBA. The results show that, in the case of tasks 1, 3, 4 and 6, where there is no load transportation, the results are similar concerning postural load. Now, for task 2, the risk level per postural load with REBA and MREBA es medium; however, when assessing the risk factor per load transportation with MREBA, a not tolerable risk level is obtained because the transported load exceeds the daily load limit.

For task 5, the risk level per postural load with REBA and MREBA is different, going from a High to a Very High level, respectively, because in the MREBA, the fact that the load is carried on the back as well as the load weight to body weight ratio are taken into account. This shows that, while scores are not different to a great extent, the MREBA has a greater sensitivity when calculating risk level, and it is consistent with the AWBA when it comes to load transportation, due to the short distance.

For the tasks 7 and 8, the analysis is consistent with that of task 5 when comparing REBA and MREBA and AWBA; however, when it comes to load transportation including the PTTD of the GINSHT method, the MREBA yields a result of a Not Tolerable risk level, since the relationship between the real transported weight with the handling frequency and the total duration of the task exceed the recommended limits.

Table 2. Results of the application of the tools RERA, RULA, AWBA and MREBA.

Task	REBA S (1–15); AL (0–4)	RULA S (1–7); AL (1–4)	AWBA RL (1–4)	MREBA		Recommendation
				S (1–15); AL (0–4)	Load transportation	
1. Kneeling washing clothes	S 10; AL 3 RL high	S 7 RL 4	RL 4 Very high	S 10; AL 3 RL high	NLT	Posture with harmful effects for the MES. Corrective actions are required as soon as possible
2. Handling fertilizers	S 7; AL 2 RL medium	S 7 RL 4	RL 4 very high	S 7; AL 2 RL medium	RL: Not Tolerable	Posture that is likely to harm the MES. Corrective actions are required in the near future
3. Harvesting potatoes	S 10; AL 3 RL high	S 7 RL 4	RL 4 very high	S 10; AL 3 RL high	NLT	Posture with harmful effects for the MES. Corrective actions are required as soon as possible
4. Standing up washing clothes	S 7; AL 2 RL medium	S 7 RL 4	RL 4 very high	S 7; AL 2 RL medium	NLT	Posture that is likely to harm the MES. Corrective actions are required in the near future
5. Tilling soil while carrying child on back	S 8; AL 3 RL high	S 7 RL 4	RL 4 very high	S 11; AL 4 RL very high	RL: Tolerable	The load caused by this posture has very harmful effects for the MES. Corrective actions are required immediately
6. Washing radishes	S 10; AL 3 RL high	S 7 RL 4	RL 4 very high	S 10; AL 3 RL high	NLT	Posture with harmful effects for the MES. Corrective actions are required as soon as possible
7. Carrying potatoes bulk approx. 50 kg	S 9; AL 3 RL high	S 7 RL 4	RL 4 very high	S 12; AL 4 very high	RL: Not Tolerable	The load caused by this posture has very harmful effects for the MES. Corrective actions are required immediately
8. Using manual sprayer	S 8; AL 2 RL high	S 7 RL 4	RL 3 high	S 11; AL 4 very high	RL: Not Tolerable	The load caused by this posture has very harmful effects for the MES. Corrective actions are required immediately

S Score; AL Action Level; RL Risk Level; NLT No load transportation; MES Musculoskeletal system.

4 Conclusions

After the MREBA is applied to the selected activities, it is more efficiently quantified that Ecuadorian indigenous women are generally exposed to heavy postural loads by continuously adopting extreme postures, such as elevated trunk, arms, and wrists angles, due to the demands of the tasks they perform. Additionally, the transportation of children, agricultural product sacks, grass, among others, on the back in an asymmetrical manner is considered, and it usually exceeds the recommended value of 10% of the body weight of the woman transporting the load.

The adapted method based on the REBA method can better assess the risk level to which indigenous women are exposed, but when simple tasks are assessed, the MREBA reports the same risk level as traditional methods. This supports the proposal that these methods underestimate risks, especially in tasks when loads are handled and transported.

Severe spine deformations in elder indigenous women, specially scoliosis and pelvic retroversion, which do not coincide with the typical deterioration caused by age and are not present in the male population [4], evidence the consequences of exposure to postural load and load transportation. Therefore, an improvement of the conditions in which agricultural and domestic activities are performed is recommended, as well as an ergonomic and training intervention in the study population.

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Analysis of Physiological Signal Characteristics of Persons Working at High Place

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Abstract. To enforce the management to the workers, measures should be taken to monitor the work's condition. 30 subjects are selected for the experiments, which are performed in three scenarios, working on the ground, working at 2.0 m high with protective equipment, and working at 2.0 m high without protective equipment. The physiological signal data are obtained through the synchronization platform. Effective physiological signal fragments are extracted, and physiological signal data are extracted. Being compared with working on the ground, the results indicate that there are significant differences on Electrocardiogram (ECG) and Photoplethysmography (PPG) when working at high place whether the subjects wear the safety belt or not. Therefore, ECG and PPG should be paid more attention on the using of recognition, supervision, and improvement to the persons at high place.

Keywords: Working at high place · Physiological signal · Variance analysis · Electrocardiogram (ECG) · Photoplethysmography (PPG) · Difference analysis

1 Introduction

In recent years, falling accidents caused by persons working at heights are increasing. In China, the rate of accidents falling from heights accounted for 47.83% of building construction accidents [1]. Falling accidents from high places around are also rank first in the world construction accidents [2, 3]. Scholars in China and abroad mainly discuss and study the causes of fall accidents and preventive measures. For example, Yuan [4] proposed that regular or irregular surveys of hidden dangers of fall accidents should be conducted during the construction process. Safety and technical knowledge should be provided to operators, and it should be isolated if the hidden danger of falling from a height cannot be eliminated. Liu et al. [5] found that the dangers of working at high place include falling injuries, injuries from falling tools, and falling injuries from high blood pressure caused by mental stress. Kim et al. [6] provides safety management guidelines for workers and safety managers to prevent previous falls on construction sites. Harjoto et al. [7] found that the incidence of fall accidents at high place is closely related to corporate social responsibility. The stronger the corporate social responsibility awareness, the lower the probability of occurrence.

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Most of the current researches are from the point of management, and there are fewer studies based on the physiological characteristics of high-rise operators. Based on this, six physiological signals are collected in the three designed scenarios: normal operation on the ground, operating at high place without safety belt, and operating at high place with safety belt. The obtained data are analyzed and compared between each two designed scenarios in order to researching the rules of changes in physiological signals when working at high place.

2 Experiment

2.1 Subjects

30 subjects are selected for the experiments, 15 males and 15 females, aged 21—45, with an average age of 26 years. The participants are in good health and voluntarily in completing this test.

2.2 Experiment Equipment

Human-machine-environment synchronization platform, including electrocardiogram (ECG), electromyogram (EMG), electrodermal activity (EDA), respiration (RESP), photoplethysmography (PPG), and skin surface temperature (SKT); 2.0 m high experimental platform.

2.3 Experimental Procedure

1. The subject completes the specified exercise on the ground of the laboratory, and the subject's physiological signal is measured for 5 min to obtain the basic signals. The data obtained in this experiment is named experiment 1.
2. 15 min after1, the subject stands at the place which is 2.0 m higher than the ground and completes the same action without safety belt in 5 min to obtain the physiological signals of the subject. The data obtained in this experiment is named experiment 2.
3. 15 min after 2, the subject stands at the place which is 2.0 m higher than the ground and completes the same action with safety belt in 5 min to obtain the physiological signal of the subject. The data obtained in this experiment is named experiment 3.

In order to increase the accuracy of the data, experiment 1, 2 and 3 are all carried on two times to avoid the influence of unexpected factors.

3 Data Analysis

The collected data are intercepted for a stable period of 3 min. The data are extracted and tested for difference to analyze the physiological signal characteristics of the subjects in different experiments. Because the physiological signal values of the clips are continuous variables, analysis of variance (ANOVO) and Kruskal-Wallis rank sum test are used to analyze the physiological signal distribution rules of the subjects in three different working situations.

3.1 Normality Test

SAS statistical analysis software is used for normality tests of single physiological signal segment in three scenarios. The results of the two tests are processed uniformly to increase data accuracy.

Experiment 1, 2, and 3 are used to represent data of normal operation on the ground, operation on high place without protection and high-level operation with protection, respectively. A detection level of 0.05 is used. The data of the ECG signal in the experiment 1 is taken as an example to illustrate, as shown in Table 1. According to Shapiro-Wilk shown in Table 1, (Pr < W) = 0.1102. That is, P-value is greater than 0.05, and the subjects' ECG signal data meet the normal distribution in experiment 1.

Table 1. Data analysis of ECG signal in experiment 1

Test	Statistic		p -value	
Shapiro-Wilk	W	0.766793	Pr < W	0.1102
Kolmogorov-Smirnov	D	0.292474	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.501327	Pr > W-Sq	0.0511
Anderson-Darling	A-Sq	2.700931	Pr > A-Sq	0.0677

3.2 ANOVO

The physiological signal detection results are shown in Table 2. In the three experiments, the subjects' PPG signals are all meet normal distribution, therefore, analysis of variance can be used to compare normal distribution data of the experiments. The ECG signal data conform to the normal distribution only in experiment 1 and experiment 2. The RESP signal conforms to the normal distribution only when working at high places as in experiment 2 and experiment 3. The rest signals do not show a normal distribution in all operating states.

Table 2. Results of normality of physiological signals

Experiment	ECG	EDA	EMG	PPG	RESP	SKT
1	√	×	×	√	×	×
2	√	×	×	√	√	×
3	×	×	×	√	√	×

Note: "√" means the data in the experiment conforms to the normal distribution; "×" means the data in the experiment does not conform to the normal distribution

1. PPG Analysis

Table 3. Results of PPG analysis in the experiment

Source	Degrees of freedom	F-value	Pr > F
Experiments	2	11.36	<0.0001
Error	86		
Total correction	88		

From Table 3, (Pr > F) < 0.0001 means that value of P is less than 0.05. The analysis of total variance shows that the difference among the three experiments is statistically significant. It can be seen from Fig. 1 that the difference between experiment 1 and experiment 2, 3 is obvious, while the difference between experiment 2 and experiment 3 is small.

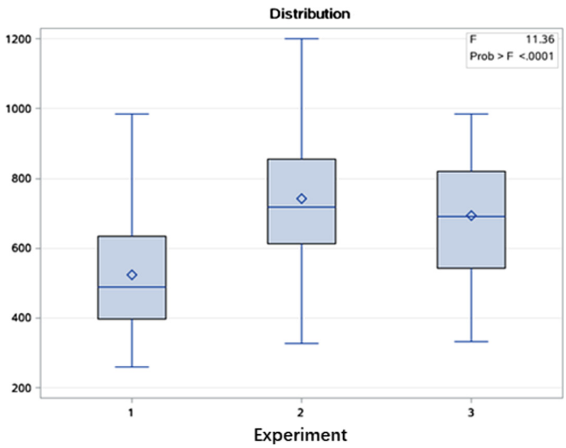

Fig. 1. PPG box-plot of three experiments

2. Test of homogeneity of variances

Table 4. Homogeneity test results of pulse signal variance

Source	Degrees of freedom	Chi-square	Pr > Chi-square
Experiments	2	1.8055	0.4055

Table 4 shows the homogeneity of variance test results. The test of homogeneity of variance (P = 0.4055) indicates that F test can be used in the analysis to the experiments. The test results are shown in Table 5.

Table 5. Comparison of mean and standard deviation of PPG

Experiment	Mean	Standard deviation
1	524.262069	169.643013
2	741.040000	208.540435
3	692.667667	167.205510

Table 5 shows the difference of PPG signal in the three experiments. The mean shows there is significant difference between working on the ground (524.26) and working on the high place with safety belt (692.67) or without safety belt (741.04). The difference of working on the high places between wearing safety belt and not wearing safety belt is only a little. The specific comparisons between groups need to be performed.

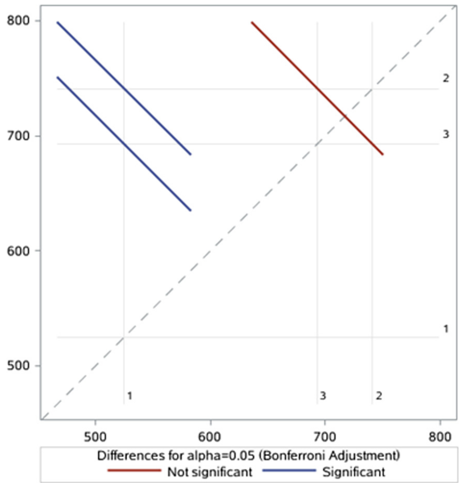

Fig. 2. Pairwise comparison of PPG

Table 6. Pairwise comparison of PPG in three experiments

Experiment	1	2	3
1	–	<0.0001	0.0020
2	<0.0001	–	0.9259
3	0.0020	0.9259	–

The pairwise comparison of PPG signal is shown in Fig. 2 and Table 6. It shows that there is significant difference ($P < 0.0001$) between experiment 1 and experiment 2. Also, there is significant difference ($P = 0.0020$) between experiment 1 and experiment 3 while there is no significant difference (P = 0.9259) between experiment 2 and experiment 3. It shows that there is a significant difference in PPG signal between working on the ground and working at high place whether the subjects use safety protection devices or not.

3.3 Rank Sum Test

The ECG data of the subjects do not conform to the normal distribution in the context with safety belt, then it only can be compared by multiple sets of non-normal distribution data. The rest of the data are analyzed by the Kruskal-Wallis test.

ECG signals are taken as an example, multiple sets of rank sum tests are performed.

1. ECG rank sum test

The ECG signal test results are shown in Table 7.

Table 7. ECG signal rank sum test

Kruskal-Wallis test		Wilcoxon rank sum test	
		Experiment	Mean
Statistics	10.2697	1	34.0333
Degrees of freedom	2	2	55.5000
Pr > chi-square	0.0059	3	46.9667

Table 7 shows the results of the Kruskal-Wallis test (P = 0.0059), suggesting that the total difference among the three experiments' data is significant, but it does not specify the experiments which have significant difference. Judging from the rank sum, the subjects have the highest signal mean (55.5000) when working at high place without safety belt, and the lowest mean (34.0333) when the subjects are on the ground. However, the differences required further comparison between the experiments.

2. ECG comparison between two of the experiments

The comparison results of the ECG signal rank sum test are shown in Table 8.

Table 8. Comparison of ECG signal rank sum test between each two experiments

Experiment	Wilcoxon Z	DSCF value	Pr > DSCF
1 vs. 2	−3.0012	4.2444	0.0076
1 vs. 3	−2.0846	2.9481	0.0930
2 vs. 3	1.4341	2.0281	0.3233

Table 9. Rank sum test results of other physiological signals

	EDA	EMG	RESP	SKT
Statistics	0.8233	1.7494	4.0238	2.0573
Degrees of freedom	2	2	2	2
Pr > chi-square	0.6626	0.4170	0.1337	0.3575

According to Table 9, no significant difference is found in EDA, EMG, RESP, and SKT in the three experiments. The significant differences in ECG signal and PPG signal prove that if the workers are performing work at heights, physiological signals can be detected, and the safety management could be strengthened to the workers to reduce the risk of accidents in the future.

4 Conclusion

1. At the significance level of 0.05, there is significant difference only in PPG signal when working at high place (2 m higher than the ground) with or without the safety belt compares with working on the ground. And at the significance level of 0.10, there are also significant differences in ECG signal.
2. There is no significant difference in ECG signal ($P = 0.3233$) and PPG signal ($P = 0.9259$) working at high place (2.0 m higher than the ground) between wearing safety belt and without safety belt.
3. After performing multiple sets of rank sum tests on EMG, EEG, RESP, and SKT signal, there are no significant difference at the level of 0.10. It proves that working on the high place has little relationship with these signals whether wearing the safety belt or not.

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Ergonomics of Date Palm Irrigation Work: Algerian Foggara as an Example

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Abstract. The Foggara as a traditional irrigation method is still used in Algeria, especially in the western deserts (Touat, Gourara, and Tidikelt regions). Human work at the Foggara system can be a digging work, maintenance work, or distributive work. In this research, the maintenance work is studied with the aim of shedding some light on tasks the worker performs while maintaining the Foggara, how much effort the worker makes to maintain it and the body areas that are exposed to the greatest possible fatigue. To complete this research, data were collected from 37 Foggara maintenance workers using Interview, Borg scale, and the Nordic scale. It has been found that the major Foggara maintenance task was: clean and repair the Foggara, the effort required to maintain the Foggara is high and the workers are exposed to high levels of physical discomfort while doing the maintenance work.

Keywords: Agriculture · Irrigation · Foggara · Date Palms · Algeria

1 Introduction

Agriculture was and is still the backbone of almost all the countries of the world especially developing countries. Likewise, farmers are the major pillars of agriculture. If farmers' concerns are not addressed, agricultural sector will not adequately develop. One of the main tasks of farmers is the watering (irrigation) either by traditional methods (pulley-system, chain pump, Foggara, and pump systems) or modern methods (drip, sprinkler and bubbler systems).

Many researchers [1, 2] point out that about 70% to 90% of water is consumed by agriculture. Whenever water is available for agriculture, production is adequately provided. Date Palms, unlike many other plant species, need plenty of water especially in the hot months (June- September) [3].

In Algeria, which has a large number of date palms estimated of about 18 million date palms [4], both traditional and modern watering methods are used. It should be noted, however, that the use of traditional methods is decreasing. The main reason is that surface water is diminishing. On the other hand, drip system as a modern watering system, is increasingly used especially in newly cultivated groves [2, 5].

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One of the traditional irrigation methods used in Algeria, especially in the western deserts, is the Foggara system. The Foggara is an irrigation system composed of several integrated parts that are as follows:

1. An artesian deep well drilled vertically to a depth ranging from 10 m to 40 m, to access groundwater.
2. An underground tunnel connected at the base level of the main well, with a varying diameter ranging from 50 to 80 cm, with a slight slope that allows water to flow through the tunnel to reach the date palm orchards.
3. A series of artesian slightly shallow wells to ventilate and maintain the underground tunnel.
4. A covered ditch (Sakia) that extends from the point where the canal reaches the surface of the earth to the Kasria.
5. The distributer (Kasria): The point at which the covered Sakia ends. It works to distribute water to its beneficiaries (owners of the farms and houses), using a serrated stone.

This type of irrigation (Foggara) has been widespread in date palm groves of the Western region in Algeria. Previously, the number of Foggaras was in the thousands. However, nowadays, the number is decreasing. According to Bellal et al. [6], on the 2000 Foggaras inventoried in the province of Adrar in 2016, 1278 Foggaras are dried up due to lowering of the water table.

The Foggara system doesn't exist only in Algeria, but it exists in most Arab countries [7]. Hofman [8] noted that more than 35 countries in the world are using this technology.

Human work at the Foggara system can be divided into three categories:

- Digging work: Such as digging the wells, tunneling the tunnels, and mining the shafts.
- Maintenance work: Such as maintaining the well, shafts and tunnels, cleaning the tunnel, and sterilizing water.
- Organizational work: It includes equitably distributing water among palm plantations, and collecting fees from participants.

In this research, maintenance work is studied with the aim of answering the following questions:

1. What are the functions of the Foggara maintenance worker?
2. How much effort should the worker make to maintain the Foggara?
3. What areas of the body are exposed to the greatest possible fatigue?

2 Method

2.1 Sample

Data were obtained from 37 Foggara maintenance employees. All of them were randomly selected males. All participants were informed about the purpose of the study and have given a written informed consent to participate in the study. Subjects differed in terms of work seniority. The majority of participants (58%) have been doing the maintenance work for 18 years. However, seniority of the remaining workers ranged from (02) years to (07) years. In addition, the educational level of participants ranged from the primary level (70%) to the intermediary level (27%) to the secondary school (01%). To recruit the participants, convenience sampling (availability sampling) was used. Table 1 shows some demographic data for subjects.

Table 1. Some demographic data for subjects

City	Number	Mean age (y)	SD
Timimoun	13	50	5.1
Oulef	05	53	5.8
Tamentit	04	51	7.2
Adrar	15	49	7.4
Total	37	50.7	6.3

2.2 Data Collection Tools

To collect data for this research, the following tools were used:

1 *The Interview*. To identify the tasks performed by Foggara maintainers, subjects were interviewed by the researchers individually (Oulef, and Tamentit workers) and collectively (Timimoun and Adrar workers). According to Aamodt, the group interview gives almost similar results to the individual interview [9]. The results obtained were recorded in the form of Likert-type five-point scales (from 01 to 05).

2 *Borg Scale*. The Borg Rating of Perceived Exertion (RPE) scale developed by the Swedish researcher Gunnar Borg, is a tool for measuring an individual's effort and exertion, during physical work [10]. Earlier studies [11, 12] showed that the scale was valid and reliable. The participants were asked to report the RPE value on the Borg CR-10 scale (Table 3) twice: Just before they start the work and at the end of the work. In both cases, workers were asked the following question: "How hard you feel your body has worked?" The workers determined on the form what suit their tiredness.

3 *The Nordic Questionnaire*. This was used to assess the work-related musculoskeletal disorders (WRMSDs) among Foggara workers. The workers were asked about feeling of WRMSDs and in which body region (s). Before its use, the questionnaire was translated into Arabic. Regarding the validity and reliability of the questionnaire, the researchers relied on earlier studies [13, 14] which found that the questionnaire was valid and reliable.

3 Results

3.1 What Are the Functions of the Foggara Maintenance Worker?

It has been found that the functions of the Foggara maintenance worker are as depicted in Table 2.

Table 2. The functions of the Foggara maintenance worker with importance.

No	Function	Importance
1	Go down to the depths of the wells and climb out from them	4.75
2	Clean and repair channels, wells, and shafts	4.25
3	Fills the bucket with silts, alluviums, and debris, and orders the external worker to raise it	4.03
4	Check the well cover (the well cap) on top of the well to ensure it is in good condition	3.93
5	Perform minor works such as fixing the new well bricks, removing the worn bricks and stones, patching the worn buckets, changing the torn ropes, etc	3.89
6	Collaborate with workers and other professionals during renovations	3.82
7	Report to a supervisor for issues or emergency cases	3.71
8	Diagnose faults in the wells, shafts and channels	3.53

The workers stipulate that going down and climbing from the well is a very important task in the maintenance of the Foggara. Without going down to the bottom of the well, maintenance cannot take place. It was found that the majority of workers use the rope and the holes and/or burrs in the wall of the well during the descent. They explained that the process is difficult and dangerous as the worker can slip and fall into the depths of the well and may die as what happened to some workers in the past.

It is clear from the results that the diagnosis of possible problems in the wells, vents or water tunnels was a task of little importance compared to other tasks. This may be justified because these problems are rare in Foggaras. As for the rest of the tasks, they came in importance between these two tasks.

In addition, it should be noted that the workers, despite their long experience in the field of Foggara maintenance, did not refer to two tasks the researchers consider as an integral part of the tasks of Foggara maintenance, namely (Ensure that the Foggara water does not mix with sewage or other contaminated water, and help carry out the yearly disinfection of the Foggara water). But when the new tasks were presented to them, they agreed that they are and should be a part of the Foggara maintenance. This fact can be attributed to the limited scientific knowledge of Foggara maintenance workers who are illiterate or semi-illiterate.

3.2 How Much Effort Should the Worker Make to Maintain the Foggara?

Results show that the Foggara maintenance workers are exposed to high levels of physical discomfort and psychological stress while doing the maintenance work (see Tables 3 and 4).

Table 3. Fatigue level determination form

No	Fatigue level	Response before doing the work	Response after finishing the work
1	Extremely light	18	00
2	Very light	17	00
3	Light	02	00
4	Moderate	00	00
5	Moderate plus	00	00
6	Hard	00	17
7	Hard plus	00	13
8	Very hard	00	02
9	Very hard plus	00	03
10	Extremely hard	00	02

Table 3 shows that before work, workers are not subject to great levels of fatigue. But after work they are suffering a lot of fatigue. In addition, it is clearly seen in Table 4, that t-test is highly significant showing that after work, workers are subject to heavy load. Therefore, the work in the Foggara maintenance is considered hard.

Table 4. t-test results comparing RP for workers before and after work

Status	n	Mean	SD	t-test	df	p
Before work	37	1.54	0.55	25.35	72	0.001
After work	37	6.91	1016			

When comparing these results with those of [15], it becomes clear that working in Foggara is more difficult than many types of agricultural work. The reason may be the work is done underground in a confined space, filled with emotional fear caused by the feeling that the well or tunnel can collapse at any moment. Researchers have shown that working in confined spaces is physically and psychologically strenuous and risky [16].

3.3 What Are the Most Affected Body Parts While Doing the Foggara Maintenance Work?

Table (5) shows that lower back 29 (86%), the shoulders 27 (78%), the knees 27 (73%), the neck 23 (62%), were the most affected parts during the previous week.

Moreover, the values of Chi square (χ^2) test for these body areas were statistically significant. However, during the last 12 months, it has been found that lower back 29 (78%), shoulders 28 (76%), neck 26 (70%), knees 22 (59%), feet 26 (70%), were the most commonly affected body areas. Similarly, (χ^2) values for these body areas were statistically highly significant.

To understand such results, we ought to remember that Foggara maintenance work is done in tight, and underground spaces. Digging in the well or tunnel while cleaning it, can cause the whole well or tunnel to collapse. Some maintenance workers say that when they go out safely from the well and the tunnel, they praise Almighty God for safety. The danger of this profession is similar to that of miners' work. In terms of safety, both are unsafe [17].

Table 5. Foggara maintenance affected body parts

Body parts affected by WRMSDs	Response	Previous seven days		χ^2 value	P-value	Previous 12 months		χ^2 value	P-value
		No.	%			No.	%		
Neck	Yes	23	62	2.189	P < 0.139	26	70	6.081	P < 0.014
	No	14	38			11	30		
Shoulders	Yes	29	78	11.91	P < 0.010	28	76	9.757	P < 0.002
	No	08	22			09	24		
Elbows	Yes	07	19	14.29	P < 0.000	09	24	9.757	P < 0.002
	No	30	81			28	76		
Wrists/hands	Yes	08	22	11.91	P < 0.010	10	27	7.811	P < 0.005
	No	29	78			27	73		
Upper back	Yes	05	14	19.79	P < 0.000	08	22	11.91	P < 0.010
	No	32	86			29	78		
Lower back	Yes	32	86	19.79	P < 0.000	29	78	11.91	P < 0.010
	No	05	14			08	22		
Hip	Yes	12	32	4.568	P < 0.033	34	92	25.973	P < 0.000
	No	25	68			03	08		
Knees	Yes	27	73	7.811	P < 0.005	22	59	1.324	P < 0.250
	No	10	27			15	41		
Feet	Yes	18	49	0.027	P < 0.869	26	70	6.081	P < 0.014
	No	19	51			11	30		

4 Conclusion

The present research tried to answer the above three questions. The results showed that the most important function of Foggara maintenance workers is to go down to the bottom of the well and climb from it. Also, it was found that workers make a great effort while maintaining the Foggara. Finally, the most important areas of the body suffering from extreme fatigue are the lower back, shoulders, upper and lower limbs. In the end, the research shed light on the ergonomic problems experienced by a number of workers in a traditional sector of agriculture, which is watering date palms by the Foggara.

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Analysis of Laboral and Non-laboral Risk Factors of Workers Diagnosed with Lumbar Pathologies. Study of Cases

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Abstract. An analysis is presented of occupational and non-occupational risk factors of four workers diagnosed with lumbar pathologies in a pet food manufacturing company. Through a survey, individual aspects were investigated, exposure to risk factors present in the working conditions of the task, the environment and organization, as well as extra-labor factors according to scientific literature. Occupational antecedents were found by carrying out load handling activities and exposure to factors of the three dimensions described. Regarding the extra-labor component, they have carried out activities similar to those outside the working day. The above is corroborated according to literature given that structures of the lumbar spine can be subjected to excessive compression and shear forces plus the presence of muscle fatigue, amplified by job characteristics, organizational and extra-labor aspects. It is required to determine criticality levels of these factors and more studies in this regard.

Keywords: Low-back pain · Radiculopathy · Risk factors · Working conditions · Non-laboral risk factors

1 Introduction

Lumbar pathologies (LP), resulting from alterations in structures that make up the lumbar spine, represents a serious health problem. It is the second leading cause of consultation in general medicine, after respiratory diseases and in western societies its incidence varies between 60% and 90% [1].

In the labor context, the causes of PL are multiple [2]. Among the possible etiologies, biomechanical factors have been cited such as lifting loads, inadequate postures, among others, environmental factors such as exposure to extreme temperatures or noise, as well as aspects of the organization of work [1, 2]. However, on extra-labor factors and their involvement in the generation of musculoskeletal disorders there is little literature [3]. These factors are understood as those situations outside the workplace that, combined with occupational requirements, can create overloads in health conditions [4, 5].

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This exploratory study makes the characterization and respective analysis of labor and extra-labor factors to which four workers diagnosed with PL reported during the period 2015–2016 have been exposed in a pet food manufacturing company in a municipality in Cundinamarca, Colombia. A theoretical support element is provided for occupational safety and health training professionals and stakeholders, presenting an analysis of how intra-labor and extra-labor factors interact with the health conditions of workers. The study seeks to provide elements for future studies of greater complexity on working conditions, which facilitate decision-making in the approach of control measures considering the participation of other elements in the analysis.

2 Materials and Methods

This study was authorized by the respective units of the company, the objective of the same was presented to 4 workers diagnosed with discopathies at level L4–L5 or L5–S1. Upon signature of informed consent, a questionnaire was applied that looked at risk factors to which workers had been exposed.

This instrument checked five dimensions related to individual aspects, aspects of the work environment, aspects of the task, organizational aspects and extra-labor aspects. Each of these categories examined a history of exposure to risk factors associated with PL according to scientific literature, as described in Table 1. The information collected was organized to identify factors present and subsequently perform the respective analysis. The study was approved by the research ethics committee of the Corporación Universitaria Minuto de Dios, Bogotá (Colombia).

Table 1. Description of variables considered in the case study for analysis.

Categories	Study variables
In the individual	* Supervising health conditions through medical examinations * Work background in terms of activities with loading handling
In the work environment	* Exposure to low temperatures. * Perception of exposure to annoying noise * Exposure to full body vibrations
In the task	* Correct gesture application to lift loads from the floor * Prolonged position in two-footed * Frequent movements of rotation or inclination of trunk * Availability, training in the use and maintenance of mechanical aids to handle loads * Limited dimensions of the space where loads are handled * Allowable manipulated weight, shape and volume of load
In work management	* Performing overtime executing activities involving handling loads * Extension of working day carrying out activities with load handling * Impossibility to leave the post due to alteration in the production process * Work rate imposed by machines or production goals * Insufficient time to ask for help from a colleague to manipulate objects * Simultaneous task involving load handling
Extra labor factors	* Outside-work activities involving work load handling more than three times in the month * Sports activities involving work load handling

Source: author

3 Results

The average age of the workers was 53 years and reported that they had carried out activities related to work load handling in previous jobs. In terms of working environment factors, the total population reported perceived annoying noise and exposure to full-body vibrations.

In relation to task factors, the total population reported having performed within their activities gestures with inclinations and trunk rotations, also reported having insufficient knowledge in the use of mechanical aids and have used these tools with some deterioration or imperfect. The total workers reported handling loads with weights greater than permissible. At least one of the workers reported difficulty alternating their bipedal posture during the execution of the tasks, the workplace space has not allowed them to apply the load-lifting gesture correctly, and the load they have handled has been presented difficulty handling it by its characteristics.

Regarding the organization of work, the total population reported that they have worked overtime or for days longer than 8 h and pointed out situations where the pace of work has been imposed by the machine or production goals. At least one of the workers indicated that there has been a situation of disruption in production if he withdraws for a while from the job, not having enough time to request help in lifting a high weight burden and difficulty take breaks.

In this regard to extra-labor factors, the total workers indicated that they have carried out activities outside the company that involved handling loads at least more than three times a month.

4 Discussion

4.1 Individual Aspects

Among the findings it was found that the working population diagnosed with PL was an average of 53 years of age. Over time collagen, the main component of structures such as the intervertebral disc, loses its mechanical properties decreasing resistance to different types of forces, among other things by water loss. This can decrease the ability to store energy and its respective distribution of loads [2, 6, 7].

Workers reported labor background, activities in other jobs involving load handling. This may be associated with increased exposure time to a number of risk factors that may favor injuries to the lumbar region [7, 8].

4.2 Aspects of the Labor Environment

In terms of the work environment was concerned, they reported the perception of annoying noise. Such an aspect is necessary to deepen by the extra-hearing effects identified at the physiological level such as the increase in muscle tone [9]. As for whole body vibration it has been suggested that exposure can lead to fatigue of spine structures, similar to mechanical structures, which can contribute to degenerating the intervertebral discs [7, 10].

4.3 Aspects of the Task

On the factors regarding in the task, the inclinations and rotations of the trunk promote at the level of the column the asymmetrical distribution of compression and shear forces in the intervertebral discs that would be aggravated if weight handling is added permissible, if the characteristics of the load make it difficult to grip or by the volume of the working load [6, 11].

In addition to the above, the dimensions of the work station may limit the correct positioning of the lumbar spine during the handling of objects [8]. On the other hand, depending on the characteristics of the task and the functions to be performed, the alternation of postures in the workplace can be limited which can facilitate the fatigue of the anti-gravitational muscles.

The possibility of increasing the risk of osteomuscular injury has been described by not performing a training or training process in the workplace [12]. Handling mechanical aids without proper preparation or under defective conditions would make it easier for the worker to apply inadequate gestures with the subjugation of soft tissues to excessive forces.

4.4 Work Organization Factors

In relation to factors identified in the organization of work, if a collaborator performs activities for longer periods of the working day could increase the likelihood of muscle fatigue injuries by overcoming their physical resistance [8, 12].

On the other hand, the fulfillment of goals, rhythms imposed by the machine or time-pressure situations can influence the mechanical load of soft tissues by changes or increases in postures, movements or forces exercised [13], as well as such situations would make breaks difficult and facilitate muscle fatigue.

4.5 Extra-Labor Factors

Regarding extra-labor factors, the possibility of exposure to situations similar to intra-labor issues has been raised, which would imply additional physical demands for gestures, postures or forces. This would generate microtrauma soft tissues with its chronic inflammatory process and facilitate inadequate healing processes for restricted recovery times [5]. In other words, it arises the possibility that risk factors in the workplace added to the time spent on extra-occupational activities can be an enhancing element for the generation of musculoskeletal pathologies.

The previous analysis takes an approximation of how the working conditions present in the task, environment and organization and the extra-labor factors can interact facilitating the generation of musculoskeletal disorders. These elements could be considered by occupational safety and health managers in organizations when managing the health conditions of their working population in similar situations.

As work is one of the social determinants of health it is necessary to analyze its conditions for the prevention of alterations in the health process in such a way that it is not affected by the extra-work component. This aspect is open for further analysis considering the influence of factors such as social ones. On the other hand, the quantification of these determinants would allow to establish their level of participation in the generation of these pathologies.

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Ergonomic and Occupant Issues Considering Elderly Female Pillion Rider Sitting Posture on Motorcycle in Indian Rural/Semi Urban Context

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Abstract. Background - In India most of the elderly female (pillion riders) of aged above 35 prefers sitting sideways upon motorcycles (commuting) in India. In this situation occupant, sitting/packaging issues have a major problem, refusing elderly female to get ride on motorcycle. Objective - The aim of this study is to find different ergonomic and occupant packaging issues including Work Related Musculoskeletal Disorders (WMSDs) mostly for elderly female (pillion rider) in Indian commuting motorcycles. Methodology – Observation, photography, analysis carried out. Result – Risk factor and discomfort of sitting sideways on existing motorcycle seat were higher (810 mm), demanding quick intervention. Conclusion - Ergonomic analysis and design intervention suggested by redesigning/optimizing the existing seat of the motorcycles considering pillion rider as elderly female.

Keywords: Motorcycle · Seat · Ladies · Indian context

1 Introduction

In India, Public transport widely used in metro cities. Mostly people used to commute with the help of two-wheeler instead of a car in Urban and semi-urban areas. India has 48.20% population of female [1]. Very less woman drive motorbikes, as the weight of the motorcycle, are high, and due to traditional dresses, they used to seat rear side. As the clothing, style in India for a woman is saree and there are about 108 types to wear saree [2]. Height of motorcycle are around 800 to 1000 mm [3]. As it followed since long back, and the clothing style is still in tradition. Due to this, they have to seat side posture on the rear side, which is risky to the seat, very unsafe, also causes lots of body pain, back pain, Improper visualization, neck pain. Hand joint pain.

To reduce body pain and risk, which causes the error. Therefore, it is essential to take feedback from the local community (Fig. 1).

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Fig. 1. Motorcycle rider with pillion female rider in Indian context

2 Materials and Methods

Two types of method adopted for collecting data from users and for testing the concepts. These were Observation and qualitative analysis.

2.1 Observation

In total, there were 20 observations done. The observation starts from the moment of starting of motorcycle and woman sitting on motorcycle until ride get started. It done using focus group [4] to get proper data and no task should missed.

2.2 Task Analysis

Different types of motorcycles seats analyzed for usability issues like size, placement, shape—this analysis done in two stages. In the first stage, seat, grab-rail, pedal stand, to different cognitive ergonomic principles have taken into perception. In the next stage, specific focus kept on these elements with the perspective of tactile, visual perception.

3 Result

3.1 Observation

It is difficult to seat for subjects as rear side and which is unsafe. In addition, some motorcycle do not have footrest or some do not have grab rail to take support.

Physical Characteristics of Subjects. Subjects mean age was 40 years old and mean experience was of 9 years (Fig. 2).

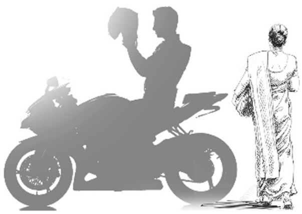

Fig. 2. Motorcycle rider with pillion female

3.2 Task Analysis

The subject has to perform the procedure to occupy on the seat. In the first stage, a biker needs to start a motorcycle. Preceded by subject has to hold the grab rail. Then, it needs to keep the right leg on foot guard after that subject needs to lift their own body to seat as pillion driver in sideways posture.

Start Engine – Turn side – Hold Grab rail by left hand – Put right hand on seat – keep left leg on footrest – seat on rear side – start journey.

By looking at all the issues which were observed and studied, it was clear that there need to be some changes in the rear side of the motorcycle, there was an unused space, very small foot guard for subjects to rest the leg. Below are the few solutions, which would be best to improve for the ergonomics of the pillion rider on a motorcycle.

If motorcycle height could manipulate.

Placing the comfortable reach foot stand to rest the leg.

Adding a fixed designated grab rail for both right hands left hand for the subjects.

A proper seating arrangement and back support for the subject to sit on when she wishes to rest.

4 Optimizations

4.1 Height of Motorcycle

Height for the rear seat has to be knew otherwise, a wrong height may increase the problems rather than solving it, for determining the optimal height anthropometric dimensions taken and further optimized to suit the situation (Fig. 3, 4 and Table 1).

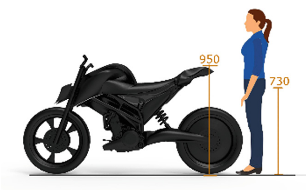

Fig. 3. Motorcycle height and women buttock extension height

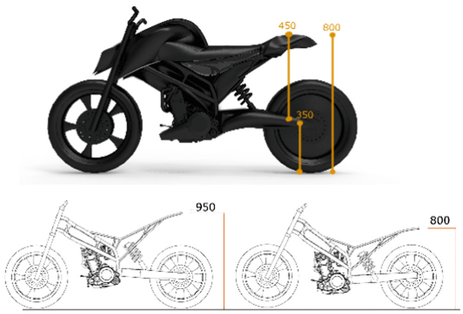

Fig. 4. Concept design change in motorcycle height

Table 1. Buttock extension

Percentile	5^{th}	25^{th}	50^{th}	75^{th}	95^{th}
Female	726	768	789	826	856

By the principle of reach and taking, the lowest of the lowest with take-off point at 726 mm. Which could rounded off to 730 mm. Further optimizations like adding tolerances would bump up the value to 800 mm, and as tested this height was comfortable to reach, therefore we considered this height [5].

4.2 Leg Rest

Elevation for the rear seat has to be knew otherwise a wrong height may increase the problems rather than solving it, for determining the optimal height, anthropometric dimensions were taken and further optimized to suit the situation (Fig. 5 and Table 2).

Fig. 5. Motorcycle with footrest design

Table 2. Height of popliteal

Percentile	5th	25th	50th	75th	95th
Female	365	386	399	417	441

By the principle of clearance and taken the minimum of the minimum value with a take-off point at 417 mm. Which rounded off to 450 mm. Further optimizations like adding tolerances would bump up the value to 470 mm and as tested this height was comfortable to clearance. As this height considered as pedal height [5].

Length of footrest.

Length for rear footrest has to be proper to rest (Table 3).

Table 3. Length of footrest

Percentile	5th	25th	50th	75th	95th
Female	207	217	227	234	249

By the principle of clearance and taken the minimum of the minimum value with a take-off point at 234 mm. Which rounded off to 230 mm. In addition, for the resting of foot half distance is more than enough for such a journey [5].

4.3 Seating

For determining the optimal comfortable seating position for the operator, following anthropometric dimensions taken and optimized. Proper sitting angle is 108° [7, 8] (Fig. 6 and Table 4).

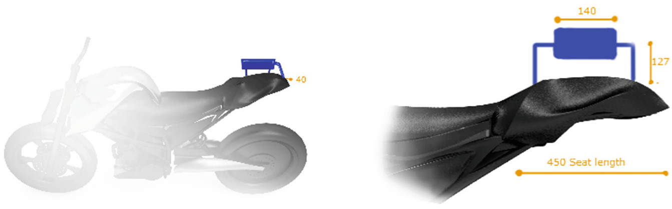

Fig. 6. Motorcycle rider with seat guard design

Table 4. Hip breadth

Percentile	5th	25th	50th	75th	95th
Female	259	296	314	341	429

By applying the principle of clearance here, we get the highest of the highest value with a take-off point at 429 mm. Further optimizing it by adding tolerance like clothes etc. the final optimized value at came at 450 mm [5] (Table 5).

Table 5. Length of the backrest – waist

Percentile	5^{th}	25^{th}	50^{th}	75^{th}	95^{th}
Female	197	216	231	447	289

By applying the principle of clearance here, we get the highest of the highest value with take-off point at 289 mm. Still, just support is needed no requirement to cover the full waist. Making design minimalistic and long lasting [6]. So, the optimized value would be around half that is 140 [5].

Height of the backrest (Table 6).

Table 6. Lower Lumbar

Percentile	5^{th}	25^{th}	50^{th}	75^{th}	95^{th}
Female	66	82	95	127	189

By applying the principle of clearance here, we get the lowest of the low value with take-off point at 127 mm. To use it, 115 considered [5].

To hold the grab rail (Table 7).

Table 7. Grip inside diameter

Percentile	5^{th}	25^{th}	50^{th}	75^{th}	95^{th}
Female	40	42	46	49	52

By applying the principle of reach here, we get the lowest of the low value with take-off point at 40 mm.

5 Discussion

The existing design of the vehicle suggests that there were very less ergonomic principles applied during its design phase from the viewpoint of passenger comfort and safety. The most significant mismatch noticed when the dimensions of the vehicle like grab rail positioning; access to the vehicle or seating system had no reference to the anthropometric dimensions of Indian. For the majority of the design factors for the females, a very high degree of mismatch between the female body and the vehicle.

Also, there was no “backrest” and “overall feeling”. Females in India wear specific attire called “saree” which is a single piece of cloth wrapped around the body. The restricted movements in such vehicles added to the level of mismatch. These mismatches in design factors further validated by the discomfort data for females which were at very high median values ranging from 4 to 6 for “lower back”, “buttocks”, “hip and thigh” and “knee and leg”. The reason most body part is associated with seating posture in the vehicle indicates a severe seating mismatch between the female body and the vehicle. Based on these design factors, the design concept developed. The Indian anthropometric dimensions adhered to, and the other ergonomic issues applied.

6 Conclusions

This research indicates the immense scope for application of ergonomic principles in the domain of pillion rider of a motorcycle in semi-urban and urban India. The mismatches are relevant to the subject’s safety and comfort. The concept designs have developed, keeping in mind the different ergonomic issues of the passengers. I hope that this concept, when fabricated onto a real motorcycle, would be a pleasant experience for the passengers.

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Ergonomics Risk Assessment of Graphics Tablet Users Using the Rapid Upper Limb Assessment Tool

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Abstract. The graphics tablet has become the most used in the field of digital art and the most important hardware equipment, more and more designers are using graphics tablet for painting, which inevitably leads to musculoskeletal disorders such as sore shoulders, cervical spine pain and neck pain. The best approach is to provide good interventions, this research mainly includes three aspects: First, evaluates the ergonomic risk level of graphics tablet users using the Rapid Upper Limb Assessment (RULA) tool. Second, evaluates the correlation between musculoskeletal disorders and ergonomic risk level of graphics tablet users. Third, provides ergonomic intervention measures, wrong posture prevention and correct posture advice for graphics tablet users.

Keywords: Graphics tablet · Musculoskeletal disorders · RULA · Rapid upper limb assessment

1 Introduction

The graphics tablet, also known as the drawing board, digital panel, is a type of computer input device. It usually consists of a board and a pressure-sensitive pen, is a professional alternative to manual painting. When the user uses the tablet for drawing, the hand is used to draw on the tablet for a long time, which is easy to cause user fatigue. Through the investigation of related communities and networks, the author found that most people would suffer from musculoskeletal diseases such as shoulder pain, cervical spine pain and neck pain after using the graphics tablet for a long time, which may be caused by their repeated movements and adverse postures. In order to reduce the human body load in this work scene, the best way is to provide good intervention measures. The use of the graphics tablet is focus on upper limb activity. Among the methods available for upper limb assessment, the most widely used is RULA (rapid upper limb assessment) [1].

RULA (rapid upper limb assessment) developed by Mc Atamney and Nigel Corlett in 1993, is an observational screening tool for assessing risk factors due to neck, trunk and upper limb posture as well as muscle status and load (external pressure) [2]. At present, RULA has been applied in many industries such as supermarket cashier, computer operation and so on, and has been evaluated for reliability and validity [3].

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The method uses body posture figure and three rating scales to assess risk factors. It is mainly divided into three stages: First, Record working postures. Second, Score through the scoring system. Third, Get the risk level according to the comprehensive score, provide guidance and Suggestions for the risk level. RULA divides the posture into two parts. Score A is the combination of upper arm, lower arm and wrist postures. Score B is the combination of neck, trunk and leg postures, each group has a score of 0 to 6 points. Score C is the combination of Score A, muscle use and force scores for group A. Score D is the combination of Score B, muscle use and force scores for group B. Finally, the total score is the combination of Score C and D.

Through literature search, the author found that there is no research on the ergonomic risk of graphics tablet users, let alone the use of RULA tools to assess the ergonomic risk of graphics tablet users. Based on the above description of RULA, the author applies RULA in this paper for the ergonomic risk assessment of graphics tablet users. First, this article use RULA to assess the level of ergonomic risk associated with the use of graphics tablet and to assess whether the posture is at high risk when using the graphics tablet. Secondly, by judging the relationship between the ergonomic risk level of graphics tablet users and musculoskeletal diseases, provide the prevention of wrong posture and correct posture Suggestions, so as to improve the efficiency of people using the graphics tablet.

2 Materials and Methods

In this paper, 30 participants were selected. Participants were required to be between 18 and 30 years old. Is the owner of graphics tablet. At least 6 months experience with graphics tablet. No history of trauma or surgery in the past year. No physical illness or disability. No chronic diseases affecting the musculoskeletal system. No neurological or orthopedic disorders or sensory deficits. No visual problems, dizziness or dizziness. Has not taken any sedative drugs or alcohol in the past 48 h.

2.1 Procedures

Before the experiment, participants were asked to fill out a questionnaire, which took about 10 min. The participants then perform the same task with the graphics tablet, and video recording of their operations was collected. After recording the video, the three evaluators watched the video, selected the most persistent posture to evaluate, and determined the score for each side of the body and the total score. Finally, the correlation between musculoskeletal disease and ergonomic risk of graphics tablet use was analyzed. Based on relevant literature survey, a questionnaire was developed to investigate musculoskeletal diseases, including demographic characteristics, graphics tablet usage survey and musculoskeletal disorders survey. Human musculoskeletal disorders were measured using the standardized Nordic musculoskeletal disorders questionnaire (NMQ) [4]. The tool was developed by a team of northern European researchers, to create a simple standardized questionnaire that can be used to screen for musculoskeletal disorders. Using video collection method [5], 30 participants were required to perform the same task in the same environment, draw the same cartoon character with graphics tablet on the computer photoshop software for 5 min. Two cameras were placed on the left and right to photograph the participants' body posture.

2.2 Statistical Analysis

After watching each participant video together by three RULA-trained professional researchers, the video is slowed down to determine the most persistent posture of the graphics tablet user during the operation, the pose is evaluated for ergonomic risk levels, and the final score is obtained. 1–2 are not required to be processed, no ergonomic risk. 3–4 are in need further investigation and further treatment if necessary. 5–6 are in need of further investigation and improvement within the next few days. 7 are must be investigated and improved. Spass17.0 was used for statistical collation and analysis of the data, mean value and standard deviation of RULA data were calculated, and chi-square test was performed for the correlation between musculoskeletal disorders and rula's ergonomic risk score.

3 Results

3.1 General Characteristics and the Graphics Tablet Use Characteristics of Participants

There were 11 males (36.7%) and 19 females (63.3%). 18 (60%) were aged between 18 and 25, and 12 (40%) were aged between 26 and 30, with an average age of 24.5 ± 1.2. 11 (36.7%) were exercised regularly. 18 (60%) were exercised occasionally, and 1 (3.3%) were never exercised. 28 (93.3%) had a normal bmi (between 18.5 and 24). No one had underlying disease. 28 (6.7%) did not smoke. 25 (83.3%) had no drinking behavior. All are right-handed.

The participants used the graphics tablet for an average of 3.21 ± 1.58 years. The daily usage is 1.32 ± 1.28 times. 7.21 ± 2.34 times per week. The duration of each use was 2.31 ± 1.87 h, and most participants (24/80%) took appropriate rest during the use. When in use, 21 people (70%) use both hands, 9 people (30%) only use their right hand. Most people use both hands to operate, click the mouse with their left hand, and draw with a pen in their right hand.

3.2 Ergonomic Risk Using RULA

The average upper arm posture score were 2.23 ± 0.43 for left and 2.73 ± 0.44 for right. While the average lower arm posture score were 1.77 ± 0.43 for left and 2.27 ± 0.82 for right. The average wrist posture score were 2.20 ± 0.72 for left and 3.27 ± 0.45 for right. the average wrist twist posture score were 3.23 ± 0.43 for left and 4.26 ± 0.45 for right. The average score C is 4.27 ± 0.45 for left and 5.26 ± 0.45 for right. The average Neck, back and leg posture scores were 2.10 ± 0.31, 2.03 ± 0.32, and 1.57 ± 0.5, respectively. The average score B were 2.80 ± 0.76. The average Score D were 3.93 ± 0.78. The final score was 4.37 ± 0.61 for left and 5.13 ± 0.51 to for right. The corresponding RULA rating table indicates that the left side needs further investigation and further processing if necessary, and the right side needs further investigation and improvement in recent days.

3.3 Musculoskeletal Disorder

Musculoskeletal disorder was investigated on the participants, the results showed that the morbidity of neck was 73.3%, shoulder was 86.7%, elbow was 33.3%, Wrist was 56.7%, the upper back was 66.7%, the lower back was 30%, the thigh was 13.3%, Knees was 13.3%, the ankle was 10%. It can be seen that the prevalence of the shoulder is the highest, followed by the neck, upper back, wrist prevalence is also more than half of the people.

3.4 Correlation Between Musculoskeletal Disorders and Level of Ergonomic Risk Among Graphics Tablet Users

As shown in Table 1, right RULA Grand Score is significantly correlated with shoulder (x2 = 9.315, p = 0.04), neck (x2 = 14.382, p = 0.026), upper back (x2 = 20.800, p = 0.014) musculoskeletal disorders. Right RULA Score A (combination of upper arms, lower arms and wrists postureis) is significantly correlated with shoulder (x2 = 8.794, p = 0.032),

Wrist (x^2 = 10.07, p = 0.007) musculoskeletal disorders. Right RULA Score C (combination of Score A, muscle use and force scores for group A) is significantly correlated with shoulder (x^2 = 8.794, p = 0.032) musculoskeletal disorders. Right RULA Score B (combination of neck, trunk and leg postures) is significantly correlated with neck (x^2 = 18.417, p = 0.031) musculoskeletal disorders. right RULA Score D (combination of Score B, muscle use and force scores for group B) is significantly correlated with upper back (x^2 = 18.417, p = 0.031) musculoskeletal disorders. Right wrist posture (x^2 = 10.07, p = 0.007) and Wrist twist posture (x^2 = 7.325, p = 0.035) are significantly correlated with wrist musculoskeletal disorders ($p < 0.05$ indicates significant correlation).

Table 1. Correlation between musculoskeletal disorders and level of ergonomic risk among graphics tablet users (n = 30)

RULA	Musculoskeletal disorders	Chi-square (p value)	
		Lt.	Rt.
Upper arm posture	Shoulder	1.921(0.59)	3.092(0.38)
Lower arm posture	Elbow	2.462(0.292)	8.24(0.083)
Wrists posture	Wrist	8.574(0.073)	**10.07(0.007)**
Wrist twist posture	Wrist	1.182(0.554)	**7.325(0.035)**
Score A	Shoulder	1.921(0.59)	**8.794(0.032)**
	Elbow	0.825(0.062)	5.286(0.071)
	Wrist	0.842(0.657)	**10.07(0.007)**
Neck posture	Neck	3.825(0.082)	

(*continued*)

Table 1. (*continued*)

RULA	Musculoskeletal disorders	Chi-square (p value)	
		Lt.	Rt.
Trunk posture	Upper back	7.222(0.301)	
	Lower back	3.192(0.203)	
Leg posture	Hip and thigh	0.532(0.427)	
	Knee	3.529(0.060)	
	Ankle	2.549(0.110)	
Score B	Neck	11.867(0.065)	
	Upper back	**6.087(0.048)**	
	Lower back	0.952(0.621)	
	Hip and thigh	0.269(0.874)	
	Knee	3.077(0.215)	
	Ankle	2.222(0.329)	
Score C	Shoulder	1.753(0.62)	**8.794(0.032)**
	Elbow	0.568(0.756)	2.188(0.335)
	Wrist	1.500(0.472)	3.182(0.231)
Score D	Neck	7.27(0.064)	
	Upper back	**18.417(0.031)**	
	Lower back	1.429(0.669)	
	Hip and thigh	4.582(0.205)	
	Knee	3.077(0.380)	
	Ankle	3.077(0.380)	
Grand score	Shoulder	4.089(0.92)	**9.315(0.04)**
	Elbow	5.586(0.47)	6.509(0.36)
	Wrist	10.744(0.097)	4.235(0.145)
	Neck	**6.9000(0.029)**	**14.382(0.026)**
	Upper back	8.527(0.128)	**20.800(0.014)**
	Lower back	0.952(0.813)	0.921(0.810)
	Hip and thigh	0.952(0.813)	1.385(0.709)
	Knee	0.769(0.857)	0.923(0.820)
	Ankle	0.247(0.970)	0.667(0.881)

4 Conclusion

4.1 About the Ergonomic Risk Using RULA

The RULA tool was used to evaluate the ergonomic risk of graphics tablet users and the left RULA average total Grand score was 4(60%), while the right RULA average total Grand score was 5(83.3%). It indicates that most users still have high ergonomic risk when using graphics tablet, which needs to be improved within a certain period of time. Possible reasons for the higher risk can be understood according to the scoring principle of RULE, which are used to score posture, muscle state and load, and then to score all three.

For posture scores, observe the participants' posture while using the graphics tablet. In group A, it was found that most of the participants' upper arms leaned forward at 20°–45° and some at more than 45°. Some studies have found that a comfortable posture requires an Angle between the trunk and arms less than 20°. Some participants had to move their right arm from side to side while drawing. Wrist angles are mostly >15°, and the right wrist often needs to be twisted and waved. In group B, for the neck position, most of the participants looked down while looking at the computer, with the neck itself in a natural curve of more than 10° or 20°. Other participants looked down at the graphics tablet from time to time, switching back and forth between the head down and head up, and bending their neck more than 45°, increasing the risk of neck. Studies have found that there is an increased risk of neck and shoulder pain when the neck is often twisted or bent during work [6], the risk of neck pain increases when the neck is rotated more than 45° during more than 25% of the working day. Obviously, risks will also increase rapidly over time [7]. As for the trunk posture, most of the participants sat forward, with the trunk bent and unable to remain upright. Part of the study found that trunk bending and contorting at more than 30° and lasting for more than 15 min significantly increased the risk [8]. As for leg posture, some participants did not have their feet on the ground and did not have good support and balance.

As for the muscle state score, the participants were mostly static when using the graphics tablet and performed repetitive movements. When the right arm is holding the pen for drawing, it often needs to carry on the repetitive wave of the arm movement, and last a long time. The graphics tablet usage characteristics questionnaire showed that participants used the graphics tablet 1.32 ± 1.28 times per day, the duration of each use is 2.31 ± 1.87 h, with a long time of continuous operation. Studies have shown that keeping muscles static for a long time at work affects their ergonomic risk levels [9]. As for load, participants did not bear any pressure load when using the graphics tablet, and the load score was 0.

Generally speaking, the ergonomic risk of graphics tablet users mainly comes from posture and muscle state. Users' neck and wrist bending, wrist twisting, back bending increase ergonomic risk when using graphics tablet. And holding still for a long time, with repetitive movements such as the right arm swing, also increased the risk level.

4.2 About the Correlation Between Musculoskeletal Disorders and Level of Ergonomic Risk Among Graphics Tablet Users

The correlation test showed right RULA Grand Scores exists significant correlation with shoulder, neck and upper back musculoskeletal disorders. Consistent with the analysis above, a combination of postures leads to shoulder, neck, and upper back muscle pain. Left RULA Grand Scores exists no correlation with shoulder, neck and upper back musculoskeletal disorders, this may be because all the participants were right-handed, drawing with their right hand, twisting their wrists on their right hand, waving their arms, etc., and posing a greater risk than the left.

Right RULA Score A and right RULA score C are significantly correlated with shoulder musculoskeletal disorders, it indicates that the combined posture of the upper arm, lower arm and wrist has a combined effect on the musculoskeletal diseases of the shoulder. Including the forward angle of the arm exceeds 20°, Repeated swinging of the right arm, the angle between the upper arm and lower arm is less than 100°, and twist the wrist. Right RULA Score B and right RULA Score D are significantly correlated with upper back musculoskeletal disorders. Including long time bending of the neck, bending angle more than 20° or even 45°, trunk posture bending more than 20°, the legs are not well balanced and supported. Right RULA Grand Scores exists significant correlation with neck disorders. It indicates that the comprehensive posture of the upper arm, lower arm, wrist, neck, back and leg can affect neck diseases. Therefore, in order to reduce the risk of use, try to avoid these combined positions. Right wrist posture and Wrist twist posture are significantly correlated with wrist musculoskeletal disorders. It indicates that the right wrist posture and horizontal angle are too large and the wrist twist will have a direct high risk to the wrist. Therefore, it is necessary to adjust the high-risk posture of the right hand painting.

4.3 Recommendation

In posture, the upper arm should avoid excessive forward tilt, keep the lower arm level with the table, and avoid excessive wrist bending and twisting. Sit upright, avoid bending your trunk and neck, keep your computer screen level with your eyes, and avoid switching between the graphics tablet and the computer screen frequently. Avoid one leg support and keep both legs flat on the floor for good balance and support. And avoid the combination of these posture, the combination of comprehensive poor posture has a great impact.

In muscular condition, the right arm is often engaged in long drawing movements, and the sitting position remains the same (neck bent, trunk bent). Such long repetitions should be avoided and rest after a certain amount of time.

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Effects of Occupational Stressors on Depressive Symptoms: Longitudinal Study Among Medical Services and Welfare Workers

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Abstract. This study aimed to examine the status of depression symptoms and occupational stress factors that triggered these symptoms among workers in medical and welfare industries. Web-based surveys were conducted in 2016 and 2019 among research company survey respondents regarding their work, life and health. This study extracted data for medical services and welfare workers who participated in both the initial survey in 2016 and the follow-up survey in 2019. First of all, 288 regular employees (221 men and 67 females of mean age 45.6 years, SD = 9.0) who worked in the medical services and welfare industries at the time of both surveys were identified. Of these, 115 presented with depressive symptoms by CES-D scale (39.9%), indicating a higher ratio compared to other occupations. Following this, for the 173 respondents who did not present with depressive symptoms in the initial survey but developed depressive symptoms during the three years following the initial survey, changes (favorable, improved, no change, deteriorated, unfavorable) in occupational stressors were analyzed using explanatory variables. As the results of logistic regression analysis, at the time of the follow-up survey, 32 respondents presented with symptoms of depression (18.5%), and environmental work stress (noise, lighting, temperature, ventilation, etc.) and interpersonal stress at work (unfavorable stress conditions at the time of both surveys) significantly affect the onset of these symptoms. Many medical services and welfare workers are required to suppress their own emotions as they go about their busy daily duties of caring for others, and this study suggests that they are working under highly stressful conditions. There is a strong sense that the workplace has reached an impasse, and a new approach is needed in a bid to revitalize the organization and create attractive company structures, as well as improve the physical working environment.

Keywords: Medical services and welfare workers · Depressive symptoms · Work environment · Interpersonal relationships · Nudge

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1 Introduction

Since introducing the Stress Check System in 2015, employees' stress conditions are better understood, and efforts are being made to prevent poor mental health among employees by promoting employees' awareness of their own stress levels as well as creating a more comfortable workplace in a bid to improve the work environment [1]. However, when looking at the actual workplace, substantial time and effort are devoted to so-called high-risk employees, such as selecting employees with high levels of stress and making time for doctor consultations, and it has been pointed out that efforts have not extended to improving the work environment and promoting the creation of a more comfortable workplace [2]. In addition to these reasons, it is also possible that workplaces are struggling to plan concrete measures and prioritize measures.

Looking at the medical services and welfare fields, as represented by Burnout Syndrome such as occupational diseases among interpersonal service professionals, mental health issues among medical services and welfare workers are also a serious issue [3]. In actual fact, looking at the transition of former employees and new employees, there is no indication that the situation has improved since the implementation of the Stress Check System. Japan is aging at a faster pace than other countries, and the demand for medical welfare and nursing care is expected to increase for both patients and users. The Ministry of Health, Labor and Welfare [4] estimates that the number of medical services and welfare workers will increase from 8.23 million in 2018 to about 10.6 million in 2040 [5]. However, the total labor force in Japan will decrease from about 66.6 million in 2018 to about 60 million by 2040. This means that a 30% increase in medical services and welfare workers is needed when the total labor force will shrink by 10%. In order to secure future medical services and welfare workers and retain current workers, creating an attractive, healthy, and safe work environment is an urgent issue.

In this study, web-based surveys were conducted in 2016, the year after the Stress Check System was introduced, and in 2019, to examine the status of depressive symptoms in medical services and welfare workers and the occupational stressors that triggered these symptoms.

2 Methods

Web-based surveys were conducted in 2016 and 2019 among research company survey respondents regarding their work, life and health. This study extracted data for medical services and welfare workers who participated in both the initial survey in 2016 and the follow-up survey in 2019.

The Center for Epidemiologic Studies Depression Scale (CES-D) was used to assess depressive symptoms among medical services and welfare workers [7]. In this study, the Japanese version of CES-D was employed [8]. it is used widely all over the world because of its usefulness as a screening test for depression. The possible range for the 20-item scale is 0 to 60, and we employed a cut off score of 16 or higher, which score indicates the presence of significant depressive symptoms.

We evaluated occupational stressors by using the subscales consisting of 9 factors with 17 items (quantitative work overload, qualitative work overload, physical burden, work environment, interpersonal relationship, job control, skill utilization, job aptitude, and job satisfaction) derived from the Brief Job Stress Questionnaire with 4-point Likert scale [6].

This study examines occupational stressors. First, the raw score of each item was converted into a 5-point standardized score based on the conversion table. For instance, the degree of psychological workload (volume) used a raw score total from the three statements "I have a large volume of work", "I cannot complete work in the required time", and "I must work extremely hard" and 1 point was given for a total raw score of 3 or less, 2 points for a total raw score of 4–5, 3 points for a total raw score of 6–7, 4 points for a total raw score of 8–9, and 5 points for scores of 10 or more.

Next, the shift in the standardized score between 2016 and 2019 was interpreted as the 3-year change in stressors, and broken down into five levels; favorable, improved, no change, deteriorated, unfavorable (Fig. 1). For example, a change from 5 in 2016 (low stress) to 1 in 2019 (high stress) was classified as "deteriorated". Then, using the no change group as a reference, the odds ratio was used to determine the possibility of affecting depressive symptoms in the other four groups by using logistic regression analysis.

The study was approved by the ethics committee of the authors' institution (Application Number: H2812). The participants were informed that participation in this study was voluntary and that no one was required to complete the questionnaire.

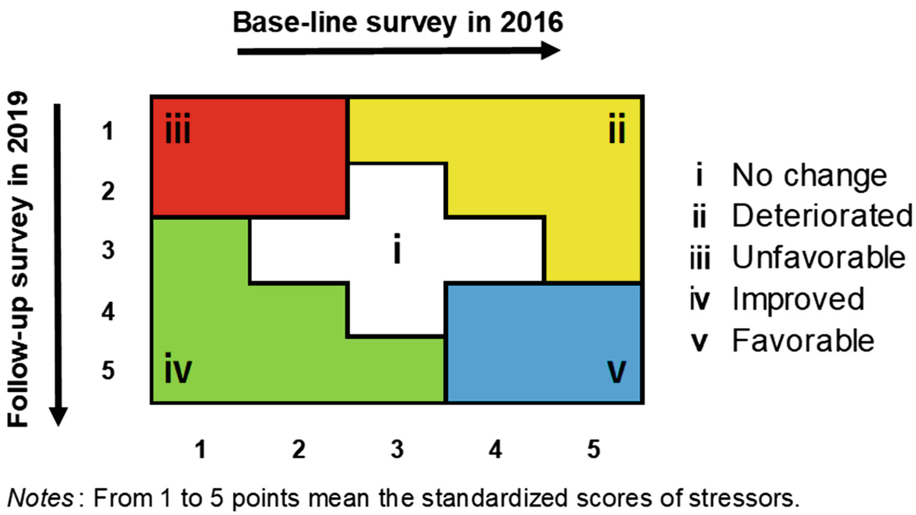

Fig. 1. Five levels of the 3-year change in stressors

3 Results

320 regular employees (239 males and 81 females) and 322 (271 males and 51 females) regular employees who worked in the medical services and welfare industries answered the questionnaire in 2016 and 2019. In the base-line survey in 2016, 288 regular employees (221 men and 67 females of mean age 45.6 years, SD = 9.0) who worked in the medical services and welfare industries at the time of both surveys were identified. Of these, 115 presented with depressive symptoms by CES-D scale (39.9%), indicating a higher ratio compared to other occupations. Following this, for the 173 respondents (138 men and 35 females of mean age 46.8 years, SD = 9.1) who did not present with depressive symptoms in the base-line survey but developed depressive symptoms during the three years following the base-line survey, changes (favorable, improved, no change, deteriorated, unfavorable) in stressors were analyzed using explanatory variables.

At the time of the follow-up survey, 32 respondents presented with depressive symptoms (18.5%). Next, a binomial logistic regression analysis was performed to examine the relationship between depressive symptoms and the stressors. The odds ratio in this analysis is the adjusted odds ratio (aOR) and is calculated so that differences in age bracket and gender do not affect the analysis results. As the results of the analysis, deterioration of the work environment (aOR 4.77, 95% CI 1.51-15.07) and poor interpersonal relationships (aOR 4.01, 95% CI 1.54-10.46) at the time of both surveys have significantly affected the onset of the symptoms, while quantitative work overload, qualitative work overload, physical burden, job control, skill utilization, job aptitude, and job satisfaction were not significantly related (Table 1).

Table 1. Results of binomial logistic regression analysis

3-year stress change	Quantitative work overload	Qualitative work overload	Physical burden	Work environmet	Interpersonal relationship	Job control	skill utilization	Job aptitude	Job satisfaction
	aOR (95% CI)	*aOR* (95% CI)	*aOR* (95% CI)	*aOR* (95% CI)	*aOR* (95% CI)	*aOR* (95% CI)	*aOR* (95% CI)	*aOR* (95% CI)	*aOR* (95% CI)
No change	1.00 (Reference) n=95	1.00 (Reference) n=78	1.00 (Reference) n=70	1.00 (Reference) n=104	1.00 (Reference) n=103	1.00 (Reference) n=76	1.00 (Reference) n=101	1.00 (Reference) n=89	1.00 (Reference) n=93
Deteriorated	2.50 (0.72-8.65) n=18	2.79 (0.78-9.93) n=35	3.62 (0.88-14.96) n=65	2.19 (0.57-8.39) n=16	2.93 (0.63-13.53) n=26	1.89 (0.56-6.37) n=17	1.53 (0.43-5.39) n=25	2.65 (0.89-7.84) n=22	0.51 (0.14-1.93) n=23
Unfavorable	2.02 (0.66-6.17) n=13	1.28 (0.45-3.69) n=13	1.88 (0.74-4.76) n=12	**4.77 (1.51-15.07)** n=15	**4.01 (1.54-10.46)** n=9	1.43 (0.40-5.14) n=17	1.83 (0.66-5.10) n=16	1.14 (0.33-3.91) n=20	0.75 (0.22-2.53) n=20
Improved	0.29 (0.03-2.41) n=14	1.08 (0.27-4.34) n=16	1.03 (0.11-9.52) n=9	1.80 (0.43-7.61) n=12	0.96 (0.31-3.02) n=11	0.90 (0.22-3.62) n=18	2.01 (0.47-8.65) n=10	1.20 (0.35-4.13) n=21	0.39 (0.08-1.83) n=18
Favorable	0.28 (0.06-1.29) n=33	0.50 (0.13-1.87) n=31	2.22 (0.59-8.42) n=17	0.49 (0.11-2.32) n=26	0.24 (0.03-1.90) n=24	0.92 (0.33-2.56) n=45	0.65 (0.51-2.32) n=21	0.53 (0.11-2.55) n=21	0.19 (0.02-1.48) n=19

Notes: All analyses were adjusted for age bracket and gender.
aOR=adjusted odds ratio; CI=confidence intervals
Bold indicates significant at p<=0.05.

4 Discussion and Future Research

Toward improvements in the work environment, at present, various initiatives for improving the work environment are being carried out at medical and welfare facilities. For instance, using insights gained from ergonomics research (e.g., Participatory Ergonomics) and from group discussions in which workers themselves participate, initiatives include evaluating the risk factors in the workplace, and proposing, implementing, evaluating, and re-proposing workplace improvements while using tools such as the work environment improvement action checklist [9]. Moving forward, it will become even more important to leverage these initiatives in workplace interventions, to measure effects, and to gather practical and comprehensive case studies.

On the other hand, in recent years, with regard to interpersonal relations, the nudge approach is attracting attention as a way to spontaneously change people's consciousness and behavior without force. For instance, rather than meeting in a conference room at a fixed time, companies are encouraging (or "nudging") employees to subtly changes their behavior by creating spaces and opportunities in the workplace for staff can go to take a break and interact, such as in multipurpose office space or while doing small tasks like throwing away trash or making copies.

Johnson & Johnson K.K. in Japan, which handles healthcare-related products, has prepared a space that focuses on "interaction" as part of office layout reforms. By visiting this space, employees can casually mingle with staff from other departments over coffee. Also, this space now housed the communal stationery supplies, which had been managed separately in each department, and this led to a secondary benefit of reducing the total stationery inventory. The company has also started reforming the office. Previously, related departments were said to not be working closely together. There were not many opportunities for staff in different departments to meet each other outside of the meeting rooms, making it difficult to engage in meaningful communication. The conference rooms have frosted glass on the windows, which restricts sight lines and results in a feeling of obstruction. However, after the layout changes where the aim was to create an open office, the new layout was said to create a better flow of people and improve communication among employees. Previous research has shown that setting up spaces near windows and around employees' seats not only increases communication but also encourages information sharing within the organization [10]

The nudge approach is starting to be used in medical field, as a measure to curtail overtime. It is difficult to develop and introduce measures that produce immediate results, and this has been an ongoing issue for nursing managers. One hospital in Japan introduced a two-color system for nurse uniforms, successfully reducing overtime from 72.1 h (2012) to 51.0 h (2015), [11]. This was thought to be effective for three reasons: (1) visual recognition of overtime workers, (2) greater awareness of working efficiently, and (3) heightened cooperation among staff. In addition to these reasons, having a different color uniform to other nursing staff, not only tells nurses and doctors that the nurse is from a previous shift, but it is thought that patients also recognize this, and therefore works as a deterrent against working overtime due to the psychological desire to be as inconspicuous as possible [12].

Previous research has compiled many studies targeting medical services and welfare workers. However, many of these are cross-sectional surveys. Therefore, it is significant that a longitudinal survey was conducted in this study and focused on how changes in stress levels over the years impact the mental health of medical services and welfare workers. However, since the survey included respondents from other industries, it was not possible to secure a sufficient number of medical services and welfare workers. Furthermore, the sample's male to female ratio was 8:2, but the actual percentage of female medical services and welfare workers in Japan is 71% ([13]. Moving forward, we will examine sampling methods, accumulate and share cases of improvement in the workplace using the nudge approach, and measure the effects.

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Workload Assessment

An Evaluation of Numerical Integration Methods for Estimating Cumulative Loading Based on Discrete Spinal Loads

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Abstract. The focus of this contribution is to evaluate numerical integration methods with regard to their comparability for estimating cumulative loading based on discrete spinal loads. In this context, the influence of both weighting factors and sampling rate are investigated using a time-varying loading profile recorded in a laboratory study with 12 subjects. A biomechanical model was used to calculate the compression force at L5/S1. Three numerical integration methods were compared. Results clearly confirm the need to establish a standardized assessment procedure for cumulative loading to ensure the comparability of assessment results and promote scientific progress in the field of physical stress assessment.

Keywords: Cumulative loading · Numerical integration · Spinal loads

1 Introduction

Low back pain accounts for a large proportion of work-related musculoskeletal disorders (WMSD) [1], which are one of the most common causes of chronic pain and also lead to high health care costs. For the prevention of WMSD, the assessment of physical stress at the workplace is of central importance. Given the dynamic nature of physical work activities in occupational practice [2], the consideration of the temporal variability of loading is a central requirement for ergonomic assessment methods. In this context, assessment methods based on the evaluation of average or peak loads, however, have proven to be not fully suitable as they carry the risk of systematic misclassification and lead to unsafe tasks being classified as safe, and vice versa [3].

A promising concept to consider the temporal course of physical stress is cumulative loading, which has been associated with the occurrence of low back pain [4, 5]. In general, the estimation of cumulative loading follows the principle of integrating the load over time [6] which corresponds to calculating the area under the loading curve. Since the loading is normally given only by discrete values, methods of numerical integration are used for approximating the area. However, little attention has been paid to establish a standardized assessment method for cumulative loading especially with regard to the relative weighting of load intensity and load duration [6]. In order to take

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into account the disproportionately higher overexertion risk of high forces derived from in-vitro studies on the failure behaviour of human vertebrae specimen, [7] and [8] propose a quadratic or even higher weighting of load intensity relative to load duration. Moreover, the spacing of the subintervals the area is approximated with corresponds directly to the rate with which the loading is recorded in occupational practice. Therefore, it is relevant to understand the influence of the sampling rate on the calculation of cumulative loading [9, 10].

Of particular interest is the comparability of evaluation results when using different methods. In this contribution, the term method refers to the combination of the three factors numerical integration method, weighting of load intensity and sampling rate. If evaluation results are significantly influenced by these factors, this could lead to both evaluation results of comparable working conditions being different and evaluation results of different working conditions being comparable only if the calculation method is identical. Therefore, the aim is to evaluate the comparability of different calculation methods for estimating cumulative loading based on discrete spinal loads. It was hypothesized that both the use of exponential weighting factors and a reduction of the sampling rate lead to differences in the calculated cumulative loading.

2 Materials and Methods

2.1 Integration Methods

The three numerical integration methods compared were the composite rectangle rule (R), composite trapezoid rule (T) and composite Simpson's rule (S), which approximate an area via rectangles, trapezoids and quadratic functions, respectively as shown in Fig. 1. Integration methods that require a function to be given explicitly were not evaluated as loading in occupational practice is normally given only by discrete values.

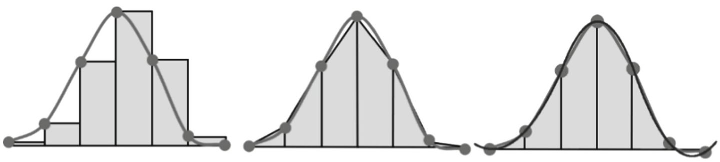

Fig. 1. Numerical integration methods (f.l.t.r.): R, T and S (dark grey: interpolated function, light grey: approximated area, circles: discrete loading data)

2.2 Data Collection, Data Processing and Analysis

The underlying data used were time-varying discrete spinal load data recorded in a laboratory study with 12 subjects (8 female, 4 male). Prior to the study, the subjects' mean (SD) age (mean = 23.7 (2.7) years), height (mean = 172.0 (7.0) cm) and body weight (mean = 64.9 (10.2) kg) were recorded. While performing a task, the subjects' body posture was recorded at a rate of 30 Hz using Microsoft KinectTM V2. A static biomechanical model based on the model for symmetrical activities by [11] was used to calculate compression force at L5/S1. As shown in Fig. 2, subjects performed a two-dimensional, symmetric lifting/lowering task in the sagittal plan with an external load (6 kilograms) in both hands. The range of movement with respect to the degree of trunk inclination was standardised to a range from 0° to 40°. The working pace was set to one lift/lowering every 3 s and audibly signalled using a digital metronome. Prior to the start, subjects completed a practice session in order to familiarize themselves with the task and given pace.

In addition to the three numerical integration methods, three load intensity weighting factors and three sampling rates were analyzed. The three weighting factors with the corresponding unit were: linear (lin) [kNs], quadratic (qu) [kN^2s] and cubic (cu) [kN^3s] load intensity weighting. Moreover, the sampling rates 3 Hz, 15 Hz and 30 Hz were compared. The frequency of 3 Hz was chosen as lower threshold for sampling rates with regard to their relative error as previously defined by [9]. Discrete loading values for the lower frequencies were calculated based on the original frequency of 30 Hz as the average value for a time interval. Numerical integration was performed in Matlab R2017b according to the Newton-Cotes formulas for the three numerical methods [12].

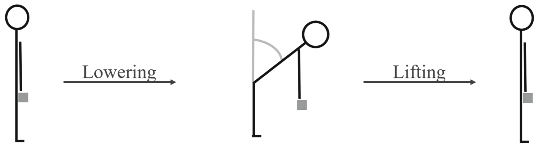

Fig. 2. Symmetric lifting/lowering task in the sagittal plane

Since the Shapiro-Wilk test indicated a deviation from normality for some data sets, Wilcox's robust statistical analysis was run. All analyses were performed in R 3.5.1 [13], using the WRS2 functions *rmanova* and *rmmcp* described by [14] for robust repeated-measures ANOVA and pairwise post hoc test based on multiple comparisons, respectively. To investigate the influence of the numerical integration method, differences of the calculated cumulative loading within a fixed sampling rate were analysed for each weighting factor. Similarly, within an identical numerical integration method, differences of the calculated cumulative loading depending on the sampling rate were examined for each weighting factor. Significance was accepted at the α-level of $p < .05$.

3 Results

Figure 3 shows a part of the calculated spinal loads of one test subject. The total mean (SD) duration of the movement across all subjects was 408.4 (60.9) s.

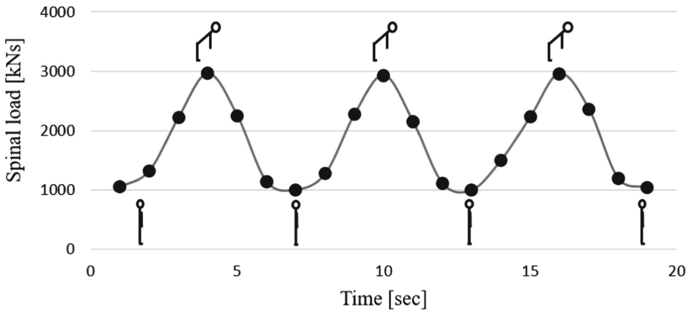

Fig. 3. Discrete spinal load profile (linear weighting) with interpolated function

All results are given as mean values ± standard error of the mean (SEM). Figure 4 shows the calculated cumulative loading for each weighting factor and numerical integration method within a sampling rate. Overall, the results are homogeneous for every weighting factor for both different integration methods and different sampling rates.

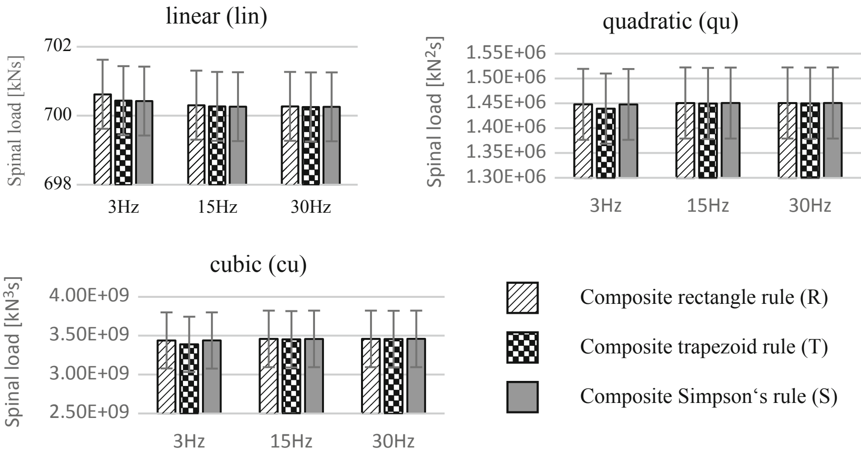

Fig. 4. Mean cumulative loading (± SEM) for each weighting factor and integration method

With regard to the influence of the integration method, the analysis indicates no significant difference for linear weighting. For quadratic and cubic weighting, the results indicate significant differences between the integration methods for every sampling rate. Pairwise comparisons showed significant differences between the results obtained with the trapezoidal rule (T) and both the rectangle rule (R) ($p_{qu,RT} < .001$, $p_{cu,RT} < .001$ for all sampling rates) and Simpson's rule (S) ($p_{3Hz,qu,TS} < .001$, $p_{15Hz,qu,TS} < .001$, $p_{30Hz,qu,TS} = .001$ and $p_{cu,TS} < .001$ for all sampling rates) but not between the rectangle and Simpson's rule ($p_{3Hz,qu,RS} = .534$, $p_{15Hz,qu,RS} = .206$, $p_{30Hz,qu,RS} = .885$, $p_{3Hz,cu,RS} = .783$ $p_{15Hz,cu,RS} = .102$ $p_{30Hz,cu,RS} = .804$). Statistics are presented in Table 1.

Table 1. Results of one-way ANOVA comparing the calculated mean cumulative loading for different numerical integration methods

Calculation method [Sampling rate, weighting factor]	F	df1	df2	p
3 Hz, linear	3.40	1.06	7.43	.104
15 Hz, linear	5.42	1.02	7.14	.052
30 Hz, linear	.37	1.01	7.05	.56
3 Hz, quadratic	68.22	1.10	7.63	<.001
15 Hz, quadratic	9.91	1.36	9.53	.008
30 Hz, quadratic	19.25	1.85	12.92	<.001
3 Hz, cubic	44.73	1.07	7.52	<.001
15 Hz, cubic	17.75	1.97	13.79	<.001
30 Hz, cubic	15.95	1.48	10.37	.001

With regard to the influence of the sampling rate used to record loading data, results indicate no significant difference in the case of linear weighting for the calculation using the trapezoidal and Simpson's rule. However, for cumulative loading calculated using the rectangle rule, results indicate a significant difference between sampling rates for linear weighting. For quadratic and cubic weighting of the load intensity, the analysis showed significant differences between the sampling rates for all numerical integration methods.

Pairwise comparisons in the case of a significant overall test showed a significant difference between the cumulative loading estimated based on loading values sampled at 3 Hz compared to 15 Hz ($p_{R,lin,3–15} = .018$, $p_{R,qu,3–15} = .002$, $p_{T,qu,3–15} < .001$, $p_{S,qu,3–15} = .003$, $p_{R,cu,3–15} = .001$, $p_{T,cu,3–15} < .001$, $p_{S,cu,3–15} = .002$) and 30 Hz($p_{R,lin,3–30} = .001$, $p_{R,qu,3–0} = .001$, $p_{T,qu,3–30} < .001$, $p_{S,qu,3–30} < .001$, $p_{R,cu,3–30} = .002$,$p_{T,cu,3–30} < .001$, $p_{S,cu,3–30} = .002$) but no significant difference between 15 Hz and 30 Hz ($p_{R,lin,15–0} = .214$, $p_{R,sq,15–30} = .403$, $p_{T,sq,15–30} < .503$, $p_{S,sq,15–30} = .805$, $p_{R,cu,15–30} = .642$, $p_{T,cu,15–30} < .164$, $p_{S,cu,15–30} = .642$). Statistics are presented in Table 2.

Table 2. Results of one-way ANOVA comparing the calculated mean cumulative loading for different sampling rates

Calculation method [Integration method, weighting factor]	F	df1	df2	p
Rectangle, linear	6.10	1.72	12.07	.017
Trapezoid, linear	1.57	1.75	12.28	.247
Simpson's, linear	2.72	1.99	13.9	.101
Rectangle, quadratic	18.23	1.54	10.81	<.001
Trapezoid, quadratic	109.35	1.22	8.53	<.001
Simpson's, quadratic	10.55	1.32	9.26	.007
Rectangle, cubic	33.75	1.31	9.18	<.001
Trapezoid, cubic	54.41	1.05	7.37	<.001
Simpson's, cubic	33.75	1.31	9.18	<.001

4 Discussion

The focus of this contribution was to investigate whether the factors numerical integration method, weighting of load intensity and sampling rate influence the calculated cumulative load. Overall, different numerical integration methods lead to homogeneous results regarding the calculated cumulative loading for the specific loading profile analyzed. In the case of linear weighting and for data recorded at a sufficient high sampling rate, different integration methods do not show significant differences in the calculated cumulative loading for the loading profile examined.

However, the results suggest that recording loading data at a low rate or using exponential weighting factors lead to significant differences in terms of the calculated cumulative loading. This could lead to a situation where, on the one hand, evaluation results of comparable working conditions are significantly different depending on the sampling rate and numerical integration method used and, on the other hand, evaluation results of different working conditions are only comparable if the sampling rate and numerical integration method are identical. In this case, the comparison of assessment results with general limit values would also be considerably more difficult.

Therefore, the results of this contribution underline the need to establish a standardized assessment method for cumulative loading. This is necessary since otherwise a continuous scientific progress through independent studies is made difficult because results based on different calculation methods cannot be compared and generalizable limit values for cumulative loading cannot be derived.

Regarding the comparison of the different integration methods, pairwise comparisons showed significant differences between the results obtained with the trapezoid rule on the one hand and the rectangle and Simpson's rules on the other hand, but not between the rectangle rule and Simpson's rule with the trapezoid rule yielding at slightly lower cumulative loading values. In fact, the trapezoid rule results in an underestimation for concave down curves and an overestimation for concave up curves as shown in Fig. 1. The rectangle rule results in an underestimation for inclining curves and an overestimation for declining curves, respectively. For the specific loading profile in this study, the trapezoid rule results in an underestimation for the sections of the loading curves with relatively higher values and, therefore, likely results in a lower estimated cumulative loading value. In the case of the rectangle rule, over- and underestimation might tend to cancel each other out for this specific periodic loading profile. Therefore, the reason for this observation probably lies in the specific loading profile evaluated in this study and cannot be generalized.

The task analyzed in this contribution was a two-dimensional lifting/lowering task in the sagittal plane. This simplification of a real working task was made in order to standardize the movement performed by the test subjects. Whereas body height and weight were considered in the biomechanical calculation of the spinal loading values, the dynamic effects due to acceleration during the movements of body parts and the external weight were neglected in the biomechanical calculation. Although the loading values would have changed overall if dynamic effects had been taken into account, these effects are not relevant to the objective of this contribution, since this contribution focuses on the estimation of the relative comparability of different calculation methods for cumulative loading.

While this contribution was limited to a small number of test subjects performing a relatively short working task, the results clearly confirm the need to establish a standardized assessment procedure for cumulative loading. In this context, further research needs can be formulated based on the results of the study.

Two exponential weighting factors were analyzed as examples. It became clear that their use influences the comparability of evaluation results substantially. In order to examine this effect more closely, it is necessary to determine exact weighting factors based on empirical studies. Also, further research is required with regard to the influence of the speed of movement on the minimum sampling rate necessary to calculate cumulative loading accurately. The influence of the speed of movement is particularly relevant with regard to the interpretation of the factor sampling rate. It is quite conceivable that for a slower movement than the movement examined here, lower sampling rates would be sufficient and lead to comparable evaluation results as high sampling rates. In addition, further investigation of less periodic exposure profiles seems appropriate.

5 Conclusion

This contribution underlines the pressing need to define a standardized calculation method for cumulative loading since otherwise neither general associations between cumulative loading and physiological parameters nor limit values can be derived. Further research is required especially with regard to the determination of empirically based weighting factors, the influence of movement speed and the general analysis of less periodic load profiles.

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The Influence of the Relative Working Position as a Function of Body Dimensions on Working Posture, Compression Load on L5/S1 and Muscle Activity

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Abstract. In the light of increasing awareness for protection of personal data condition-based analyses in ergonomics will gain more importance. For postures, however, observational personal-based analyses are usually carried out. The article therefore examined whether the relative working position has an influence on working posture, compression load on L5/S1 and electrical muscle activity in order to be used as a condition-based risk factor for future analyses. An empirical study was conducted with 20 subjects. Results revealed that the relative working position on all investigated factors. This allows consolidating that a condition-based analysis is also possible for postures.

Keywords: Working posture · Working position · Compression load · Muscle activity · WMSD · Risk assessment

1 Introduction

Awkward working postures are known to be a major risk factor for work-related musculoskeletal disorders (WMSD) [1]. A necessary prerequisite for the reduction of such adverse consequences is the ergonomic analysis of working postures and the subsequent development and implementation of corresponding corrective measures. In occupational practice, usually observational methods are applied which use score systems to evaluate the risk on the musculoskeletal system [2]. From a methodological point of view, these score systems are flawed, because it is difficult (or even impossible) to determine whether these score systems are "true" or "correct", and equally difficult to determine whether they are "untrue" or "incorrect" [3]. Yet, due to their ease of use, they are frequently applied in practice. Hence, there is a pronounced demand for the development of methods for the assessment of WMSD risk factors, which satisfy the test criteria of objectivity, reliability and validity, as well as practical requirements.

The General Data Protection Regulation regulates the data protection and privacy in the European Union. This makes the individual-related collection of personal ergonomic data more difficult, even if they are to be used for occupational safety and health. For working postures in particular, it is unclear from a scientific perspective whether it is always necessary to observe the working posture extensively (people-based analysis)

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or whether a risk assessment can be carried out based on the working position (condition-based analysis). The work position refers to the location at the workplace where the work actually takes place. It is operationalized by horizontal and vertical distances between component and worker. However, the same working position already leads to a variance in the working posture for different worker, e.g. due to different body dimensions. Correspondingly, a conditional analysis would have to consider a large variance in the working posture. A promising approach to reduce this variance seems to be the use of relative work positions as a function of body dimensions.

The question arises whether an accurate prediction of WMSD risk based on relative working positions is possible. Therefore, an empirical study was conducted to examine the influence of the relative working position on risk-relevant indicators of the WMSD. The research question is investigated using the example of WMSD risk of the back. Specifically, it is examined whether there is an influence of the relative working position as a function of body dimensions on working posture, compression load on the intervertebral disc L5/S1 and electrical muscle activity.

2 Methods

2.1 Participants, Experimental Task and Experimental Design

An empirical study was conducted to evaluate the influence of the relative working position on working posture, compression load on L5/S1 and muscle activity as relevant WMSD risk indicators. 20 right-handed subjects aged 19 to 64 years (mean = 37 yrs.) participated in the empirical study. The body weight including clothing of the persons varied between 52 and 113 kg (mean = 71 kg). At the time of the empirical study, none of the test persons reported having musculoskeletal complaints or diseases in the last 12 month. Dermatological complaints or diseases which would have avoided the application of markers and sensors on the skin were also not reported. The anthropometric measurements were collected according to DIN 33402-2 (Table 1).

Table 1. Anthropometric measurements of the subjects (n = 20).

Anthropometric measurements	Mean	Max.	Min.
Body height	1.74 m	1.93 m	1.62 m
Eye height	1.64 m	1.80 m	1.51 m
Shoulder height above floor level	1.45 m	1.63 m	1.33 m
Elbow height	1.08 m	1.23 m	1.01 m
Tibial height	.55 m	.63 m	.51 m
Height of the hand (handle axis) above floor level	.80 m	1.02 m	.73 m
Reach upward, both arms (handle axis)	2.07 m	2.33 m	1.91 m
Reach forward, both arms (handle axis)	.73 m	.81 m	.64 m
Foot length	.29 m	.33 m	.24 m

The experimental task was to change an air valve return spring on a carburetor. For this, the carburetor cover had to be removed with a cordless screwdriver and then remounted. The experimental task was carried out by means of an image-supported work step instruction and consisted of the following work steps.

1. grasp cordless screwdriver from shelf with right hand
2. loosen screw top right first and screw bottom left afterwards
3. place cordless screwdriver on shelf and place screws in bulk material container
4. grasp and pull off carburetor cover with right hand and spring with left hand
5. put spring on shelf and grasp new spring with left hand, while holding the carburetor cover in right hand
6. place spring in carburetor with right hand and push on carburetor cover with left hand
7. pick up cordless screwdriver with right hand from shelf and pick up screws with left hand from bulk material container
8. mount screw top right first and screw bottom left afterwards
9. put cordless screwdriver on shelf

The experimental task was carried out in different working positions. The working positions were defined individually depending on the anthropometric measurements of the subject in order to achieve a standardization. Accordingly, these are relative work positions. The horizontal position (h) was defined relative to the forward reach of the arms and the vertical position (v) relative to the upward reach of the arms, both according to DIN 33402-2. A total of 20 relative working positions were investigated (Fig. 1). The horizontal position varied between h = 50% and h = 130% of the forward reach of the arms. The vertical position varied between v = 20% and v = 65% of the upward reach of the arms. The vertical positions were defined to correspond approximately to heart height (60%), elbow height (50%), crotch height (35%) and tibial height (20%). A Microsoft Excel sheet was used to calculate the relative working positions for each subject individually.

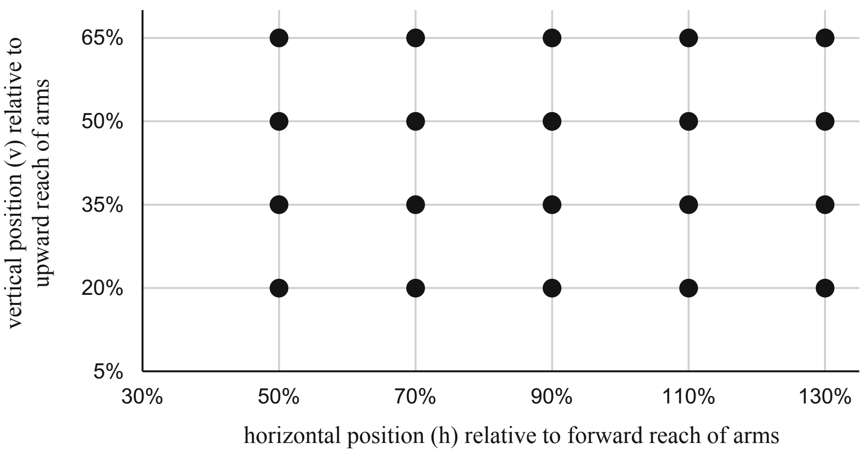

Fig. 1. Investigated relative working positions on the sagittal plane.

As dependent variables the back posture, the compression load of the intervertebral disc L5/S1 and the electrical muscle activity in M. Erector Spinae (ERSP) are measured. The back posture was calculated based on the motion capture data as the percentage of the total execution time of the neutral posture category R-1 (back straight) as defined by Ovako Working Posture Analysing System (OWAS) [4, 5]. The compression load of the intervertebral disc L5/S1 was also calculated based on the motion capture data using the biomechanical model as defined by [6]. Electrical muscle activity was recorded for M. Erector Spinae and normalized with the maximum voluntary muscle contraction as defined by [7]. Repeated measures analysis of variance (ANOVA) was performed with an accepted α-level of $p = .05$.

2.2 Apparatus, Experimental Procedure, Data Collection and Processing

The experimental setup consists of a shelf, a horizontally movable foot barrier and a height-adjustable table with the carburetor setup. The carburetor setup was designed so that all relative working positions could be adjusted for the 5^{th} percentile female to the 95^{th} percentile male. It consists of a height-adjustable table and a constructed frame to which four identical carburetors have been attached at 0.45 m intervals one above the other. An additional room was used for the preparation and follow-up of the subjects.

The study was conducted over a period of approximately 2 h and 30 min for each subject. The study was carried out with the subsequent five-stage test procedure.

1. Starting with a welcome, the access requirements of the subject was checked and a statement about the procedure was given. Subsequently, the subject signed the experimental information and agreed to participate voluntarily. Finally, the preliminary survey was conducted to record personal characteristics.
2. The anthropometric measurements and weight of the test person were measured. Electromyography electrodes were attached and the maximum voluntary muscle contraction was recorded. The markers for motion capture then were attached.
3. The experimental task was explained and trained in ten repetitions. The test subjects were immediately informed of errors in the execution of the work step instruction.
4. The main experiment was carried out in permuted order of the relative working positions.
5. Finally, the markers and electromyography electrodes were removed and the subject was questioned.

A camera system consisting of six Vicon Bonita 10 with reflective markers was used to record working posture and compression load of the intervertebral disc L5/S1. The data processing was carried out with Vicon Nexus (version 2.1.1). The electrical muscle activity was recorded with a Noraxon TeleMyo 2400T DTS. The placement of the electrodes was carried out according to the recommendations of [8]. The procedures for generating the reference measurements of maximal voluntary contraction (MVC) were based on the findings of [9]. Data processing was performed with Noraxon MyoResearch XP (Version 1.07, Clinical Edition). Data preparation for statistical analysis of the variables was performed using MATLAB R2013a (version 8.1.0.604) and Microsoft Excel 2010. IBM SPSS Statistics 23 was used for statistical analysis.

3 Results

The statistical analysis of back posture shows significant main effects of the horizontal ($F(4,396) = 44.099$, $p < .001$, $\eta_p = 0.734$) and vertical position ($F(3,397) = 155.847$, $p < .001$, $\eta_p = .907$). Furthermore, a significant first-order interaction with ordinal classification could be identified ($F(12,388) = 14.686$, $p < .001$, $\eta_p = .479$). In Fig. 2, the descriptive results of back posture are shown. Results show that percentage of OWAS R-1 back posture increases with deceasing horizontal position and increasing vertical position.

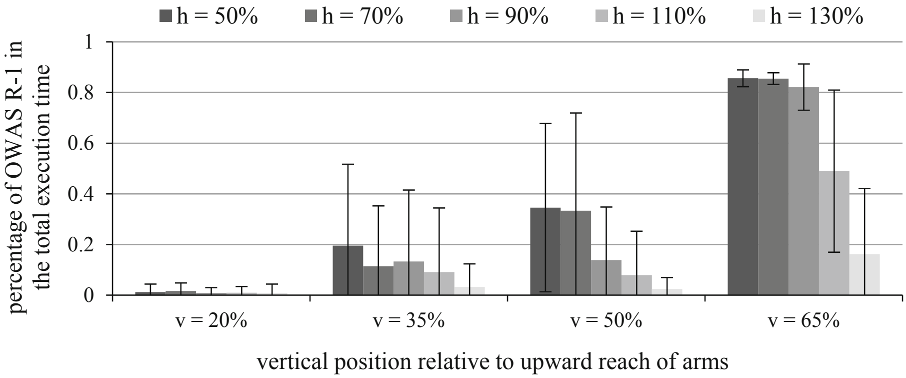

Fig. 2. Means and standard deviations of the dependent variable back posture.

The statistical analysis of compression load of the intervertebral disc L5/S1 shows significant main effects of the horizontal ($F(4,396) = 96.774$, $p < .001$, $\eta_p = .858$) and vertical position ($F(3,397) = 76.922$, $p < .001$, $\eta_p = .828$). Furthermore, a significant first-order interaction with hybrid classification could be identified ($F(12,388) = 155.847$, $p < .001$, $\eta_p = .907$). In Fig. 3 the descriptive results of compression load are shown. Results show that compression load increases with increasing horizontal position and decreasing vertical position.

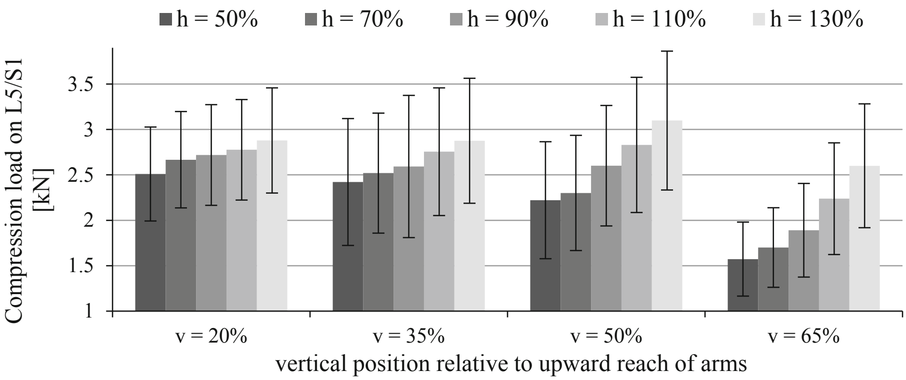

Fig. 3. Means and standard deviations of the dependent variable compression load.

A significant influence of the horizontal ($F(4,396) = 36.485$, $p < .001$, $\eta_p = .695$) and the vertical position ($F(3,397) = 4.638$, $p = 0.006$, $\eta_p = .225$) on the electrical muscle activity could be shown. Furthermore, a significant first-order interaction with ordinal classification could be identified ($F(12,388) = 2.719$, $p = 0.002$, $\eta_p = .145$). In Fig. 4 the descriptive results of electrical muscle activity are shown. Results show that electrical muscle activity increases with increasing horizontal position and shows inverted parabolic behavior with increasing vertical position.

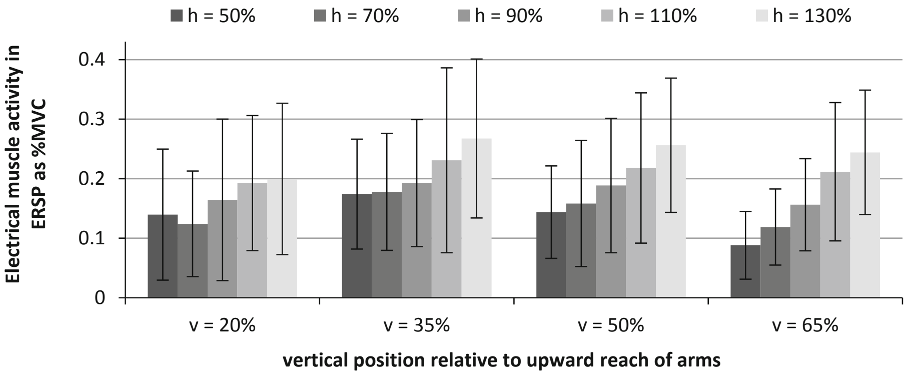

Fig. 4. Means and standard deviations of the dependent variable muscle activity.

4 Discussion

Overall, it can be concluded that the relative working position has an influence on all investigated WMSD risk indicators of the back. The study is subject to certain limitations due to assumptions made. First, it should be mentioned that the relative working position was calculated in a user-friendly way on the basis of two body dimensions, whereas more complex calculation procedures are conceivable. The anthropometric measurements of the subjects recorded are somewhat larger in comparison to DIN 33402-2, which can be explained in particular by the known acceleration of people since 2005. However, due to the standardization of the relative working position as a function of body measurements, this difference should be insignificant. In addition, only one assembly task was tested and the defined working positions are subject to a limited working area within which the study took place. The results of the laboratory study show a significant effect of the working position on the percentage of OWAS R-1 in the total execution time, the compression load of the intervertebral disc L5/S1 and the electrical muscle activity in M. Erector Spinae as suspected. The results are general in line with other finding such as in [10] or [11].

Condition-based analyses have already become established in practice for other WMSD risks, such as manual lifting, repetitive movements, pulling and pushing. The study illustrates that condition-based analysis is also possible for postures.

In the light of increasing awareness of the need for data protection laws and the associated move away from people-based analyses, ethical, legal and social implications must also be taken into account when choosing and developing WMSD-associated risk factors. For example, on the one hand, the question can be asked whether the purpose of improving occupational safety and health does not automatically entail the need for the highest possible accuracy of an ergonomic analysis (i.e. basically a people-based analysis). On the other hand, data protection is also a high value and may raise the question whether condition-based analyses, regardless of their lower accuracy, should not always be applied in principle. In order to answer such questions satisfactorily, further research on the validity of ergonomic assessment methods is needed, but also a critical discussion of ethical, legal and social issues by scientists.

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Using Simplify-Enable-Leverage-Resource (SELR) to Develop Solutions to Identified Opportunities

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Abstract. The SELR approach was developed by the U. S. Navy Reserve Force to make its associated operations more efficient and responsive to an ever-changing environment. SELR is similar to such programs as $6\sum$, Lean, Continuous Process Improvement, etc. The letters of SELR are defined as: *Simplify* by streamlining activities, programs, and policies to make them more efficient; *Enable* personnel to provide effective capabilities through innovative technology, supportive policies and solutions to identified opportunities; *Leverage* personnel skills, talents and relationships to further enhance their contributions to the organization; and *Resource* as the staffing, training, and equipment provision to deliver more responsive talent capabilities to the organization. These topics are discussed in depth and a case study is provided to illustrate the application of SELR.

Keywords: Ergonomics · Simplify · Enable · Leverage · Resource · Intervention

1 Introduction

The following information is provided to define each word in the SELR approach.

Simplify: Simplification of processes has been the focus of Industrial Engineering, management science and business for decades. These approaches are required in order to streamline activities, programs and policies to make them more efficient. Burdensome policies, processes and activities are not sustainable in the 21st Century as they require too much time, effort and often reduce flexibility and maintenance of the organization and are not competitive in the environment of rapidly changing demands.

Enable: Allowing talent to more effectively deliver required capabilities through the use of innovative technology and support policies are designed to modernize the way in which individuals manage their careers, eliminate salary and personnel issues and change from hiring and managing personnel to hiring and managing talent. These efforts create a winning organization that recognizes individual skills and allows a more smooth transition between a specific position within an organization and a project team.

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Leverage: The skills, talents and relationships of individuals within an organization should be supported and championed to further improve their contributions to the organization. Individual talents cover the entire spectrum of professional fields and their associations with industry and academia create a powerful force multiplier. Individuals within the organization are the face of the organization in their local communities, where key relationships are ideal to harness the power of trust, honesty and integrity with the community in which the organization operates. Organizations need to better utilize that unique combination of individual skills/talents that will give the organization a competitive advantage.

Resource: Prompt, available, designated and focused resourcing ensures that the talents, skills, training and equipment provides capabilities to the organization when required by organizational and competitive demands. Organizations must have innovative processes that have the right tools for the job in the hands of the right talent at the right time to remain competitive.

2 Background

Several sources were evaluated to determine the impact of each of the SELR variables One of the main resources was the Deloitte 2015 report entitled: Global Human Capital Trends 2015: Leading in the New World of Work [1]. Additional resources were consulted to provide additional information related to each SELR variable.

The Deloitte 2015 report [1] indicated that little more than 50% of the responding organizations had some level of work simplification programs in place. Furthermore, only 10% had a main program in place.

The reason for these gaps may be related to the perceived complexity of the work. Agarwal, van Berkel and Rea [2], found that the respondents of the complexity of work indicated the following contributors to their perception of the work complexity: (a) Generalized technology and connectivity; (b) complexity in technology; (c) globalization; (d) increase administrative and compliance demands; and (e) too complex business processes and systems.

When administrative and procedural processes are too complex, finding simple solutions to the identified ergonomic opportunities is nearly impossible. Why? When the individuals see the system as complex, they assume the solutions must be also complex. Paraphrasing Ockham's razor, the simplest solution is often the best solution.

In order to integrate the tenants of work simplification, organizations must allow their personnel (talent) to make decisions and develop solutions to identified opportunities. Organizations should also take advantage of the skills, talent and desires of these individuals to develop and manufacture solutions/interventions to identified opportunities.

Personnel, vice talent, are most often hired to perform a specific task within an organization. However, they can have other unique skills and talents that can be used to not only simplify work, but can also be used to improve methods, develop solutions and manufacture the interventions to identified ergonomic opportunities.

Organizations that have implemented programs such as FastWorks [3, 4] have found that better solutions require a focus on the following concepts: (a) a company's success is determined by its customers; (b) going fast requires staying slim; (c) winning requires learning to adapt quickly; (d) enabling and leveraging resources talent, tools, equipment) is essential; and (e) results must be delivered in an uncertain world.

Individuals who are allowed to make decisions regarding the effectiveness of methods, processes, tools and the equipment, used to provide goods and services yield the faster development and implementation of internal solutions.

Taking advantage of individual, and most often untapped, skills and talents (enabling and leveraging), combined with supplying the resources for execution, enhances the implementation of Lean. Lean should not only be used in business processes, but must also be used in the identification of ergonomic opportunities and related design, manufacturing and implementation of solutions for the identified opportunities.

Finally, resource implementation must be a priority to address identified ergonomic opportunities. Why, when individuals suffer from work-related injuries associated with ergonomic indicators, a number of issues arise:

- Injured workers may not report injuries because they do not want to lose the job. Such work continuation most likely will exacerbate the injury.
- Unreported injuries may result in permanent disability and likely reduced productivity (work capacity).
- Workers who are aware of these conditions may become distracted by thinking about being injured themselves, rather than focusing on their tasks resulting in other work-related injuries, decreased productivity, equipment and/or product damage.
- The organization's reputation will be impacted by community knowledge of a high injury rate environment resulting in talent acquisition difficulties.
- Talent will leave to find a 'safer' place to work.
- Failure to address these issues will undermine Lean program effectiveness and overall organization competitiveness.

3 Results

The following case study illustrates the application of the principles of SELR. The case study was conducted in a utility company that is involved with the generation and transmission of electricity, distribution of natural gas and distribution of drinking water.

One of the tasks that are involved in the process of treating water is to clean the distribution plant treatment ponds. In order to access the ponds, large stainless steel panels must be removed so that high-pressure water can be sued to clean the pond walls. These panels are moved manually. The panels range from 6.096 m (20 ft) to 9.144 m (30 ft) weighing from 93.40 kg (205.92 lbs) to 140.11 kg (308.88 lbs). These panels are presented in Figs. 1 and 2.

Scheduled moving of panels was often pre-empted due to windy conditions, as the panels act like sails when slightly tilted into the wind. Temporary pre-emption was also required during other environmental conditions such as rain (slippery conditions), ice (slippery conditions) and snow (additional weight and slippery conditions) Therefore, the identified opportunity was to be able to move these panels in any weather condition so that scheduled maintenance could stay on track.

An attempt was made to use a large gantry to move the panels, as illustrated in Fig. 3. However, the gantry width was not adjustable and could only be used in specific areas and for specific panels (panels sizes were not standardized due to plant expansions). As result, other options needed to be explored.

An alternative to using the gantry to move the panels was identified as a wheeled hydraulic 'Padilift' [5]. This device is presented in Fig. 4. This device would be used to lift the panels. However, the design of the lift would still require personnel to actually move the panels manually to allow access to the pond below.

During the solution process, one of the personnel working in the facility used their talent to develop a more simple preliminary design of a device that could be used to move the panels (*Simplify*). This individual was encouraged to use their insight and design to further the design from a drawing on a napkin to a more detail drawing to be presented to engineers (*Enable, Leverage*). Once presented, the individual also volunteered to fabricate (leverage) a prototype and was provided the material for both prototype and final device (*Resource*).

The resulting design and final device is presented in Fig. 5. The final device uses a simple cable pulley device to lift and adjust the height of the panel. Wheels are alighted in the direction of movement so that personnel do not need to manual move the heavy panels. Then, the lift is lowered to place the panels in a temporary storage position, allowing access to the pond below.

Fig. 1. Large panels over deep pond.

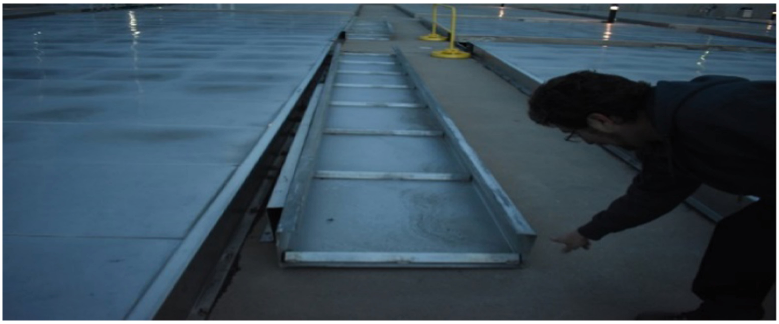

Fig. 2. Panel turned upside down to show panel design details (right).

Fig. 3. Gantry used to move some panels.

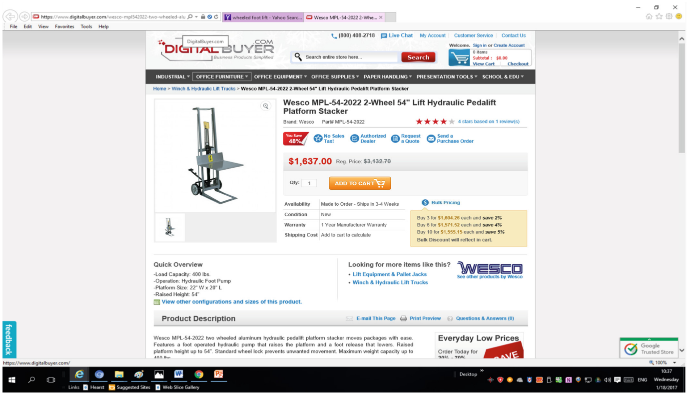

Fig. 4. Wheeled hydraulic 'Pedalift' platform stacker available in the market [5] identified to address the opportunity.

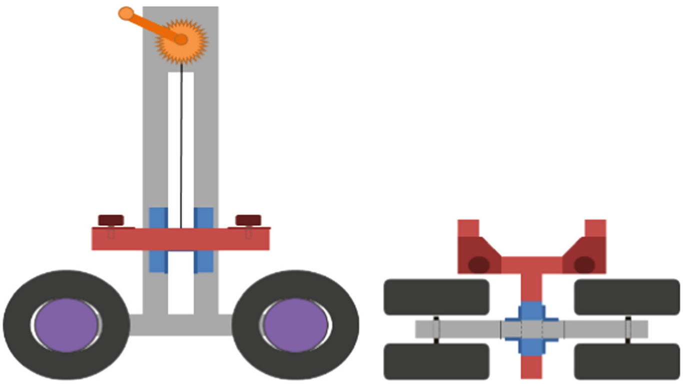

Fig. 5. Panel lifting device designed and fabricated (in house) by talent working at the facility

The impact of the implementation is detailed below.

- The solution resulted from a simple design through enabling and leveraging in-house talent and providing the resources to execute the intervention.
- The average direct cost of back pain per person for this company was $2,500 USD.
- The 6 back pain incidents related to lifting and moving the panels were reported in this department resulting in an annual cost of $95,000 USD (6 × $2,500 = $15,000).
- The cost of the solution (2 devices, one for each end of a panel) is $1,000 (material costs); fabrication took place during normal working hours
- The cost of SELR solutions was 0.06 (6%) of the incidence costs of one year.
- Conservatively amortized over the life of the device and saving 6 back pain injuries per year results in a value of $82,884 (F/A, 5%, 10).

4 Discussion

As can be seen, the application of a SELR approach to the identified ergonomic opportunities can result in enormous benefits for both workers and organizations. The SELR must be applied in all organizations to be a better place to work and improve the well-being of workers. This is also imperative as illustrated in Deloitte's 2019 Global Human Capital Trends report indicating that organizations are changing from traditional workforces to alternative workforces; from employee experience to human experience; and from hiring personnel to hiring talent [6].

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Study of the Furniture Used for Students in a Peruvian University

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Abstract. The furniture used by students in schools and universities is usually purchased in average dimensions so that all male and female students, small and large, use them without distinction. It is very difficult to find furniture that fits the dimensions of each individual and it is common to work with molds or patterns that come from other countries. The purpose of this study was to determine the percentage of the university population that cannot use comfortably said furniture, for which tables and chairs recently bought in a new classroom building of a Peruvian university were taken into account. For this, and in order not to use anthropometers, a methodology was proposed that allows students to find the dimensions based on their height. Additionally, the weight of the same students is taken into account, that is, with only two variables, very easy to determine, a more complex study can be done. The most significant result is that a percentage close to 40% of students, have difficulty sitting and using the tables in the classrooms, so their health could be at risk, due to the large number of hours they can spend using the chairs and tables in their classrooms. The results can be used as a basis to have anthropometric data of the students of this university and also to be able to determine the dimensions of furniture, instruments, machines to be used by them.

Keywords: Furniture · Physical ergonomics · Human factors

1 Introduction

Anthropometry is defined as "the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body" [1].

Anthropometry is the branch of the human sciences that deals with body measurements: measures of body size, shape, strength and work capacity [2]. It is about the physical characteristics of a person, particularly with individual variations, ontogenesis and generic development. Anthropometric data on the general population are essential in ergonomics to specify the physical dimensions of the workspace, equipment, furniture and clothing to adapt to the user and to avoid a physical mismatch between the dimensions of the products and equipment and the corresponding dimensions of the user [3].

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Tools, machines, workplaces, clothing, and in general all products, must be proportional to the dimensions of the users, however, in practice, musculoskeletal disorders are common among people, including students, workers, housewives, and others. As in many workplaces, one of the common problems in the classroom is the poor quality of the seats and tables for the students, especially considering that they remain seated for a long time [4].

In that sense, the field of anthropometry covers a variety of measures of the human body, such as height, lengths and widths of limbs and other fundamentals for the design of the workplace, in order to avoid musculoskeletal disorders in workers [5, 6].

For example, it is quite common to find chairs in Ecuadorian universities, without evidence that it is designed to adapt to the anthropometric characteristics of students who use it [7]. On the other hand, the greatest average differences in anthropometric data among male high school students and female found themselves at the height of the sitting elbow. In addition, a comparison of anthropometric data of male and female university students showed that the data for men and women were significantly different, except for the gluteal-popliteal length, the height of the sitting elbow and the thigh space [8].

Therefore, an implementation of anthropometric data will help to create comfort, safety, well-being, fitness, reduce musculoskeletal disorders and improve student performance in terms of care, so it is important to consider the dimensions of students when designing the Classroom furniture and conduct seminars or workshops to educate students about the negative impact towards adapting poor posture in the prolonged use of classroom furniture [9].

In this way, furniture is one of the most important parts of any workplace, even in vehicles, parks, gardens, factories, offices and in the house so it is necessary to consider anthropometric measurements, as well as follow ergonomic guidelines when designing any furniture in which people perform their usual activities. The students of the university hall spend most of their time in a day with any of the furniture such as table, chair, bookshelf, and others. These furnitures are responsible for many types of physical problems, such as back pain, if not properly designed. Defective furniture design also reduces user efficiency [10].

Finally, it can be said that the health problems associated with the use of school furniture that disagrees with the anthropometric dimensions of the user-student have required the necessary attention given to its design in recent years. The use of anthropometric variable regression models is important in the ergonomic design of products and workplaces when the required anthropometric data is not available. Economically, it can be very expensive in developing countries to obtain anthropometric data when necessary, and as such, measuring an anthropometric value to determine others would be useful and affordable [11], so it is necessary to create economic means of measuring dimensions Body of the different users to consider.

The objective of this work is to develop an anthropometric study of furniture used in a Peruvian university, following an economical and practical anthropometric evaluation method to be able to evaluate the furniture design of the classrooms used.

2 Methodology

2.1 Population Data and Determination of the Number of Samples

The research focuses on the industrial engineering students of the selected university, Around 1050 students are enrolled in this university during every academic semester. Subsequently, the number of samples is determined according to the formula described in Eq. (1). To prepare the sample, the number of students required is 75 (n = 74.52). 113 students were tested.

$$n = \frac{Z^2_{1-\frac{\alpha}{2}} N\sigma^2}{(N-1)E^2 + Z_{1-\frac{\alpha^2}{2}}\sigma^2} \tag{1}$$

Where:
n = Number of students needed.
N = Total of Industrial Engineering students (1050 students).
Z = Confidence level 95% = 1.959963 (95% + $\frac{\alpha}{2}$).
σ = Standard deviation (4.5 students).
E = Permissible error (1 student).

2.2 Determination of the Relevant Dimensions

In the study of furniture used by students, two fundamental elements, chairs and tables, were considered. In each case, depending on the greater impact on the health and comfort of the students, the following variables were determined: in the case of the chair, the height of the seat and the depth of the seat and in the case of the table, the upper height of the table. In each case, the dimensional variables of the human body to be measured were identified, in the case of the chair two dimensions were considered, the popliteal height and the popliteal length, given that the main problems in the use of chairs that are not Adjustable are the support of the feet on the floor directly and the support of the lower back on the back of the chair. On the other hand, in the case of the tables, the height of sitting elbows was considered, since the main problem occurs with small people who have to raise their elbows to be able to support them on the table.

Since this furniture is used by male and female students, no separation by sex was made to conduct the study.

2.3 Anthropometric Data Collection and Determination of the Values to Be Used in the Study

To find the indicated body dimensions and given the difficulty of using an anthropometer, we proceeded to determine only one dimension, which is easy to find, the height. With this data and using the tables shown in the Ergolandia software (https://www.fbfsistemas.com/ergonomia.html), which present the body dimensions of the human being, without distinction of sex, only according to the stature, you can determine the different dimensions of the human body. As the software presents the dimensional data for some specific statures, a mathematical regression is carried out to determine the function in each of the three dimensions involved, depending on the height. From these calculations, each of the three dimensions sought is determined for each of the students.

With these data already defined, we proceed to determine the mean and standard deviation of each of the dimensions.

2.4 Estimation of the Lack of Comfort of Student

To estimate the lack of comfort of the students involved, the criteria of extreme values were used, given that the dimensions of the chair were not adjustable criteria. In this way it is identified that it is less bad, to design for the smallest or the largest, in each of the cases and the percentage of users who, not only are not comfortable, but, In addition, they may have health problems.

In this case, the following was determined for each dimension: popliteal height - smaller, popliteal length - smaller, sitting elbow height - smaller.

Additionally, based on the current dimensions of chairs and tables, considering the criteria indicated and using the relationship proposed by Mondelo et al. [12], the percentage of the population that does not meet the established conditions must be determined:

$$\mathrm{Xp} = \mathrm{Xprom} \pm \beta \times \mathrm{S} \tag{2}$$

In this relationship, Xp is the design dimension of the chair, Xprom is the average of the dimension of the population studied, S is the standard deviation of the dimensions of the population studied and β is a coefficient linked to the percentage of the population that measures the indicated value or less.

In each case the respective β is determined and therefore the percentage of the population that could have problems.

3 Results

3.1 Anthropometric Data Collection and Determination of the Values to Be Used in the Study

The measurement was made to the students of the sample obtaining the height in each case, and additionally the sex and the weight as shown in Table 1.

Table 1. Survey summary

Sex	Stature	Weight
Male	174	75
Female	155	63
Male	172	73.5
Female	158	46
Male	172	70

From the data found, for each of the cases, the values of each of the three dimensions that are required are determined, for this we work with a regression of the data found in the ergonaut software. This software contains the dimensional data for defined heights as shown in Table 2.

Table 2. Ergonautas dimensions

Stature	Popliteal height	Popliteal length	Sitting elbow height
177.8	43.7	46.2	23.1
175.3	43.2	45.7	22.9
172.7	42.7	45.0	22.4
170.2	41.9	43.9	21.8
167.6	41.1	43.2	21.6
165.1	40.4	42.4	21.1

With this data and with the use of a linear regression, the value of each of the dimensions is determined by student stature as shown in Table 3.

Table 3. Student dimensions

Values with regression model			
Stature	Popliteal height	Popliteal length	Sitting elbow height
175	43.2340605	45.4945116	22.4406417
171	42.1638918	44.2014223	21.8683264
168	41.3612652	43.2316053	21.4390899
158	38.6858432	39.9988821	20.0083015
178	44.0366871	46.4643286	22.8698782
167	41.093723	42.908333	21.296011
162	39.756012	41.2919714	20.5806169

With these data already defined, we proceed to determine the average value and standard deviation of each of the dimensions for the sample of 113 students as shown in Table 4.

Table 4. Average value and standard deviation

	Popliteal height	Popliteal lenght	Sitting elbow height
Average value	41.29142009	43.147211	21.4017374
Standard deviation	2.391039572	2.8891029	1.27870357

3.2 Estimation of the Lack of Comfort of Student Users

Once the average values and the standard deviation of the three dimensions defined for the evaluation of student comfort have been determined, and using the relationship indicated in the methodology, the β value is found in each case. For the calculation it has been considered that the students employ, mostly sports shoes with 2.5 cm high soles. This value has added the average popliteal height.

$$Xp = Xprom \pm \beta \times S \tag{3}$$

From this value of β the percentage of the student population that has a measure equal to or less than the dimensional value of the chair is determined as can be seen in Table 5.

Table 5. Percentage of students who will have problems

	Design value (cm)	Average value (cm)	Standard deviation (cm)	β	% students
Popliteal height	43	43.7914	2.3910	0.3309	37.0
Popliteal lenght	44	43.1472	2.8891	0.2951	61.5
Sitting elbow height	32	21.4017	1.2787	8.2882	100.0

As can be seen from the table, 37.0% of the student population will have problems with the height of the chair, 61.5% will have problems with the backrest, so that they cannot properly support their backs and finally almost 100% do not have your arms in a relaxed position; you should raise your arms to rest them on the table.

4 Conclusions

In the present research the inappropriate use of chairs between the student population of a Peruvian university has been determined and it has also been determined that the tables have a height that is not appropriate for proper use.

This situation is more noticeable among the female population because its dimensions are smaller, so they will have more problems when using chairs and tables destined in classrooms

As can be seen in the results of the study, the biggest problem represents the depth of the chair, with about 61.5% of students who will not properly support their backs in the backrest because their popliteal distance is less than that depth of the chair. This is followed by the upper height of the tables, since, although almost 100% of students cannot comfortably lean on the table, the type of activity they have and the possibility of supporting their arms reduces their impact.

It is also important to keep in mind that almost 40% of students will not be able to support their feet correctly due to the height of the chair.

Finally, it is important to consider the possibility of having height and depth-adjustable chairs and height adjustable tables, but not so sophisticated, since there is not much budget available for the purchase of this furniture.

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Ergonomic Evaluation of Agriculture-Related Activities Performed by Ecuadorian Indigenous Women

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Abstract. Most of the agricultural activities in Ecuador are carried out by indigenous communities. Most of the elderly women from these communities suffer moderate to severe spinal deformities; previous studies suggest that one factor that could affect their back health is the lifting of heavy loads. The aim is to calculate the low back compression force using commercial software. Tasks consisting of lifting a sack by two methods were recorded in a gait laboratory. Although it is common for indigenous women to handle loads up to 45 kg, they were limited to 15 kg to reduce injuries risk. The input data to the software included gender, mass and height, and forces acting on hands, back and one shoulder. Measured and extrapolated results show that the low back compression force is significantly higher than the NIOSH recommended limits.

Keywords: Low back compression force · Indigenous · Lifting · Agriculture · Work-related injuries

1 Introduction

Nowadays, musculoskeletal disorders (MSDs) are the most studied occupational diseases since they are the most common in the industrial environment and produce the highest rate of absenteeism. These disorders are known to be caused mainly by postural demands, repetitive movements, load manipulation, vibrations, poor lighting and cold environments [1]. Specifically, the MSDs of the body mid-section are related to inadequate postures, efforts in heavy load manipulation, and static and dynamic muscular work all these affecting the integrity of the spine and the pelvic area [2].

The indigenous women of Ecuador highlands are dedicated to agricultural and domestic tasks that are carried out manually and without technical assistance, which makes most of these chores physically demanding. To be highlighted is the manipulation of sacks of agricultural products, since the standard in the country for products such as potatoes, carrots, onions, among others, is a weight measure named *quintal*, equivalent to 100 lb or approximately 45 kg, see Fig. 1.

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Among the methods for ergonomic evaluation, those issued by NIOSH are the most used for load lifting and lowering tasks, allowing to calculate through an equation the recommended weight and thersholds as the Action Limit (AL) and Maximum Permissible Limit (MPL) [3]. The Revised NIOSH Lifting Equation [4] is based on three criteria, one biomechanical centered on the calculation of mechanical moments that are transmitted through the body to the lumbar vertebrae, one physiological that takes into account, not only the magnitude of the load, but the amount of repetitions of the lift and its associated energy expenditure, and one psychophysical that combines the effects of the previous two. The equation measures how far the evaluated lifting is from the ideal one, being the ideal the one that starts at the standard location, in sagittal position (without turns and symmetrical), done occasionally, with good grip and an elevation of less than 25 cm [5].

Fig. 1. Indigenous women carrying *quintals* of carrots resting on one shoulder.

A technique widely used in the evaluation of tasks that involve the lifting of loads consists of a 3D motion capture data of the task and the subsequent use of software that with the position and the ubication of the load over a human body model allow estimating the compression force in the column [6]. In these programs, one of the most critical aspects is the correct modeling of the external loads to obtain realistic strains in the spine for each position that is analyzed [7]. The software 3DSSPP® of the University of Michigan performs simulations that includes posture data, force parameters and gender anthropometry, and calculates the percentage of men and women who have the strength to perform a defined job, the low back compression forces, and comparisons to NIOSH guidelines [8, 9].

The goal of this work is to calculate the low back compression force using a static strength prediction software in a young adult indigenous woman, who is a university student and works in farm-related activities during the weekend, with no apparent musculoskeletal disorders, analyzing two tasks consisting on the lifting of an open sack by two different methods.

2 Materials and Methods

The subject is a 24-year-old woman, pertaining to the Otavalo ethnic group, from Ecuador, who is 1.54 m tall and has a weight of 45 kg. The subject was previously interviewed, obtaining the following information:

- The subject has no training for the safe handling of loads. This a common condition in indigenous communities.
- The subject lifts weights of up to 30 kg, from the ground. Other women reportedly lift and carry weights of up to 45 kg.
- Agricultural products are carried in closed sacks, open sacks, and boxes.
- Two of the methods used by the subject with open sacks are symmetrical (stoop) lifting and asymmetrical (over the shoulder, OTS) lifting.

Experiments were set-up to simulate both types of lifting. To reduce the probability of an injury during the tests, loads were set to 5 kg, 10 kg, and 15 kg. The aim of using three different weights is to extrapolate results for higher loads, closer to the 30 kg maximum lifted loads declared in the interview. Lifting activities were repeated five times each, with a one-minute rest between them, to account for the variability of the movements.

Measurements were done in a gait analysis laboratory fitted with a BTS Bioengineering motion capture system, including six cameras for markers tracking, cameras for lateral/frontal video recording, and two force plates. Optical markers were used in several joints; however, besides the plates data, only the information of markers in both hands, right shoulder, low back, and the sack were finally used for calculations.

Position and force information was exported to a plain text file and processed with a Matlab® [10] script to filter data, detect events and calculate forces acting on hands and joints. Symmetrical lifting has been thoroughly examined in the literature [11, 12]; however, the OTS lifting of sacks has been less studied. Events were detected by examining force plates data; in the case of stoop lifting, the maximum load is achieved when the sum of vertical forces of both plates is the highest; this considers the dynamic effect when lifting the load. Hands load was obtained by subtracting the weight of the subject to the maximum vertical force registered; it was assumed that each hand carries half of the load. For OTS lifting, two events were studied: maximum load, when the sack is just lifted from the ground, and maximum unbalance, when the sack is resting in the back of the subject. To calculate forces on the joints, a simplified model was developed (see Fig. 2), its values are calculated with Eqs. (1).

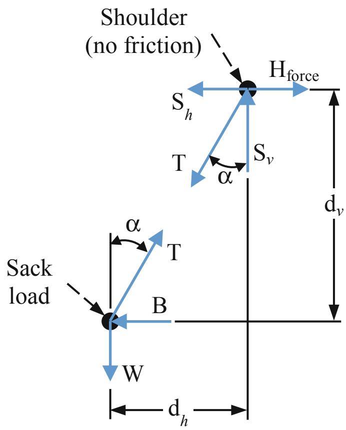


Fig. 2. Free body diagrams of the shoulder and the sack load. T is the internal force of the sack, distances d_v and d_h were calculated from the marker's positions and considering the distances to the center of mass and the shoulder.

$$\begin{gathered} H_{force} = W/cos(\alpha). \\ S_h = W(1-sin(\alpha))/cos(\alpha). \\ S_v = W. \\ B = W\,tan(\alpha). \end{gathered} \tag{1}$$

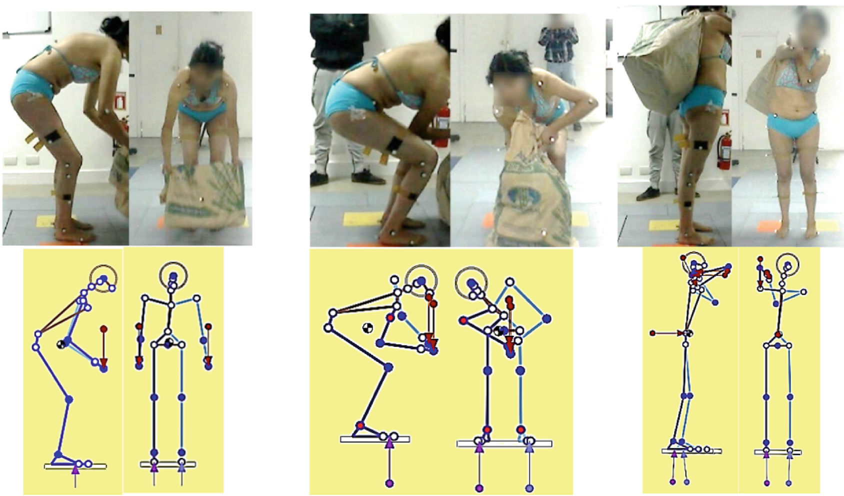
Where W is the load weight, H_{force} is the reaction force of the hands, S_h and S_v are the components of the reaction force of the shoulder, and B is the reaction force of the back.

A representative posture was selected for each of the three events: separation of the load from the ground (maximum load) during stoop lifting and OTS lifting, and maximum unbalance during OTS lifting. Selected postures and calculated forces were modeled in 3DSSPP® 7.10 [9] to obtain the low back compression force and the strength percent capable values. According to the anthropometry database of 3DSSPP®, the weight and height of the subject correspond to 7th and 18th percentiles, respectively. Due to this discrepancy, direct data entry was used.

3 Results

Images taken from video recordings were used as background images in 3DSSPP to model postures. Note that postures for maximum load in stoop lifting (Fig. 3a) and in OTS lifting (Fig. 3b) are different since in the latter, the subject is already preparing to handle the load over her shoulder.

Figure 4 shows the low back compression forces for the three studied events. The first three points of the lifting curves correspond to the handled loads 5 kg, 10 kg, and 15 kg. The fourth point was extrapolated from the data; the best fit for the stoop lifting was a straight line, while for the OTS lifting were quadratic polynomials. No extrapolation was made beyond 20 kg since as the handled load increases, not only the loads acting on the hands and joints change but also the posture of the subject; therefore, results lose reliability as the extrapolated point is located farther away. The Back



(a) (b) (c)

Fig. 3. Images and models of postures studied, (a) stoop lifting, (b) maximum load during OTS lifting, (c) maximum unbalance during OTS lifting.

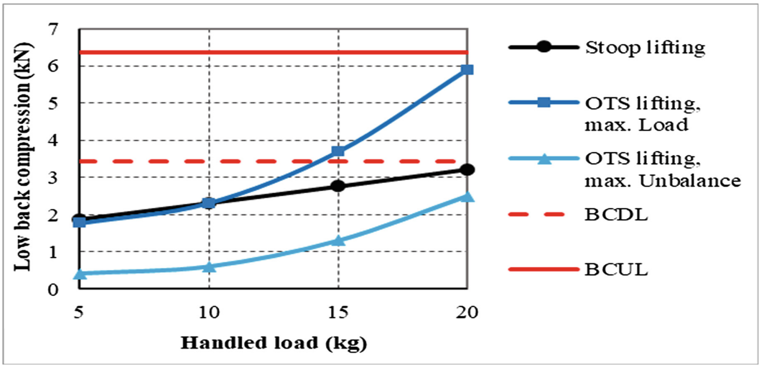


Fig. 4. Calculated (5 kg to 15 kg) and extrapolated (20 kg) low back compression forces for the two considered lifting methods. The Back Compression Design Limit (BCDL) and Back Compression Upper Limit (BCUL) are equivalent to the NIOSH AL and MPL [9].

Compression Design Limit and Back Compression Upper Limit [9], were included in the graph as a reference. It can be seen that the maximum load events, both in the stoop lifting and OTS lifting methods, cause the low back compression force to be considerably higher than in the maximum unbalance event of the OTS lifting. Moreover, due to the suboptimal posture adopted to perform the initial lift in the OTS maneuver, and with a handled load of 15 kg which is a half of the declared maximum handed load, the low back compression force is already in the undesirable zone over the BCDL value; the extrapolated value of 20 kg is in this zone as well, but very close to the hazardous BCUL value. Due to the tendency of the data, it is easy to see that for a handled load of 30 kg, the low back compression forces will be over the design limit or the upper limit.

4 Conclusions

In Ecuador, the handling of harvested agricultural products is carried out almost exclusively by indigenous women with anthropometry similar to that of the subject of this study, or even with a higher body mass index. The standard packaging used for the marketing of most of these products is a sack weighing 45 kg which, when contrasted with the results obtained in this work, makes it evident that it is an excessive load, even though it is lifted and carried symmetrically; the problem becomes worse if it is considered that women aged over 60 continue to work at farms and markets transporting these sacks. The main consequence of this commercial practice, along with some cultural habits and the absence of formal training in the safe handling and transportation of loads, is the high prevalence of musculoskeletal alterations, causing moderate to severe pain, among other ailments [13, 14]. These facts should be considered by the Ecuadorian government to issue regulations leading to a reduction of the standard weight for these sacks, and the compulsory education in the safe handling of loads for agricultural workers and employers.

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Social & Occupational Ergonomics Analysis and Methods

Omax and Fuzzy Logic as Productivity Tools and Ergonomic Analysis in Automotive Maintenance

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Abstract. Productivity is today an important factor in the growth of companies, for this, it is necessary to have an adequate ergonomic environment for the sake of workers. This work aims to show the use of the Objective Matrix (OMAX) and the analysis of environmental conditions from the use of fuzzy logic to determine the behavior of factors such as temperature, noise and lighting and its direct effect on productivity from the workers. A group of employees from the maintenance area in an automotive agency that offers mechanical washing and maintenance services was analyzed. With the OMAX method, the level of productivity was determined for a predetermined time by analyzing fatigue and physical wear for certain schedules. According to the Mexican regulations established by the Ministry of Labor and Social Welfare (STPS by its acronym in Spanish), it is necessary to comply with some requirements that are established by law, so once the current environmental conditions were analyzed based on the use of fuzzy logic, an adjustment based on regulations, making the changes required to subsequently measure the final result with OMAX, which showed a productivity increase.

Keywords: Fuzzy logic · Ergonomics · Productivity · Automotive industry

1 Introduction

The personnel comfort in every organization is essential to reach the maximum productivity level, in the case of study the washing staff and mechanical workshop, are exposed to high temperatures that are what determines the environment, without, however, as it is a hot zone, temperatures become very high during most of the year,

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this means that the productivity level is greatly affected, as employees look for ways to cool down in different ways, neglecting their work, which increases the operation time of the activity, which causes the standard time to multiply, and greatly delay the delivery time of vehicles.

When it talks about weather conditions, a comfortable environment is essential to feel good and to obtain maximum efficiency, caloric overload causes a state of tiredness and drowsiness, a decrease in performance and a great predisposition to make mistakes.

According to the Ministry of Labor and Social Welfare (STPS for its acronym in Spanish) [1], It is necessary that the knowledge of the human body, its needs, and limitations, be known in the labor field, as well as that the employee fits into the work environment in a positive way.

Monitoring the environment, furniture and interpersonal relationships in the workplace, are the foci that can cause psychological distress and physical illness in the workplace are basically of Two types: the first is related to furniture, especially computer chairs and tables; and the second has to do with the environment, such as ventilation, temperature, and lighting, as well as the square meters available per worker.

In the Car One automotive agency located in Tuxpan, Veracruz, Mexico, the workers in the washing and mechanical workshop area, work in temperatures exceeding 35 °C. The infrastructure of the work area, in the case of the washing area does not completely cover the sun, so the workers dry the cars outdoors, which makes them run out faster, work more uncomfortably and above all raise their body temperature, decreasing its performance and take more time to finish washing a unit, due to the breaks it takes to get away from the sun.

The washers argue that they feel short of breath by opening a car that was in the sun for a long time and that the feeling is really annoying.

In the service workshop area, the mechanics are under a laminated and completely closed dome, which does not run air, the dome material makes the place very hot and without natural ventilation, only 2 mechanics of the 5 Workers have a basic fan to dissipate heat from their work area, however this is not enough to maintain an adequate temperature, because they are in quite a lot of movement and even more making a lot of physical effort.

The mechanics look for a moment, and thus cool off, due to the discomfort of the work with the heat, this causes delays in delivery of the units, and as a consequence a low productivity. That is why it is decided to make an ergonomic study of environmental conditions, using Objective Matrix (OMAX) [2] and Fuzzy Logic (FL) [3] to determine the level of impact on productivity.

2 Background

A work is analyzed where an ergonomic analysis is carried out in the first phases of an R&D project where the objective was to investigate the operation of the training of automotive service technicians (AST) for the design of a teaching aid for augmented reality (AR) [4].

In automotive industry, mechanics habitually use awkward back posture in their course of manual activity, and hence may be at risk of work-related back pain; in a study in Eastern Nigeria of 684 automotive mechanics, information about back pain was collected, by detecting some variables such as heavy physical workload manual material handling, strenuous posture, noisy environment, vibrations, work schedule, and inadequate auxiliary support [5].

In a work about macroergonomy based on observations, interviews with mechanics, the performance company statistics and the activities carried out before, during and after work, was identified common hazards encountered during the work process. The identified factors were assessed by risk evaluation methods [6].

Fuzzy Logic and RULA (Rapid Upper Limb Assessment) was used to assessment of risk in maintaining in representative areas of a hardware store in Mexico; the use of fuzzy logic in this case study aimed to minimize the valuation work for every operator with RULA method, indicating, through fuzzy sets, the levels of risk that may arise [7].

In a study about productivity, a control model is developed for a paint shop department in an automotive company the optimum operating setting of a paint shop production line of an automotive company in Turkey is determined using a hybrid simulation-optimization approach [8]. Studies have shown that Ergonomic factors such as lighting, temperature and noise, can contribute to the performance of the employees [9].

A field study was done to identify the main factor environmental ergonomics in engines workshop, where it was determined that thermal comfort is considered the factor which is often emphasized by the occupant of the accommodation unit, in relation to thermal comfort and relative humidity [10].

A company in the gas industry suffered a fluctuation of sales, and there was a gap between production and production objectives, the Objective Matrix (OMAX) was used for given productivity data, 10 of the 12 months during 2017 where did not meet the production objectives. Part of the result of increasing productivity was ergonomics [11].

3 Methods

The study was carried out in an automotive maintenance company that serves new and pre-owned cars. For this work, was considered the maintenance and self-cleaning department, which is made up of seven people.

Through the ergonomic and operations analysis, productive and non-productive elements are examined to increase productivity per unit of time (Table 1). The main activities of each operator from OMAX, were analyzed to determine the productivity indexes, this was compiled in matrices as indicated by the method (Table 2).

Table 1. Work-related musculo-skeletal disorder (WMSD)

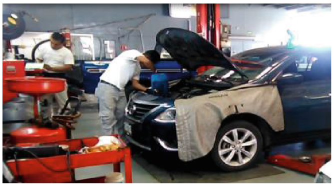
Posture	Identified Muscles	Work-related musculo-skeletal disorder (WMSD)
	• Sternocleidomastoid • Deltoid • Biceps • Abdominal rectum • Wrist and fingers • Flexor retinaculum	• Low back pain, • Cervical tension syndrome • Tendonitis
 .	• Flexor retinaculum • Deltoids • Biceps • Trapezius • Pectoral • Wrist and fingers	• Dorsalgia, • Low back pain, • Cervical pain syndrome

Table 2. Activities (time in minutes)

Transfer vehicle	Car washed	Rugs washed	Car cleaning	Car dried	Inspection	Car oiled	Evaluation criteria
1.5	4.33	2	5.58	1.5	17	3	Performance
1	3.56	1	5	1	14	2.5	10
1.071	3.67	1.142	5.082	1.071	14.428	2.571	9
1.142	3.78	1.285	5.165	1.142	14.857	2.642	8
1.214	3.89	1.428	5.248	1.214	15.285	2.714	7
1.285	4	1.571	5.331	1.285	15.714	2.785	6
1.357	4.11	1.714	5.414	1.357	16.142	2.857	5
1.42	4.22	1.857	5.497	1.428	16.571	2.928	4
1.5	**4.33**	**2**	**5.58**	**1.5**	**17**	**3**	3
1.66	4.86	2.166	6.053	2	18	3.666	2
1.83	5.44	2.333	6.526	2.5	19	4.333	1
2	6	2.5	7	3	20	5	0
3	3	3	3	3	3	3	Score
10	15	10	15	10	30	10	weighing
30	45	30	45	30	90	30	Value

With OMAX Productivity is determined through the following operation:

$$[(\text{Currently Score} - 300)/300]100 = \text{Productivity Index} \quad (1)$$

In Fig. 1, it shows the result of measuring worker productivity for 35 weeks with the OMAX method.

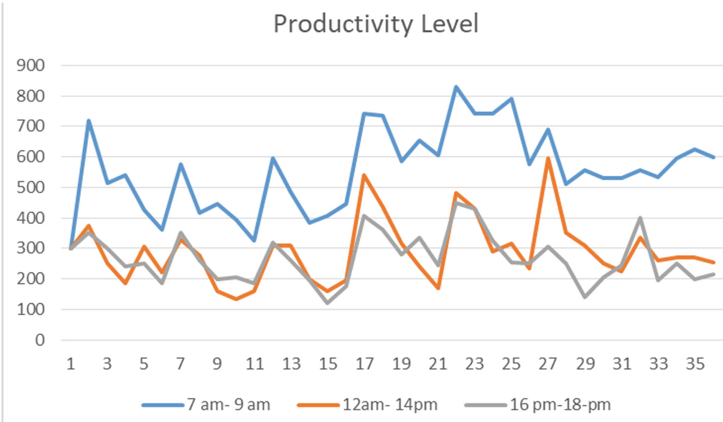


Fig. 1. Productivity level after 35 weeks

After having carried out the measurement of productivity and the analysis of the positions in the work area, we proceed to develop the fuzzy logic model (FL), in order to identify which environmental factors have the greatest influence on the productivity of Workers. The FL model is based on Mandami type, composed of three stages: Fuzzification, Inference mechanism and Defuzzification; Defuzzification stage consist in the representation of the output variables (Fig. 2).

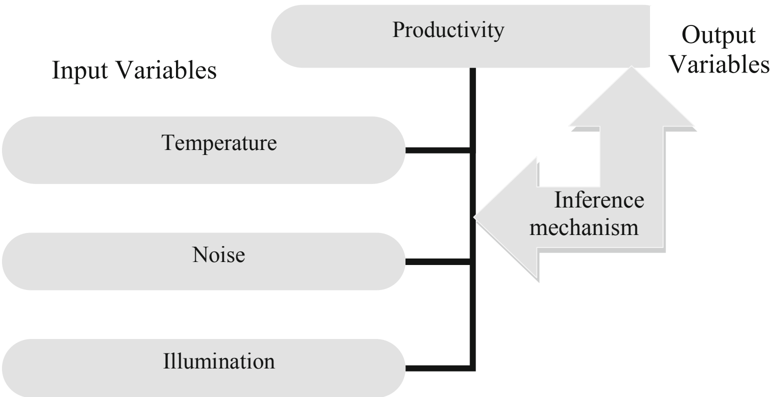


Fig. 2. Fuzzy Logic Model of environmental ergonomics and productivity

In the Toolbox Fuzzy Logic Designer of MATLAB software [12], the process of merging the input variables and output it is carried out. The fusion process consists in the analysis of geometric figures proposed the FL model, to select those in which the membership function best fit the type of variable, that is intended to represent, whether continuous or discrete, quantitative or qualitative, this also implies associating linguistic values to the figures that are representative of a range of values, figures with their linguistic value and range in the model are known as fuzzy sets. In this case, the input variables are Temperature, Noise and Illumination (Fig. 3).

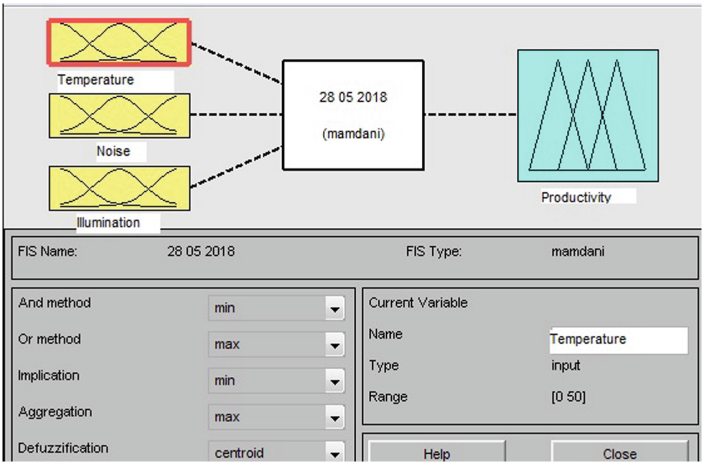


Fig. 3. Fuzzy Logic Model Mandani type *MATLAB 2009

4 Result

As shown in the following figure, in the MATLAB Rule Viewer window, you can also manipulate the value of the input variables and observe the corresponding value in the output variable, this value in the output varies according to the defuzzification method selected (Fig. 4).

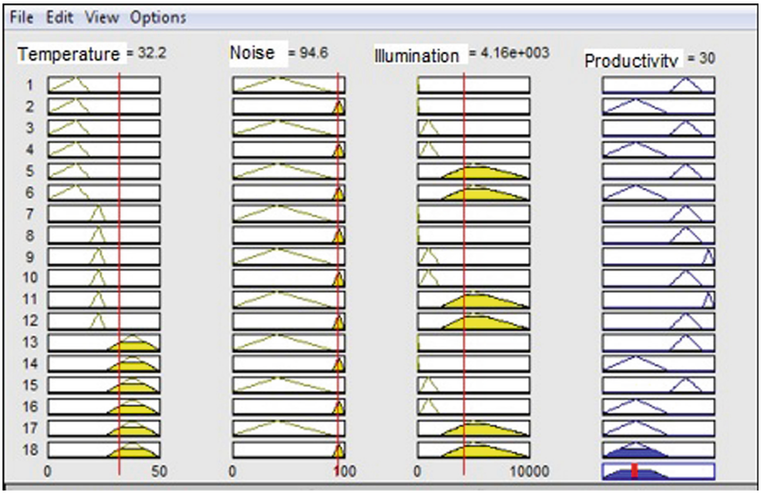


Fig. 4. Fuzzy rule (Recovered from MATLAB 2009)

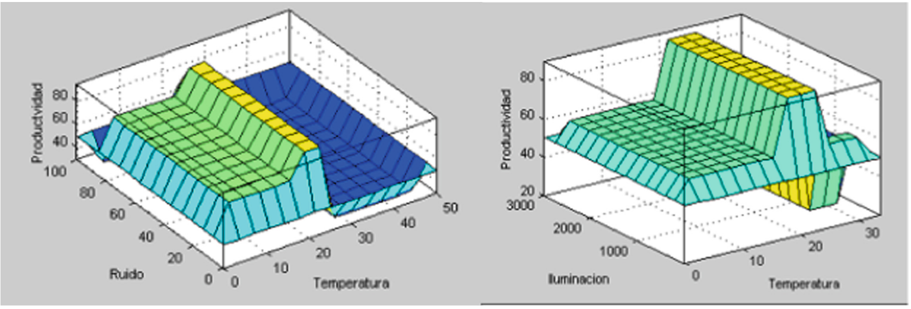


Fig. 5. Relation between noise and temperature vs productivity and illumination and temperature vs productivity.

The graphs show that temperature, noise, and lighting exceed the limits recommended by the STPS [1] and decrease productivity (Fig. 5). To achieve an adequate and constant level of work performance by workers, a temperature of 23.1 °C, a noise level of 84.1 dB, and the illumination of 2,551 lx must be maintained, thus maintaining productivity at 95% in all business hours.

5 Discussion

The temperature and noise values exceed the permissible limits established by the STPS [1], making the conditions not adequate, which results in a decrease in productivity. The temperature directly affects workers because they work in outdoor environments and even outdoors, which causes physical wear.

With the use of the Omax method it was possible to appreciate the variability of productivity, in the hours of half a day and afternoon in which the heat is more intense, and the physical exhaustion increases, which causes comfort due to temperature.

By applying the FL model, it can be verified that the variable that most influences the productivity of workers is temperature. It is determined that if this is maintained at 23.4 °C, the noise at 84 dB and the illumination at 2551 lx, the production remains constant at 90%.

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Analysis of Ergonomics Risk Factor Among Cobblers at Jabalpur, India

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Abstract. This research study focused on the different ergonomic risk factor for work-related Musculoskeletal disorders (WMSDs) in the job of Cobblers at Jabalpur, India. With the prospect of improving the occupational health risk and safety of the workers involved in this profession. A large number of people associated with this profession in India and in this sector occupational ergonomic issues of work-related musculoskeletal disorders (WMSDs) are a big problem and a threat to this profession. In order to ensure the objectives are met, the different methodology was used, such as still photography and video photography were used to record different activities. Different types of tools like Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), and OWAS were used. Psychophysical measures were investigated by RPE scale and VAS. After the all analysis the result indicating that the tasks in this profession are in the high-risk and demands immediate ergonomic intervention in the form of re-design of the tools used and workstation or/and the design of the work process.

Keywords: Ergonomics · Design · Risk factors · Injury prediction

1 Introduction

Worldwide it is known to the fact that the work-related musculoskeletal pain (MSP) or disorders are major cause for the health problems in the industry. Thereby decreasing the ability to work and also degrading the quality of the life [1, 2]. Due to various working concluded from the various numbers of studies suggest that the working in the awkward postures, repetition of the work as well as the various ways of working leads to man such injuries. As Neupane et al. [3] showed the increment in the work-related disabilities in every 4 years from 15% to 22% that too with the raise in the various other parts of the body occurring pain. Hence it would be very crucial in finding those risk factors related to work related musculoskeletal thereby resulting for creating strategies for its prevention.

India is a developing country where workers works both in organised sector and also in the unorganised sector. The sector where not much benefit to the workers are provided are the unorganised sector. These are the sectors where the worker work in

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their own unit. These are the workers working on the roadside on variety of products or the repair shops. Unorganised sectors are the sectors which are widely open to most of these risk factors leading to the work-related musculoskeletal disorders. As S. Gangopadhyay et al. [4] states that though developing countries like India take no such concern about the workers working in the unorganised sector about their health and safety which are also contributors to their country's economy. Such sectors are important part of the society which are operated by single unit or multiple by wholly on human labour force. Such sectors require ergonomic interventions such that the life hood of the workers is enhanced as well as the productivity of the work is increased and also the efficiency of the workers.

Foot wears are essential in everyone's life. It's a no longer simply a footwear for people wearing it, it's a style statement in the current lifestyle. Footwear work is to protect the people bare foot from getting hurt while walking or running. As most of the middle class and low-class people are emotional as well as due to the financial constraints, we tend to repair our old footwear for the further use. These repairs of the footwear are not serviced by the manufacturing company. These are done by these workers of the unorganised sector where many of the India's population thrive in. There are these labours who work in the sector where these skilled workers who can be distinguished by categories of two. One who work in by their own and others who works in the factory. In India the Gatai Kamgar (the person who repairs the slippers and the shoe) installs their workshop besides the road and repairs the old slippers and the shoes. As Sutradhar, [5] states that the community to which these workers belong are known as “Muchi”.

The work of the cobbler is an exhausting job requiring most of the work to be done by the hands and the legs for the supporting of the tool. These tool primitive tools are been used since ages requiring for the job to be done. The cobbler's job is to mend the worn-out shoes or the bags such that the users get their products repaired as new again. They operate such operations by sitting on the ground and most of their work done in sitting positions in which legs folded. The primitive tool (Fig. 1) which they have is used as the support space for the shoe to be put where he applies the stitching as well as the glue according to the operation needed. For the repairing for the shoe which has been worn out the cobbler firstly brushes the inner sole of the shoe by a stainless-steel kind of brush. Such that to make the inner surface of the shoe could be attached to the new sole by their adhesive glue and keep them to dry for some time. After some time the cobbler puts the shoe on the shoe stand where he operates known as “Hatta” (Fig. 1) and beats the new sole by the Hatodi (Fig. 2) which is known as hammer to us. Then he uses needle like instrument known as “Katani” (Fig. 3) and their thread for stitching the new glued sole to the upper part of the shoe such that it gets attached to it permanently. The cobblers cut the extra thread by using the scissor kind of instrument. These tools are the primitive tools which have been used since the ages and has been designed and prepared not using the principles of ergonomics into their shape and structure.

Fig. 1. Hatta

Fig. 2. Hathodi

Fig. 3. Hatta

The work of the cobbler or the process which they took for repairing of the shoe in which the injury by the needle tools known as Katni is also too be highly concerned. There have been several works on the unorganised sector but of the cobbler no proper investigation has been done. These group of people working is a part of the working community of the India which also do contribute directly or indirectly to the country economic. The working conditions, the tools and the workstation and workspace should be intervening for ergonomic intervention such that risk factors could be identified. Such the health of the workers is safe such that their efficiency increases and the productivity is increased with the quality of the product as well their working life. Thus, the aim of the research is a step towards this direction of enhancing the working life of the cobblers.

2 Methodology

2.1 Questionnaire

The questionnaire for the purpose, the Standard Nordic Questionnaire, validated by Kuroinka [6] which was further validated into Indian context by Das [7], was implemented in the study to measure the impact of the musculoskeletal disorder to the cobblers. For the better understanding of the questionnaire the visual human diagram was also presented for better understanding. A scale of 1 to 5 was provided for the answers in which 5 represented insupportable pain to 1 being no discomfort.

2.2 Direct Observation

The process of direct observation was applied such that cobbler working in this repairing process could be analysed. The working postures they do adopt as well as the repetitive actions and their movement of their hands as well as their legs were observed.

2.3 Interview

To fetch the data for the insights of the problem, the unstructured and informal interview was done with the individual cobblers. The main purpose to do such to get the hidden story as insights of their problems which they come across while working.

2.4 Postural Analysis

The posture analysis were done by using tool like the Rapid Entire Body Assessment (REBA) [8], SI [9] and Ovako Working Posture Analysis System (OWAS) (Karhu et al. 1977) [10] methods were applied for the postural analysis. The analysis is carried using the process such as videography and photography. The mostly adopted postures by cobblers during repairing process is taken into the consideration for the analysis.

2.5 Measurement of Psychophysical Parameters

For the measurement of the psychophysical parameters, a scale of 10 cm of Visual Analogue Scale to inform about the level of discomfort cobblers finds after 30 min work. The Rated Perceived Exertion (RPE) by Borg's scale score to find out the amount of the effort was put into the work of 30 min work and marked on scale of 0 to 10.

3 Results

The participant's cobblers for the analysis of the working of the cobbler in the region of Jabalpur was conducted from the age group ageing from 30 to 55 years.

3.1 Questionnaire

For the questionnaire study the cobbler showed discomfort feeling at different parts of the body. In this study it was observed that 80% of cobblers on their lower back and knee. 78.67% onto their lower leg. 77.33% onto their upper back. The mean, standard deviation and the minimum and maximum of the Nordic Questionnaire in Table 1 for the cobblers.

Table 1. Responses of the Nordic Questionnaire

Body Parts	Standard Deviation (S.D)	Mean	Min	Max	Percentage
Neck	0.52	0.25	2	3	50.67
Shoulder	0	3	3	3	60
Upper back	0.35	3.87	3	4	77.33
Upper arm	0.26	3.07	3	4	61.33
Lower back	0	4	4	4	80
Fore arm	0	3	3	3	60
Wrist	0.35	2.87	2	3	57.33
Hip/Buttocks	0.41	3.80	3	4	76
Thigh	0.51	2.60	2	3	52
Knee	0	4	4	4	80
Lower leg	0.26	3.93	3	4	78.67

3.2 Direct Observation

In the process of repairing shoe carried out, the cobbler used different tools for the process ranging from the Katani for the sewing and the Hattha for the fixing of the shoe. The workspace of the cobbler was not particularly a set place it was a temporary one sitting beside the road. The Work process of the cobbler are shown in Fig. 4 and the workstation of the cobbler is shown in the Fig. 5.

Fig. 4. Cobbler working

Fig. 5. Workstation of cobbler

3.3 Interview

They explained their work process. The unstructured interview gave us the insights of the cobblers which worked all day from morning 9 am to 8:30 pm and earned ranging from INR 100–400 as an average of 200 per day. They don't take leave. Also repair worn out umbrella and bags. Big challenge they come across is injury by needle while stitching and no proper workstation.

3.4 Postural Analysis

The postural analysis of the cobblers working was carried using their photographs of the major posture they adopt while operating. The REBA scores were very high at 15 which informed us it was very high risk, to implement change and RULA score as 7 and warned of investigation and changes to be required immediately. In the postural analysis by OWAS in which the score attained was 4 and warned for the corrective action for the improvement required immediately. Figure 6 – shows the mostly adopted postures by the cobbler.

Fig. 6. Posture adapted by the cobblers

3.5 Measurement of Psychophysical Parameters

The SI score cobblers scored were greater that 7 which resulted hazardous and the VAS score after working for 30 min onto scale of 10 was average to 6.27.

4 Discussion

4.1 Questionnaire

The cobblers experienced pain onto their various parts of their body though they have been in that certain work for many years. The pain areas were the knee, the lower leg and the back due to the prolonged hours of squatting onto the floor of the work. The pain onto their backs were also due to their flexion and twisting while working as for the tools to get from their place. The long hours of work eventually result in injury, pain and finally to the musculoskeletal disorders. The pains onto their hands were also the reasons of the unidimensional tools which been held and been worked for several hours.

4.2 Direct Observations

In the direct observation the workspace also added to major twisting of the cobblers while working. The workspace being on the roadside and cobbler doing the precision work that by sitting on ground on squatting position itself adds to the risk of musculoskeletal disorders. Due to prolonged hours of work daily and doing the precision work also leads to the bending or deformation of the fingers of the cobblers. They are getting injured by the sewing needle every time they work. The loss of vision due to excessive precision work they do in bad lighting conditions.

4.3 Interview

The work they work are passed onto generation after generation and the low wage they can't afford to study. The prolonged hours work daily and everyday shows they have to work daily to feed their family. And the injuries which they do come across they have to bear.

4.4 Postural Analysis

It was learnt the cobblers were very much exposed to the risk of getting the musculoskeletal disorders which demanded immediate actions for the intervention in the ergonomically design of the tools and the workspace. The process resulting into the deviated postures of the cobbler working for that precision work. The forceful exertion when sewing and hammering resulted in pains occurring onto the hands and the shoulders. And the force exertion for the grabbing of the Hatta for the process also resulted in pain and injury. The repetitive works of the forearm resulted in the occurrence of the lateral epicondylitis.

4.5 Measurement of Psychophysical Parameters

The SI score greater than 7 which states of work being hazardous to the cobblers due to hammering job. The wrist postures support the scores being high of the workers. The VAS score of 6.27 supports cobblers being tired and exhausted as continuous sitting and applying force of the work done with deviated posture. Such movements of the hands while working repetitive which being associated with the spine are open to the injury of WMSDs eventually turning up to lateral epicondylitis [11].

5 Conclusion

The work-related musculoskeletal disorders are the most common threat to any profession which is requiring a human force. As most of the India's population thrive by this profession, the risk are dangerous for the workers working in such sector whose family are depended upon them and their work. As this profession is passed onto generations to generations it's not good job to push workers to work under such condition which are open to such risks and injuries. The findings from the research is that unorganised sector of the cobbler working need to be intervene with ergonomic principle such as to keep this craft or activity alive. Thus, enhancing the work life of the cobblers and the efficiency of the cobblers and also increasing their productivity. Such implementation should be done such that more benefits could be achieved.

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Determination of Assessment Elements That Restrict REBA Implementations Within Aseptic Areas. A Study Case

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Abstract. A method to determine drawbacks during REBA implementation inside aseptic areas was established employing opinions from twelve specialists. They assessed six aseptic areas. During the assessment, the specialists wore aseptic garments that difficult the observation of angles adopted by workers during job tasks, load demands and work cycles; information needed to achieve REBA. The method determines critical drawbacks through establish the procedure elements required to implement REBA, define ten main drawbacks, determine critical drawback items using a determination matrix, finally a procedure to implement REBA inside aseptic areas was proposed. It includes changes in the way of measure angles adopted by body segments and work task analysis.

Keywords: Human factors · Risk evaluation · REBA · Ergonomic interventions

1 Introduction

An aseptic area is a Clean Zone inside a building in which the particles and microorganisms is controlled to meet a specified airborne cleanliness [1]. To maintain its aseptic conditions, all person inside has to wear aseptic uniforms. The cloth used restricts the movement and visibility (e.g. gloves, gowns, and shoe covers), this difficult the analysis of angles adopted by body segments in certain positions indispensable to evaluate awkward postures, or any other characteristic of work movement; information needed to estimate work risks. Ergonomists or specialists who must achieve a simple risk assessment of work tasks in these conditions, faces many adverse circumstances that limit his good judgment during the evaluation.

The Rapid Entire Body Assessment (REBA) is an ergonomic assessment tool to whole body postural analysis [2], sensitive to musculoskeletal risks in a variety of tasks [3] (the steps to implement REBA is described in Table 1). Usually, the technique includes take photos and video, which are used to coded body segments and determine

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inadequate postures. Moreover, videos allow comprehend work tasks and load demands when work cycle is observed several times [4]. On the other hand, a standardized training is necessary to get reliable evaluations [5], considering it is necessary to fill out a REBA score sheet and determine the total score to define the risk of injury.

Table 1. REBA procedure.

Element	Description
P1	Identify the workplace and the task to carry out a previous postural analysis, considering movement distance and height, and the weight loaded or manipulated
P2	Identify the movements developed and define movement planes with coded body segments (trunk, neck, legs and upper and lower arms)
P3	Assess the working posture using REBA score sheet
P4	Determining the total REBA score
P5	Identify the action level to define the risk of injury and corrective actions

In this work, the determination of assessment elements that restrict REBA implementations within aseptic areas are developed, to determine if the conditions allow to specialists develop reliable evaluations.

The article is organized as follows: a case study carried out inside aseptic area is described in Sect. 1, the method used to determine the critical drawbacks during REBA assessment implementation is presented in Sect. 2. The method to determine elements that restrict REBA implementations within aseptic areas is showed in Sect. 3. The results and discussion are given in Sect. 4. Finally, a conclusion is developed in Sect. 5.

2 Study Case

Six departments (filling, sealing, printing, packing, extrusion and mill.) were inspected by twelve ergonomic specialists, during a routine assessment to determine risks in awkward postures. All departments produced components that will be used in dialysis process in hospitals. Thus, the environmental conditions of production areas must be rigorously controlled according to standards. During the assessment, specialists and personnel wore aseptic garments that difficult the observation of load demands, work cycles and angles adopted by workers, information required to implement REBA properly. All complains and problems lived by specialists were recollected and the ten main drawbacks about implement REBA assessments inside aseptic areas were defined, see Fig. 1.

Item	Drawback description	A1*	A1	A2	A2	A3	A3	A4	A4	A5	A5	A6	A6	F	$\hat{p}$
1	The method does not take into account the posture duration	1	1	1	1	0	0	1	1	1	1	1	1	10	0.09524
2	The method does not allow to identify applied force levels exerted by the different body segments.	1	0	1	1	1	1	0	0	1	1	1	1	9	0.08571
3	The measure of position angle is at the discretion of the evaluator.	1	1	1	1	1	1	1	1	1	1	1	1	12	0.11429
4	The method does not include frequency of movements	1	1	1	1	1	1	1	1	1	1	1	1	12	0.11429
5	The machine layout prevents visualization of worker movements	0	0	0	0	1	1	1	1	1	1	1	1	8	0.07619
6	The uniform, dressed by workers was voluminous or tight and in both cases, it hindered the movement of work. Therefore, flexion, extensions and trunk positions were difficult to observe.	1	1	1	1	1	1	1	1	1	1	1	1	12	0.11429
7	The presence of the analyst distracted the operators, because it required to approach to observe the movements below the uniforms	1	1	1	1	1	1	1	1	1	1	1	1	12	0.11429
8	The uniform, dressed by analyst was voluminous or tight and in both cases the hood and the detachable face mask difficult the analysis and observation	1	1	1	1	1	1	1	1	1	1	1	1	12	0.11429
9	The duration time of awkward postures cannot be recorded because chronometers were not allowed, and the wall clocks inside the area sometimes were no visible.	0	0	1	1	0	0	1	1	1	1	0	0	6	0.05714
10	Analysts have been poorly trained in use properly the REBA score sheet	1	1	1	1	1	1	1	1	1	1	1	1	12	0.11429
	Total	8	8	8	8	8	8	8	9	9	8	8	8	105	1

Fig. 1. Opinions from specialists about the ten drawbacks in implementing the REBA evaluation inside aseptic area. it includes the opinion frequency and it statistic proportion. *Description areas, A1 - filling, A2 - sealing, A3 – printing, A4 – packing, A5 – extrusion and A6 –mill.

3 Methods

With the purpose of to determine critical drawbacks that allows suggest changes in the observation of work tasks during REBA implementation, the follow steps were implemented:

1. *Definition of REBA Procedure*

Establish the procedure elements required to implement REBA in accordance with Hignett and McAtamney [3] (see Table 1).

2. *Determine main drawbacks*

Ten main drawbacks were selected from several specialists' opinions regarding the inconveniences occurred during the period of evaluation (see Fig. 1).

3. *Define relationship between drawbacks items and REBA elements*

The relationships between the ten main drawbacks and REBA procedure elements were analyzed to decide if some of them have to be discarded, using a relationship diagram (see Fig. 2). After analysis, only six items remaining as follow:

- D3 - Angle evaluation is at the discretion of the evaluator.
- D5 - The machine layout prevents visualization of worker movements including in photos and videos.
- D6 - The uniform wore by workers was voluminous or tight and in both cases it hindered the movement of work, therefore, flexion, extensions and trunk positions were difficult to observe.
- D7 - The presence of specialists distracted the operators, because they required to approach to observe the movements inside the uniforms.
- D8 - The uniform wore by specialists was voluminous or tight and in both cases the hood and the detachable face mask difficult the analysis and observation.
- D10 - specialists had lack training in use the REBA score sheet properly.

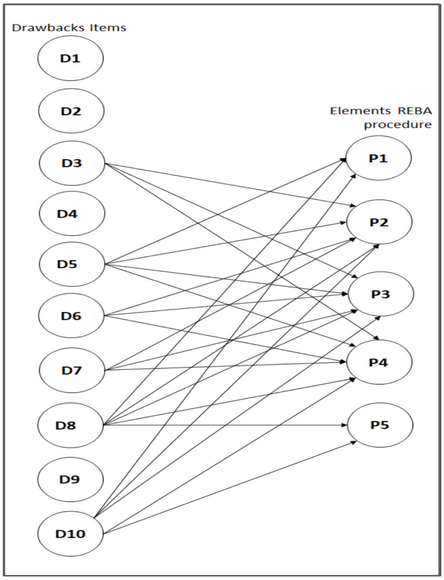

Fig. 2. Relationship diagram between drawbacks items and the elements of REBA procedure

4. *Determine critical drawback items using a determination matrix*

The determination matrix for defining critical drawbacks is a tool, which allows identifying critical variables of one process [6, 7]. The column of criteria were the elements of REBA procedure, the alternatives (to be evaluated) were the drawback items identified by the relationship diagram. A weight was assigned as criterion value defined by specialists as importance respect each other. The proportions are data from opinions that influence the criterion value statistically and were estimated using the drawback frequency (see Fig. 3). Finally, the highest value resulted in the section Results Chart the Critical Drawback Item are identified, as is shows in Fig. 4.

Item	Drawback description	A1*	A1	A2	A2	A3	A3	A4	A4	A5	A5	A6	A6	F	$\hat{p}$
3	The measure of position angle is at the discretion of the evaluator.	1	1	1	1	1	1	1	1	1	1	1	1	12	0.17647
5	The machine layout prevents visualization of worker movements	0	0	0	0	1	1	1	1	1	1	1	1	8	0.11765
6	The uniform, dressed by workers was voluminous or tight and in both cases, it hindered the movement of work. Therefore, flexion, extensions and trunk positions were difficult to observe.	1	1	1	1	1	1	1	1	1	1	1	1	12	0.17647
7	The presence of the analyst distracted the operators, because it required to approach to observe the movements below the uniforms	1	1	1	1	1	1	1	1	1	1	1	1	12	0.17647
8	The uniform, dressed by analyst was voluminous or tight and in both cases the hood and the detachable face mask difficult the analysis and observation	1	1	1	1	1	1	1	1	1	1	1	1	12	0.17647
10	Analysts have been poorly trained in use properly the REBA score sheet	1	1	1	1	1	1	1	1	1	1	1	1	12	0.17647
	Total	8	8	8	8	8	8	8	9	9	8	8	8	68	1

Fig. 3. Final proportions from opinions using for influence criterion value statistically

Critical Drawback Item - Determination Matrix													
	ITEMS							***Results Chart - Results Table***					
REBA procedure	I3	I5	I6	I7	I8	I10	Criterion value	I3	I5	I6	I7	I8	I10
P1		x			x	x	1	0	1	0	0	1	1
P2	x	x	x	x	x	x	2	2	2	2	2	2	2
P3	x	x	x	x	x	x	1	1	1	1	1	1	1
P4	x	x	x	x	x	x	1	1	1	1	1	1	1
P5	x	x			x	x	1	1	2	0	0	1	1
								0.882	**0.8**	**0.706**	**0.706**	**1.059**	**1.059**
Proportions	0.176471	0.114286	0.176471	0.176471	0.176471	0.176471		**selected critical item**					
							EVALUATION					X	X

Fig. 4. Determination Matrix for the first selection of critical drawback item

4 Results and Discussion

Using the results from the Determination Matrix, improvement proposal can be suggested, considering as critical drawback items: D8 - The uniform wore by specialists was voluminous or tight and in both cases the hood and the detachable face mask difficult the analysis and D10 - specialists had lack training in use the REBA score sheet properly, followed by D3 - Angle evaluation is at the discretion of the evaluator, see Fig. 3. Unfortunately, the drawback D8 did not have a real solution, because the uniform cannot be changed due to standards requirements, consequently, the difficult observation about angles adopted by workers, load demands and work cycles remain. However, using the other critical drawbacks, corrective actions were implemented, and a new procedure was suggested see Table 2.

The Corrective Actions
The corrective actions implemented were the follows:

1. Training the specialists in the use the REBA score sheet in order to standardize the assessment.
2. Training the specialists in the ISO 11226:2000 standard [8] in order to standardize the method for determining working postures and angles.
3. All worker's size was reviewed, to eliminate loose or tight uniforms and improve the comfort.
4. All work methods were updated, to include work cycles times and movements by hands or feet.
5. Special layout of work areas was developed to include movement distances and reaching of materials among others.

Procedure Suggested for Implementing REBA Inside Aseptic Areas

Table 2. new procedure suggested for implementing REBA assessment

Element	Description	New procedure
P1	Identify the workplace and the task to carry out a previous postural analysis, considering movement distance and height, and the weight loaded or manipulated	Using the special layout of work areas and the new work methods estimate the movement distance and height, and the weight loaded or manipulated
P2	Identify the movements developed and define movement planes with coded body segments (trunk, neck, legs and upper and lower arms)	Using the new work methods and the ISO 11226 standard to determine angles adopted and pre-coded the body segments
P3	Assess the working posture using REBA score sheet	With the pre-coded body segments, assess the working posture using REBA score sheet, inside aseptic areas
P4	Determining the total REBA score	Remains as the same
P5	Identify the action level to define the risk of injury and corrective actions	Remains as the same

5 Conclusions

In spite of the drawback D8 did not have a real solution, because the uniform cannot be changed due to standards requirements, a procedure to implement REBA inside aseptic areas was proposed, the new procedure was developed using the resultant critical drawbacks from the determination matrix. The new procedure includes changes in the way of measure angles adopted by body segments and work task analysis through special layout of work areas and new work methods, however it is necessary two or three new assessment to verify if the recommendations really works.

Acknowledgments. To the company and its workers for their disposition, the Chemistry and Engineering College for it support and Industrial Engineering students for it enthusiastic participation.

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The Effects of Recovery Method and Refractive Status on the Recovery Process of Visual Fatigue

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Abstract. The aim of this study was to investigate the effects of recovery method and refractive status on the generation and recovery progress of visual fatigue in the dynamic visual search tasks. A human factor experiment was conducted, in which a two-factor mixed design was adopted (2 recovery method × 2 refractive status). 31 subjects participated in this study. The results indicated that the refractive error subjects' fatigue level was always higher than that of normal vision subjects when conducted dynamic visual search tasks. Compared to eye massage, using eye drops could lead to a quick recovery at the initial stage, then slowed down. The recovery trend of using eye massage was closer to a linear trend.

Keywords: Dynamic visual search · Visual fatigue recovery · Refractive status · Eye massage · Eye drops

1 Introduction

As the widespread uses of digital screens in daily work and life, visual fatigue has been an important problem which influences user experience and health of the users. Existing researches mainly focused on static visual search using digital screens, but a lot of visual search tasks are dynamic in actual usage scenarios. Prolonged dynamic visual search tasks on video display terminals (VDT) can lead to blurred vision, dry eyes, eye irritation, burning, headaches, sensitivity to bright light and other visual fatigue symptoms. The critical flicker frequency, near point accommodation, blink rate and pupil parameters are common indicators for measuring visual fatigue [1]. Previous studies indicated that CFF is of high sensitivity and convenient to measure. The decrease of CFF means visual fatigue, the increase means recovery [2].

Previous studies suggest that the uncorrected refractive error is associated with digital eye strain and computer vision syndrome [3, 4]. Visual fatigue is more likely to occur in people with myopia [5]. There are some methods to alleviate visual fatigue and improve visual search performance. Using lubricating eye drops (artificial tears) could help to alleviate eye fatigue symptoms [4]. By eye massage, varying degrees of improvement were also observed in some patients [6]. In a visual test task, subjects completed a visual test task faster when they received eye drops and eye massages prior

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to the visual test [7]. Wu et al. studied the effects of 4 different recovery methods on visual fatigue. In the study, recovery methods included eye drops, two different types of eye massage (one massage method involved massage of the eyeballs, and the other only massaged the periphery of the eyes), and natural recovery without auxiliary method. The experimental results showed that after 15 min, the effect of eye massage was significantly better than using of eye drops and natural recovery, and the recovery of only massaged the periphery of the eyes was the best [8]. However, previous studies haven't studied the process of visual fatigue generation and recovery. Therefore, the goal of this study was to investigate the effect of two different recovery methods and refractive status on the generation and recovery process of visual fatigue.

2 Method

A laboratory experiment was conducted in which a 2 (recovery method: eye massage, eye drops) $\times$ 2 (refractive status: normal vision, refractive error) mixed design was adopted. The critical flicker frequency (CFF) values were measured as the visual fatigue indicator. Participants completed a dynamic visual search task to generate visual fatigue. Then they were asked to adopt eye massage or eye drops to recover from visual fatigue. Each participant employed both recovery methods respectively in two different days.

2.1 Participants

The experiment recruited 31 university students, consisting 15 males (9 were normal vision, 6 were refractive error) and 16 females (6 were normal vision, 10 were refractive error). The average age of them was 21.6 years old. All of them had normal or corrected to normal vision.

2.2 Apparatus and Software

A lenovo C560 all-in-one computer was used in the experiment which was 23 in. in screen size, 1920*1080 in screen resolution and 60 Hz in refresh rate. The self-developed vision testing system was used in this experiment. The testing system is a dynamic visual search performance testing software. Users can adjust the search target, distractor, movement speed and the appearance location of the target. The BD-II-118 critical flicker frequency measuring apparatus was used to measure the CFF values. A height-adjustable chair was provided to the participants to ensure each participant's eyes were at the same height as the centre of the screen. The eyes of each participant were at a distance of approximately 800 mm from the front of the display.

2.3 Stimulus Material

The background of stimulus material was black, and the characters were white, as shown in Fig. 1. The distractors (i.e. X) and 1 target (i.e. O) were randomly arranged. The entire search area was divided into 60 columns and 21 rows. Target didn't appear at the position between line 6 to line 14 for preventing nearness to the central field of vision at the first appearance. There was one and only one target in the search area, other positions were filled with distractors. The target and distracters were moving horizontally at a constant speed on the screen. When the items disappeared from the right end, it would reappear from the left end, keeping the state that target always present in the search area.

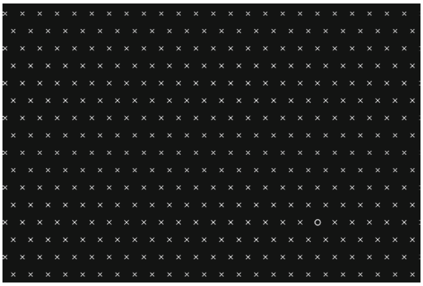

Fig. 1. The partial diagram of the stimulus material.

2.4 Procedure

Subjects were asked to participate in the experiment in two different days in which they adopted two different recovery methods. Each set consisted of two phases.

At the first phase, subjects were asked to perform the dynamic visual search task for 35 min on the experimental platform in order to generate visual fatigue. The first phase consisted of several single dynamic visual search trials. The translational velocity of the items was set as 8 deg/s. Before the start of each single search task, subject should click the fixation point in the center of the screen to start the task. Then the stimulus materials appeared. Subject should determine whether the target was on the upper or lower side of the screen as quickly as possible. During the first phase, the CFF values were recorded every 5 min.

At the second phase, the subjects adopted eye drops or eye massager, then rested with eyes closed to recover from visual fatigue. The recovery phase was 15 min and CFF values of the subjects were recorded every 2.5 min.

3 Result

As shown in Fig. 2, during the fatigue generation phase, the CFF values of the normal vision group were always higher than that of the refractive error group. Descriptive statistics of CFF values in the fatigue generation phase are shown in the Table 1. Results of ANOVA for testing the effect of time on CFF values showed that the main effect of time was significant ($p = 0.000$).

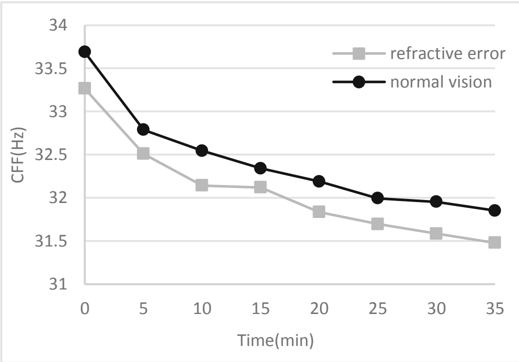

Fig. 2. The variation trend of CFF values in the fatigue generation phase.

Table 1. Descriptive statistics of CFF in fatigue generation phase.

Time	$Mean_{nv}$	SD_{nv}	$Mean_{re}$	SD_{re}
0	33.687	1.648	33.266	1.531
5	32.787	1.683	32.509	1.423
10	32.543	1.587	32.141	1.475
15	32.340	1.260	32.119	1.581
20	32.187	1.363	31.834	1.388
25	31.993	1.333	31.694	1.408
30	31.953	1.185	31.584	1.656
35	31.850	1.103	31.478	1.422

For the recovery phase, CFF value of 35 min point in the fatigue generation phase was used as the initial value. The CFF value at each time node during the recovery process minus the CFF value at 35 min was recorded as ΔCFF as the indicator to measure the degree of fatigue recovery. The variation trend of ΔCFF values is shown in Fig. 3.

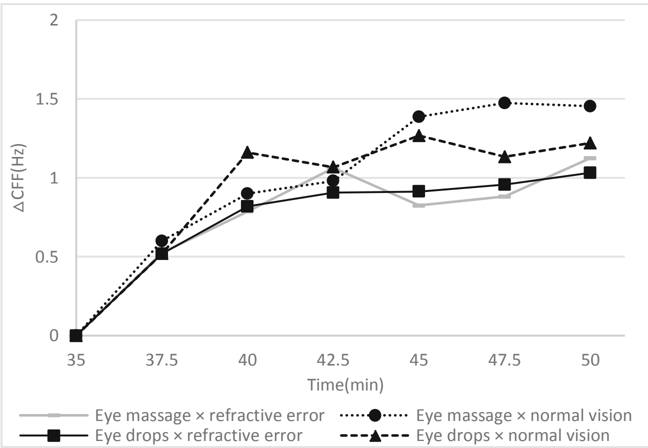

Fig. 3. The variation trend of ΔCFF values in the recovery phase.

The results indicated that at the 10 min point of the recovery phase, refractive status had a significant effect on ΔCFF ($p = 0.038 < 0.05$). And at the 12.5 min point of the recovery phase, refractive status had a borderline significant effect on ΔCFF ($p = 0.073$). When the recovery time was no greater than 7.5 min, the refractive status had no significant effect on ΔCFF.

As shown in Table 2, the characteristics of the fitting functions of ΔCFF values and recovery time differ when using different recovery methods. The data of eye massage group fit the linear trend better than the eye drops group. They both follow a quadratic function trend. Compared to eye massage group, the maximum point of the quadratic fitting function of eye drops group is closer to the left as shown in Fig. 4.

Table 2. Fitting equations of two recovery methods.

Recovery method	Fitting function	R^2
Eye massage	$\Delta CFF = 0.076t + 0.2835$	0.8523
Eye drops	$\Delta CFF = 0.0645t + 0.3358$	0.7083
Eye massage	$\Delta CFF = -0.0066t^2 + 0.1756t + 0.076$	0.9744
Eye drops	$\Delta CFF = -0.0086t^2 + 0.1938t + 0.0664$	0.9457

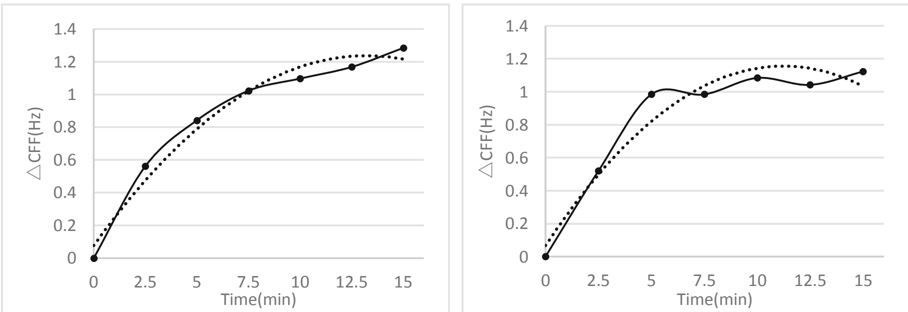

Fig. 4. The quadratic fit curve of ΔCFF values and recovery time (left: using eye massage; right: using eye drops).

4 Discussion

For the fatigue generation phase, the results indicated that the level of visual fatigue increased with the increase of the search time and gradually stabilized in the later stage. Compared with normal vision subjects, the refractive error subjects' fatigue level was always higher than that of normal vision subjects.

The recovery effect of the normal vision group is better than the refractive error group after 7.5-min rest, which lead to a significant difference at 10 min point and a borderline significant difference at 12.5 min point. After 7.5 min, the subjects with normal vision still had obvious recovery, but the subjects with refractive error recovered slowly.

The two recovery methods differed in recovery trends of visual fatigue. The recovery trend by using eye drops was quick at the initial stage, and then slowed down. The recovery trend of CFF values by using eye massage was closer to a linear trend.

5 Conclusion

This study investigated the effect of refractive status and two recovery methods on the fatigue and recovery process in dynamic visual search tasks. The results indicated that the refractive error subjects were easier to get fatigue than normal vision subjects when conducted dynamic visual search tasks. Compared to eye massage, using eye drops could lead to a quick recovery at the initial stage, but there was no significant difference finally. The conclusion of this study could provide advice on recovery method of visual fatigue for dynamic visual search work design.

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Effect of Air Quality Alerts on Intended Behavior Change

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Abstract. In 2015, Air pollution caused 8.8 million premature deaths worldwide and has reduced life expectancy by 2.9 years [6]. The increasing impact of wildfires and other emissions will lead to more days and locations with poor air quality. This research references and builds on previous work on how visual anchoring within the Air Quality Index (AQI) Alerts rating affects intended behavior change to ultimately protect against adverse health outcomes. Additionally, this study examines how past behavior and personality may impact future behaviors. Results show a significant effect of past behavior change specifically on intent to wear a face mask ($t = -2.069$, $p = 0.0413$). However, no effect of behavioral change was found between the two AQI Alert visuals presented as well as no effect between dominant or passive personality. As air quality continues to decrease worldwide the importance of understanding AQI Alerts on resulting behavior change becomes more critical.

Keywords: Human factors & health · Air quality alert · Behavior change

1 Introduction

In 2015, Air pollution caused 8.8 million premature deaths worldwide and has reduced life expectancy by 2.9 years [6]. Today, wildfires in the United States burn on average 78 days longer and cover twice the area compared to 50 years ago [12]. The increasing impact of wildfires and other emissions will lead to more days and locations with poor air quality. In 2018, the California wildfires caused California cities to rank as the world's most polluted cities over places in India and China [1]. Researchers have studied the effect of Air Quality Index (AQI) Alerts on actions, primarily focusing on avoiding the outdoors and physical activity [8, 10]. Building on the aforementioned research and other similar studies, this research looks to understand how visual anchoring within the AQI rating affects intended behavior change (i.e. staying home, changing location to be inside, reducing time outside, wearing a face mask) to ultimately protect against adverse health outcomes. Additionally, this study examines how past behavior and personality may impact future health-conscious behaviors.

1.1 Preventative Actions

To date, there have been studies on protective actions people can take from poor air quality. For example, Laumbach et al. [5], compiled the methods to protect against

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poor air quality. These protective behaviors include staying indoors, cleaning indoor air, reducing physical activity outside, reducing exposure to microenvironments of high air pollution (highways, etc.), and using face masks (air respirators). All protect to a degree, but none of which guarantee full protection from poor air quality [5].

1.2 Changing Behavior with AQI Alerts

AQI alerts are a way for the United States Environmental Protection Agency and other government agencies to keep track and publish the air quality ratings. This measure is built around ground-level ozone, particulate matter, carbon monoxide, and sulfur dioxide to give a safety range value to the air [2].

Various authors have researched behavior change associated with poor AQI alerts. The primary findings of past studies have been avoidance of poor air quality from at-risk groups such as the elderly and children. Noonan [8] found these at-risk groups to exhibit greater avoidance behaviors, specifically in reducing outdoor physical activity, with the presence of alerts. A separate study conducted in Portland, OR and Houston, TX revealed that only a third of participants were aware of alerts provided to the public. Only a small portion of alert-aware participants self-reported behavior change due to the perception of poor air quality [11] with a person's perception of low air quality and professional advice leading to greater self-reported behavior change [5].

Several authors cite that AQI Alerts do not alter behavior across the population; a person's behavior will change between context and the activities in question [3, 8]. Furthermore, demographics do not predict if a person will follow an AQI Alert, instead, psychosocial factors have a larger influence (knowing how and where to check AQI, impact belief; i.e., symptoms are caused or antagonized by air pollution, perceived severity of air pollution, and professional health advice) [3].

Given the above review, present research addresses gaps in the existing research bodies. One clear gap is understanding causes and behaviors around wearing a face mask as a preventative measure. Little research has connected wearing a face mask and AQI Alerts other than a short piece examining the effects of mask wearing on systolic blood pressure [5]. Hansstein et al. looked at psychosocial reasons for why young adults in urban China wear face masks, finding that social norms and the individual's social circle's attitude shapes intention to wear a face mask [4].

There is a gap in understanding visuals in the AQI alert to motivate a person to change their behavior. In a similar field, Zikmund-Fisher et al. [13] studied the visual effect of understanding medical laboratory results. This study examined the effect of visually anchoring medical laboratory results when outside of a safe range through different visual treatments. Zikmund-Fisher et al. found that visual anchoring with harm anchors could help patients understand what is dangerous or unsafe [13]. Similarly, an AQI Alert represents a safe and unsafe range. This study looks to understand how seeing the AQI number in the context of the full-scale impacts the intention to change behavior.

Combining gaps assessed with AQI Alert visuals, face mask-wearing habits, and harm anchoring as a visual treatment, this study examines three hypotheses.

Hypothesis 1: The usage of a sliding scale in AQI Alerts to visually anchor the rating compared with a single number will affect intended behavior change. Hypothesis

2: Past behavior change related to air quality will affect intended behavior change related to air quality. Hypothesis 3: Personality traits such as decision making, opinion leadership, and social connection will factor into intended behavioral changes related to air quality.

2 Methods

2.1 Study Design

The study used a between-subjects design. Visuals associated with the AQI rating (single AQI rating number or the AQI rating number in the context of the full scale) served as the independent variable. Researchers posed a scenario where participants planned to attend the local outdoor market on a day with a poor AQI Alert. Dependent variables included five different behaviors a person could take, (a) reschedule for a better day, (b) hang out with your friend, but go somewhere else inside, (c) attend the outdoor market to hang out with your friend, but spend less time outdoors, (d) hang out with your friend at the outdoor event while wearing an air mask or respirator, and (e) attend the outdoor market to hang out with your friend as planned with no changes. Behaviors were measured through participants rating the likelihood to do each behavior using a slider scale from Very Unlikely 0 to Very Likely 100. Post-task questions included cataloging past behavior change due to air quality alerts and assessing personality. Personality questions centered around opinion leadership, decision making, and social behaviors which were systematically translated into the dominant and passive personality groupings. Past behavior and personality were chosen based on previous studies indicating their influence on behavior change in relation to viewing AQI.

2.2 Participants

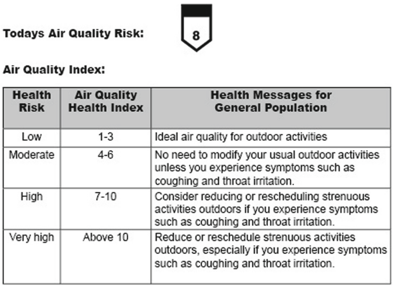
The participants were in the United States over the age of 18, using a laptop/desktop computer recruited through Amazons Mechanical Turk. A total of 140 respondents were paid $0.20. Of the 140 responses 113 qualified, the remaining 27 were eliminated for the following reasons: incomplete survey, not meeting requirements, and inconsistent open response questions (Table 1).

Table 1. Participant information

Gender	53 male, 58 female, and two non-binary/declined to respond
Age range	18–24 (13); 25–34 (33); 35–44 (28); 45–54 (13); 55–64 (15); 65+ (11)
Visual group	51 in the single number AQI rating and 62 in the AQI full scale

2.3 Tasks and Materials

Amazon's Mechanical Turk provided respondents and Survey Monkey was used to build and host the survey. The survey took on average three minutes to complete. Each participant saw the following scenario and one of two different visual scales with the AQI of "8", (see Figs. 1 and 2). The scenario provided was: *Air pollution in your city has become more common, often contributing to sore throat and coughing. Today, you are planning to go to an outdoor market to meet a good friend to shop and eat together. As you are deciding whether or not to bring a jacket you notice you have a slight sore throat. You check the weather application on your smartphone and notice your city's air quality rating below.*


Todays Air Quality Risk: 8

Air Quality Index:

Health Risk	Air Quality Health Index	Health Messages for General Population
Low	1-3	Ideal air quality for outdoor activities
Moderate	4-6	No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7-10	Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very high	Above 10	Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

Fig. 1. Group 1-single number AQI alert

The visuals were presented in black and white in order to control for the effect of color on the perception scale severity. The Canadian AQI scale was used to control for previous exposure, language, and actionability of the associated health message which has been shown to drive behavior change [9].

3 Results

Hypothesis 1. The usage of a sliding scale in AQI Alerts to visually anchor the rating compared with a single number will affect intended behavior change. There were no significant differences between visual groups found. Table 2 contains each measured behavior change and the respective p-values. Due to no changes found between the visuals, the two groups were combined for analysis of Hypothesis 2 and Hypothesis 3.

Hypothesis 2. Past behavior related to air quality will affect intended behavior related to air quality. Past behavior has a significant effect on people's likelihood to Wear an Outdoor Air Mask in the future ($t = -2.07$, $p = 0.04$). While this represents a significant difference, test results display low statistical power (0.34). The remaining intended behavior changes were not significant. Although, staying at home yielded $t = -1.81$ and $p = 0.08$, showing promise for past behavior affecting willingness to stay at home in the future. Table 3 contains each measured behavior change and the respective p-values (Figs. 3 and 4).

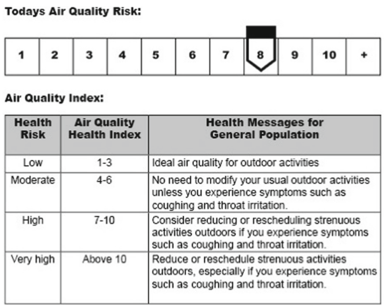


Fig. 2. Group 2-scale AQI alert

Table 2. AQI alert visual (single number vs scale) on intended behavior change

	Stay at home	Change to be inside	Less time outside	Outdoor with an air mask	Outdoor, no change
p-value	0.52	0.41	0.48	0.46	0.66
t-value	0.65	0.84	−0.71	0.75	−0.44

Table 3. Difference of past behavior on intended behavior change

	Stay at home	Change to be inside	Less time outside	Outdoor with an air mask	Outdoor, no change
p-value	0.08	0.29	0.78	**0.04**	0.75
t-value	−1.81	−1.06	0.28	**−2.07**	0.32

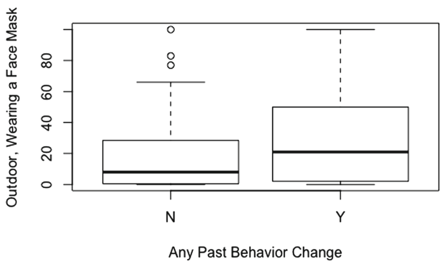


Fig. 3. Past behavior change & wearing a face mask

Hypothesis 3. Personality traits will factor into intended behavioral changes related to air quality. No difference found between dominant personalities and passive

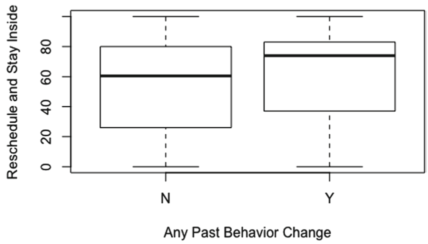


Fig. 4. Past behavior change & staying inside

personalities on intended behavior change. Table 4 contains each measured behavior change and p-values.

Table 4. Difference between dominant vs passive personalities on intended behavior change

	Stay at home	Change to be inside	Less time outside	Outdoor with an air mask	Outdoor, no change
p-value	0.98	0.33	0.25	0.94	0.22
t-value	0.03	0.97	−1.16	−0.08	−1.25

Miscellaneous Results: The lowest average rated intended behavior change was wearing an outdoor air mask. Figure 5 contains each measured behavior change and their average rating.

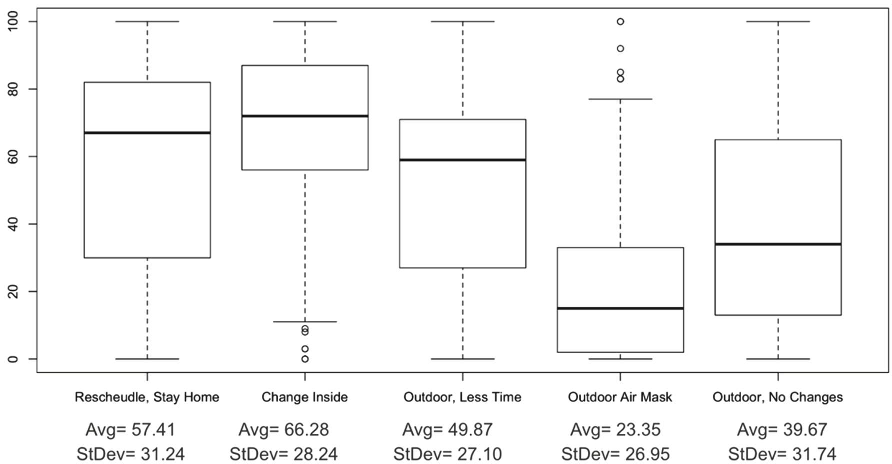


Fig. 5. Average of each intended behavior change across the group (0–100)

4 Discussion

When inspecting averages from each intended behavior change, the interesting take-away is that the intention to wear a face mask's average rating is lower than the other methods, despite this being a known preventative and protective health measure. This could be due to the social stigma of wearing air masks in the United States. Continued findings show that past behavior had the strongest influence on the intention to wear a face mask in the future. In order to bolster global impact of these results, an effort in an area where mask wearing is more normalized, like Japan is advised. However, the climate in the US of wearing a face mask may have changed since this study took place due to COVID19, which has caused may more people to begin wearing a face mask for protection. Further research is needed in this area.

This study was inconclusive on anchoring visuals in AQI Alerts indicating that more research is needed in this area. Typically, an AQI alert contains the AQI rating number, an accompanying descriptor word (Good, Bad, Hazardous etc.), a color indicator (green to red/purple), a recommended health action, and some have visual illustrations to indicate severity. The current research team believes that the descriptive information provided underneath the scale may have outweighed any effect the anchoring visual may have had. Researchers should explore the impact that the different AQI alert components listed above have on behavior change.

Previous researchers found the primary reason for wearing a face mask to be the role of social norms and the attitude of one's social circle [5]. However, Hansstein et al. 2018 found that personality had a significant effect on behavior change [4] specifically within young adults; who may be ultimately more susceptible to social factors when making health decisions than older people. Further study of this potential correlation is clearly warranted. If social acceptance of behavior modification based on air quality is found to be an important factor in encouraging people to be proactive about their health decisions, it may behoove governments and public health organizations to orchestrate societal change through a variety of factors that are not necessarily connected.

Immediate next steps for this research include two primary efforts. First researchers should break down different aspects of visual communication for AQI Alerts to understand what could move the needle with behavior change. Next, test for any difference between AQI Alert information exposure (presence and absence) and AQI visual communication components (anchoring, color, severity, etc.) by utilizing an information absence condition as a control group.

Study Limitations. There were several key limitations to this study. 1) This study's sample size was too low due to limited time to collect data and needed 120 per group to have a strong enough statistical power (0.80) to gain confidence in findings. 2) The personality questions were not robust or validated, future research should look into refining these questions or exploring other psychological attitudes. 3) The activity chosen for the scenario was not pre-tested and could have unintentionally confounded behavior change. 4) While known limitations of using Mechanical Turk include low quality data, substandard open questions, and evidence of foreign workers using server farms [7]; the following steps were taken to ensure data quality. Questions were asked to ensure participants met survey criteria and open text questions were asked to ensure attention and literacy.

5 Conclusion

The most salient benefit of this research study points to what it takes to potentially increase intent to wear a face mask in the future focusing on past behavior and visual information displayed. This should be retested and expanded on in order to increase confidence. The impact of predicting this type of intended behavior change for both decreasing air quality and in today's pandemic climate is monumental. As health concerns continue, it is necessary to understand how to best communicate important information that has the best chance at influencing protective health behaviors.

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Mass and Density of Materials: Knowledge and Perceptions

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Abstract. Many construction injuries are musculoskeletal related in the form of sprains and strains arising from the handling of materials. The paper reports on a study conducted among construction management students in a South African university, the objectives being to determine their knowledge and perceptions relative to the mass and density of materials and construction ergonomics. Findings include: knowledge relative to the mass and density of materials is limited, and students appreciate that the mass and density of materials impacts on construction ergonomics. Conclusions include: students lack knowledge and awareness relative to the mass and density of materials, and the undergraduate programme must be reviewed in terms of addressing/referring to the mass and density of materials. Recommendations include: tertiary construction management education must address construction ergonomics; employer and professional associations, and statutory councils must raise the level of awareness relative to construction ergonomics and the mass and density of materials.

Keywords: Construction · Ergonomics · Mass and density · Materials

1 Introduction

According to Reid et al. [1], construction is a high-risk industry for work-related musculoskeletal disorders (WMDSs), and Monk [2] states that construction materials may be heavy and/or inconveniently sized and shaped, thus presenting manual materials handling problems. The Center for Construction Research and Training [3] underscores Reid et al.'s statement by stating that WMSDs are common in the construction industry. They add that 65% of WMSDs in construction are related to sprains, strains, and tears. Furthermore, one-third of all construction industry accidents reported to the HSE in the United Kingdom (UK) every year involve manual handling [4].

The South African Construction Regulations [5] require in general that contractors must identify the hazards and the risks to which persons may be exposed.

The aforementioned highlight the relevance of construction ergonomics and the mass and density of materials to the discipline of Construction Management, and the rationale for the study reported on, the objectives being to determine:

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- students' knowledge relative to the mass and density of materials, and
- students' perceptions relative to the mass and density of materials relative to construction ergonomics.

2 Review of the Literature

2.1 Legislation and Recommendations

Prior to the promulgation of the Construction Regulations in South Africa, all designers were required to address H&S in terms of Section 10 of the Occupational Health and Safety Act (OH&SA) [6] as they must ensure that any 'article' is safe and without risks when properly used. This requirement implies that the mass and density of materials must be considered by designers.

Clients and designers have a range of responsibilities, in terms of the Construction Regulations [5]. Designers are required to, inter alia: advise the client of any dangers or hazards relating to the construction work, identified or anticipated; provide the necessary information to assure the healthy and safe execution of the work; amend the design or substitute materials where the design necessitates the use of materials or methods that entails hazards and risk, and consider hazards and risk relating to subsequent maintenance during the use phase of the structure. These requirements have implications as the mass and density of certain materials may constitute a hazard and entail risk.

The South African Ergonomics Regulations [7] require that before an activity that may expose workers to ergonomics risks is commenced, an employer must have an ergonomic risk assessment conducted. Such a risk assessment must be conducted at intervals not exceeding two years, and must include: a complete hazard identification; identification of all the persons who may be affected and how they will be affected by the ergonomic risks; the analysis and evaluation of the ergonomic risks, and the prioritization of the ergonomic risks.

The United Kingdom (UK) Manual Handling Operations Regulations require a range of interventions by employers. Regulation 4(1)(b)(iii) requires employers "to take appropriate steps to provide general indications and, where it is reasonably practicable to do so, precise information on the weight of each load, and the heaviest side of any load whose centre of gravity is not positioned centrally" [8]. The HSE [8] states that 'general indications' in turn should form a part of any H&S induction or basic H&S training, so that employees have sufficient information to undertake the tasks they are required to do. Training should also cover practical techniques handlers can use to assess the weight of unfamiliar loads.

In terms of the OH&SA [6] and South African Construction Regulations [5] contractors must identify hazards and the risks, analyze and evaluate them in a documented manner, produce a plan such as a method statement, evolve related safe work procedures, and inform and train workers to mitigate, reduce, or control the hazards and risks.

2.2 Materials Handling

Handling heavy materials has been repeatedly flagged in terms of the frequency eighteen ergonomics problems are encountered in South African construction [9–11]. Handling heavy materials was deemed to be encountered frequently as opposed to infrequently.

Furthermore, materials handling was identified first among nine ergonomic aspects requiring attention by the majority of management and worker respondents during a study conducted in South Africa [9]. A subsequent study conducted solely among workers identified materials handling as the predominating ergonomic aspect requiring attention [10].

2.3 The Relevance of the Mass and Density Materials to Construction Ergonomics

A further South African study identified that mechanisation could make between a near major to major/major contribution, and specification between a contribution to a near major/near major contribution to an improvement in construction ergonomics [12].

3 Research

3.1 Research Method and Sample Stratum

24 BSc (Honours) (Construction Management) students registered at a comprehensive university in South Africa constituted the convenience sample stratum, all of which completed the self-administered questionnaire at the inception of the honors lectures in 2019.

Six closed ended questions constituted the questionnaire, the first two pertained to the mass and density of materials, and the remaining four questions required a response to a five-point scale. The study replicated prior studies conducted among, inter alia, honors level civil engineering students [13].

The data analysis entailed the computation of percentages, and a mean score (MS), a measure of central tendency.

3.2 Research Findings

The first question entailed a response in the form of the mass or density of nine materials, and overall, 88.0% of respondents attempted the questions, and 12.5% did not (Table 1). The precast concrete kerb attracted the least response (79.2%), and the solid clay brick, Double Roman concrete roof tile, concrete, and steel attracted the most response (91.7%).

Table 1. Summary of mass and density of materials responses.

Material	Responded to (%)	
	Yes	No
Solid clay brick	91.7	8.3
Two-cell concrete block	87.5	12.5
Precast concrete kerb	79.2	20.8
Double Roman concrete roof tile	91.7	8.3
m^2 glass 5 mm thick	87.5	12.5
Concrete	91.7	8.3
Marble	87.5	12.5
Sandstone	83.3	16.7
Steel	91.7	8.3
Mean	88.0	12.0

Interrogation of the mean response mass/density, the percentage difference between the mean response and actual mass/density, and the responses that were within a 10% range of the actual mass or density provides further insight with respect to the respondents' knowledge and perceptions (Table 2).

Precast concrete kerb (−7.1%), followed by steel (−14.8%) recorded the lowest percentage difference between the mean response and actual mass/density. Sandstone (−65.2%), followed closely by two-cell concrete block (62.5%) recorded the highest difference. The mean percentage difference of −39.3% is notable.

The lowest percentage response that was within 10% range of the actual mass/density is relative to steel (0%), and the highest is relative to concrete (33.3%), and a mean of 11.6%. These are notable, as reinforced concrete construction, which includes concrete and steel, predominates in South Africa, and the Construction Management programme includes the subject 'Structures' in the three-year undergraduate programme.

Table 2. Actual mass/density and mean mass/density response, percentage difference, and summary of responses within a 10% range of the actual mass or density.

Material	Actual	Mean response	Difference (%)	Within 10% (%)
Solid clay brick (kg)	3.0 – 3.5	2.7	(16.7)	16.7
Two-cell concrete block (kg)	17.5	6.6	(62.5)	4.2
Precast concrete kerb (kg)	95	88.2	(7.1)	12.5
Double Roman concrete roof tile (kg)	4.8	3.5	(26.9)	8.3
m^2 glass 5 mm thick (kg)	13.5	5.7	(57.5)	4.2
Concrete (kg / m^3)	2 400	1301.6	(45.8)	33.3
Marble (kg / m^3)	2 755	1171.7	(57.5)	16.7
Sandstone (kg / m^3)	2 323	807.5	(65.2)	8.3
Steel (kg / m^3)	2 393	2038.0	(14.8)	0.0
Mean			(39.3)	11.6

The MS of 4.57 ($4.20 \leq 5.00$) in Table 3 indicates the mass and density of materials impacts on ergonomics between a near major to major/major extent. Although this finding reflects perceptions it is reinforced by the findings of literature, and reality. Furthermore, even though the percentage responses that were within 10%

range of the actual mass/density (Table 2) are low, the level of understanding and appreciation in terms of the impact of the mass and density of materials is notable.

Table 3. Extent to which the mass and density of materials impacts on ergonomics.

Unsure	Response (%)					MS
	Minor….. ……………………..…......... Major					
	1	2	3	4	5	
4.2	0.0	0.0	4.2	33.3	58.3	4.57

The MS of 2.67 (>2.60 $\leq$ 3.40) in Table 4 indicates the respondents' rating of their knowledge of the mass and density of materials is between below average to average/average. However, it shoudl be noted that the MS of 2.67 is margianlly (0.07) above the lower range >1.80 $\leq$ 2.60, which indicates a rating of limited to below average/below average. This self-rating reflects the respondents' knowledge reflected in the findings relative to the mass and density of materials (Table 2).

Table 4. Respondents' rating of their knowledge of the mass and density of materials.

Unsure	Response (%)					MS
	Limited………………………..…..............Extensive					
	1	2	3	4	5	
0.0	16.7	25.0	45.8	0.0	12.5	2.67

In terms of the frequency built environment disciplines should consider the mass and density of materials, Engineers (Design), Engineers (Construction), Construction Managers, Project Managers, and Architects have MSs > 4.20 $\leq$ 5.00, which indicates the frequency is between often to always/always (Table 5). Given that construction management students are the subject of the study, it is notable that Construction Managers are ranked third. Quantity Surveyors is ranked last with a MS of 3.74, which is > 3.40 $\leq$ 4.20, which indicates the frequency is between sometimes to often/often. Given the impact of the mass and density of materials on ergonomics, all built environment disciplines should consider the former.

Table 5. Frequency at which built environment disciplines should consider the mass and density of materials when practicing their discipline.

Discipline	Response (%)						MS	Rank
	Un-sure	Never….. …………………... Always						
		1	2	3	4	5		
Engineers (Design)	0.0	0.0	0.0	0.0	4.2	95.8	4.96	1
Engineers (Construction)	0.0	0.0	0.0	0.0	4.2	95.8	4.96	2
Construction Managers	0.0	0.0	0.0	0.0	12.5	87.5	4.88	3
Project Managers	0.0	0.0	0.0	20.8	20.8	58.3	4.38	4
Architects	0.0	0.0	4.2	16.7	20.8	58.3	4.33	5
Quantity Surveyors	4.2	0.0	12.5	33.3	16.7	33.3	3.74	6

The MS of 4.48 (> 4.20 ≤ 5.00) indicates that there is between near major potential to major potential/major potential for the consideration of the mass and density of materials to contribute to an improvement in construction ergonomics. This is despite the respondents' self-rating of their knowledge of the mass and density of materials being between below average to average/average (Table 4).

Table 6. Potential of the consideration of the mass and density of materials to contribute to an improvement in construction ergonomics.

Response (%)						MS
Unsure	Minor…........... …………………..…Major					
	1	2	3	4	5	
4.2	0.0	0.0	0.0	50.0	45.8	4.48

4 Conclusions

The respondents are lacking in knowledge relative to the mass and density of materials due to: an average of 88.0% having attempted to record a mass or density relative to the materials presented; on average 11.6% being within a 10% range of the actual mass or density; the percentage differences between actual mass/densities and the mean mass/densities, and the respondents' self-rating of their knowledge of the mass and density of materials, namely 2.67, which indicates below average to average/average.

Respondents understand and appreciate: the extent to which the mass and density of materials impact on construction ergonomics, as the MS (4.57) indicates the appreciation to be between near major to major/major; the frequency at which five disciplines should consider the mass and density of materials, and the potential of the consideration of the mass and density of materials to contribute to an improvement in construction ergonomics, which is between near major potential to major potential/major potential.

5 Recommendations

Tertiary built environment education should deliver holistic construction technology/materials and methods modules, which address the environmental, health and safety, and ergonomics aspects of materials and the related activities, including engendering an awareness of the mass and density of common construction materials. Academia and industry liaison panels should address this aspect, and professional and statutory council accreditation panels should review the extent to which designing for construction H&S and ergonomics is addressed in such programmes.

Construction managers should consider the mass and density of materials when preparing method statements, undertaking temporary works designs, conducting HIRAs and developing safe work procedures, and addressed the aspect during H&S induction, toolbox talks, daily H&S task instructions, and H&S training delivered to workers.

Designers should deliberate the mass and density of materials when designing, detailing, and specifying materials, and so too cost engineers/quantity surveyors when compiling bills of quantities and preparing contract documentation. Furthermore, they should facilitate adequate financial provision for H&S by tenderers, ergonomics included.

All South African statutory built environment councils and professional associations, in addition to the South African Council for the Project and Construction Management Professions (SACPCMP), and Chartered Institute of Building (CIOB) should evolve construction H&S and ergonomics practice notes, and promote continuing professional development (CPD) relative to construction ergonomics.

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Analysis of the Operation in a Woodwork Shop: Layout Aspects, Work Safety and Interaction with Ergonomics

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Abstract. The present work has the objective of proposing solutions that can adapt a joinery in the municipality of São Gonçalo to the current legislation, which concerns Occupational Health and Safety, having the main goal of providing safe and healthy conditions for workers. The methodology used was divided into two stages: Documentary survey and object recognition and characterization, using techniques such as unsystematic observation, interviews and questionnaires. In the final part of the research, the results of the methodology were presented and the criticality points of woodworking related to Occupational Health and Safety were identified so as to propose improvement projects that meet the employees' needs inserted in the context of the factory, in order to contribute to a healthier, safer and more comfortable working environment.

Keywords: Joinery · Occupational ergonomic risk · Health and Safety · Furniture sector · Physical arrangements

1 Introduction

Workplace safety in Brazil is created by legal provisions, which are enforced by companies, not much because of the understanding of the need and impact on workers and research.

The present work was developed in a carpentry shop, in the municipality of São Gonçalo in the state of Rio de Janeiro, in Brazil. The Municipality of São Gonçalo is home to a significant number of carpenters, who use local labor and provide services from small consumers to large companies.

In order to analyze the operation of this joinery with a focus on layout organization and Occupational Health and Safety for proposing improvements in the environment with a focus on Ergonomics, unsystematic observation techniques were used, which means free observation to know the object of study. In this sense, interviews were conducted composed of questions previously structured and based on issues related to Occupational Health and Safety, in addition to the well-being of employees so that there was a better understanding of the current scenario of the company and formulating a diagnosis. Finally, a check-list was carried out in order to check if some

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Regulatory Norms - NR of the Ministry of Economy of Brazil were complied with in the carpentry in question.

The NR are under review and as for Ergonomics in the document that was for public consultation, there was emphasis on the survey of ergonomic aspects and separation of what can be solved with the company's Work Safety personnel and the aspects that must be analyzed by specialists. The author's belief is that with adequate training, most needs are solved by own staff, with simpler projects.

As required by NR, ergonomic issues should be analyzed in terms of the severity of the damage, and the probability of occurrence, a level of risk being determined and from there a prioritization and work plan is made. Then, in the final stage of the research, the results were presented, identifying the critical points of the carpentry related to Health and Safety at Work. These results focused mainly on aspects related to the company's outdated knowledge of legal requirements; absence of signs that indicate the risks present in the factory and in the areas of the machines used, as well as escape routes in case of emergency; non-regular use of individual and collective protection equipment, as well as the lack of inspection regarding their use; manual cargo transportation done incorrectly; ergonomic risks not raised; confusing flow patterns, unnecessarily long stock of materials and processing times and inadequate location for operators to have their meals, such as disorganized and dirty environments. From the identification of these deficiencies of the company, projects were elaborated to remedy them. In the design, the favorable characteristics found in the company's environment were considered.

2 Theoretical Reference

2.1 Environmental and Comfort Conditions According to NR 24

Regulatory Norm 24 [1] establishes the minimum conditions of hygiene and comfort to be observed by companies, according to the dimensioning of all the facilities regulated by it, based on the number of workers in the shift with the greatest contingent. In the carpentry in question, the areas outside the production environment (toilets, changing rooms, cafeterias, kitchens and accommodation) were analyzed according to the requirements established by NR 24 [1].

2.2 Physical Arrangements According to NR 12

In order to determine the minimum requirements to prevent accidents at work and occupational diseases caused by operation, maintenance or other activities arising from the interaction of man with machinery and equipment, the former Ministry of Labor and Employment - MTE, now Ministry of Economy, established NR 12 - Work Safety in Machinery and Equipment [2]. This norm also establishes guidelines related to physical arrangements and installations, directly impacting the layout of establishments. In the carpentry studied, the six machines used in the production process need an operator for each one of them. Thus, it is mandatory to observe the parameters defined in this standard regarding the disposition of the machinery, in addition to demarcations of the spaces occupied by these and the circulation areas.

2.3 Signaling According to NR 26

Regulatory Norm NR 26 – Safety [3] signs, establishes that colors for safety must be adopted in establishments or workplaces, in order to indicate and warn about the existing risks. In the carpentry environment, chemical, physical and biological risks are present, therefore, it is necessary to apply the requirements established in this NR.

2.4 Ergonomics and Interface with Other NRs

NR 17 – Ergonomics [4], aims to define parameters that enable the adaptation of working conditions, the psychophysiological characteristics of workers in order to provide maximum comfort, safety and efficient performance.

In the furniture sector, there are several activities that require continuous physical effort from the workers who perform it. Such tasks generate muscle pain and injuries such as low back pain and spinal disc herniation (FIEDLER ET AL, 2003) [5]. In this sense, non-conformities were raised in the carpentry studied that infringed related items, not only NR 17 [4], but also NR 15 - Unhealthy Activities and Operations [6], NR 11 - Transport, handling, storage and handling of materials [7] and NR 6 - Personal protective equipment – PPE [8]. Since the subjects covered in this are part of the carpenters' work routine, it affects their health, safety, comfort and well-being.

3 The Joinery

The carpentry in question was founded in 1986 by its current owner with the purpose of creating planned furniture with a fine finish. From the beginning, its mission is to deliver differentiated and quality products. Operating in the furniture sector for over thirty-three years, the carpentry in question began its activities serving the market in the city of Rio de Janeiro. Serving about 100 annual orders, each of them containing, at least, planned furniture in one room, one of the most manufactured products by the studied company are paint lacquers with a fine finish. The joinery has thirteen permanent employees, these are divided into administrative and factory floor activities.

4 Research Methodology

In order to better understand the studied carpentry environment, the researchers went to the field to collect relevant information for the preparation of this work. For this, unsystematic observation, interview and check list techniques were applied.

Without the need to have previously defined planning, the so-called casual or simple observation, consists of conducting free observation in order to know the object of study and formulate hypotheses (Moraes and Mont'Alvão 2003) [9]. In the present study, an initial analysis was carried out in the study environment in order to raise the main criticisms related to Occupational Health and Safety. This observation consisted of an analysis of the work process, of workers, their work materials, safety equipment, activities performed and the environment, identifying collective, individual, physical, chemical, biological, ergonomic and accident risks.

The researchers applied an interview, previously prepared, with the managers of the factory, aimingto have a better understanding of the current scenario of the company regarding Health and Safety at Work.

The check list is a tool that aims to certify the conditions of a service, product, process or any other activity, with a focus on ensuring that all phases or items on the list have been carried out as planned. In this sense, a check list of NRs 6 [8], 11 [7], 12 [2], 15 [6], 17 [4], 24 [1] and 26 [3] was carried out, in order to verify whether these were fulfilled in the carpentry in question.

5 Improvement Opportunities

Through the techniques mentioned in the methodology, it was possible to evaluate the most critical points of the carpentry regarding issues of Occupational Safety Health.

In the first visit to the factory, some aspects were identified, such as poorly organized layout, absence of signs in general and irregular use of PPE by employees. In addition, it was noticed that the joinery had a lagged knowledge in relation to the legislation inherent to Health and Safety at Work. In the interview with the managers, the perception that the company's mentality in relation to Occupational Health and Safety needed to be developed was confirmed. From the applied check list, it is concluded that the carpentry in question does not achieve most of the requirements set out in NRs 6 [8], 11 [7], 12 [2], 15 [6], 17 [4], 24 [1] and 26 [3] and evidenced the company's highest criticisms regarding Health and Security that needed to be worked on.

6 Improvements to Be Implemented

The proposed projects were defined according to the main deficiencies found, also taking advantage of the favorable characteristics found in the studied woodwork environment.

To remedy the company's outdated knowledge in Regulatory Norms, it is proposed to qualify some collaborator, from the productive area, to act in the implementation and inspection of Regulatory Norms.

In order to improve the physical layout of the machines by distributing them aiming to maximize the functionality of the production process and optimize the working environment, it was proposed to allocate the machines in a more functional way, obeying the principles of proper layout.

In order to comply with NR 6 [8], it is suggested that a process flow be established to ensure that the employee uses the PPE correctly, in addition to having control over the PPE according to the activities carried out and adequacy according to the Certificate of Approval - CA; control of PPE delivery with individual file for each employee and training control as to the indication, use and conservation of the PPE offered.

To meet the requirements established in NR 17 [4], it is suggested to apply a load handling training. It is also necessary that the studied carpentry elaborates an Ergonomic Analysis of Work, which according to NR 17 [4], aims to establish parameters for the adaptation of working conditions to the psychophysiological characteristics of workers. In addition, it is necessary to implement a system of rest breaks in order to preserve the physical conditions of workers.

It is recommended the elaboration of technical unhealthy expertise and issuance of the Social Security Professional Profile - PPP for employees exposed to unhealthy agents in virtue of NR 15 [6], as the activities carried out by workers in the joinery offer occupational risks for them.

The factory does not have any signs related to Occupational Health and Safety. Thus, it is proposed to implement, in strategic locations of the factory, signposts according to the items of NR 26 [3]. In addition to the signs, the standard establishes in item 26.2 that the body of the machines must be painted in white, black or green. It is worth emphasizing the importance of ensuring that the signage of machinery and equipment is as indicated in NR 12 [2] to warn workers about the risks to which they are exposed. In this sense, it was suggested to implement a demarcation on the floor in order to alert about possible risk in the area involved.

The factory has two freight elevators that have no protection. It is recommended that protective grids be installed around the elevators. This operation system allows the operator to use the elevator safely and efficiently, helping to avoid accidents at the workplace, in compliance with NR 11 [7] related to the system of security. In addition, it is necessary to have the signaling indicating the maximum load that can be transported in the freight elevators and its exclusivity in transporting only materials.

In compliance with NR 24 [1], it is suggested to build a suitable place for workers to have favorable and wholesome conditions to have their daily meals and rest during lunch hours.

7 Final Considerations

The present work, through methodological tools and theoretical foundation, generated results that indicate the non-conformities related to the Occupational Health and Safety legislation are the inherent weaknesses of the layout organization. Regarding Health and Safety at Work, the carpentry has numerous flaws. These can be seen on any shop floor, where there is no signage, irregular use of PPE and poorly organized layout.

The suggestions for improvements contained in this work were developed with the aim of adapting the structure of the place to the current legislation, providing company employees with elements that allow them to develop their activities in comfort and safety. The studied environment has full conditions for implementing the recommendations. It is worth mentioning that the carpentry studied implemented part of the improvements suggested in this work.

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An Assessment of Whole-Body Vibrations Exposure in Transport Truck Drivers

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Abstract. Objectives: The purpose of this study was to asses whole-body vibration (WBV) exposure from transport truck drivers. Methods: Field measurements of WBV were measured according to the National Standard Decree 594/99, was implemented in Chile through the vibration protocol. They were measured simultaneously according to ISO 2631-1. The Decrees contain legal obligations and minimum requirements for the evaluation by direct measurement, which is the reference method. Results: The sum of the vectors of frequency-weighted r.m.s. acceleration varied between 0.35 and 0.94 m/s^2, which meant that none of the vehicles exceeded the action value stated by decree 594/99 (X-Axis 0.71($[m/s^2]$), Y-Axis 0.71($[m/s^2]$) and Z-axis 1,06 ($[m/s^2]$). In general, the dominant vibration direction for the truck driver was the Z-axis. The other axis measurement levels were under the Chilean and European legislation. Significant differences were identified between the levels measured in each of the axes (X, Y, Z) and great differences can be identified between the levels obtained in trucks from the year 2011 and trucks from the year 2019. Despite obtaining high levels on the z axis, none of the measurements exceeded the established limits. Conclusions: The dominant vibration direction varies depending on the transport truck type and the state of the road or highway on which truck circulates. The study shows that no worker is under health guidance caution zone (HGCZ) so the probability of contracting musculoskeletal injuries is very low.

Keywords: Truck drivers · Whole-body vibrations · Transportation

1 Introduction

The energy of an object that vibrates is absorbed by the human body and can produce various effects that depend on the characteristics of the vibration [1]. Biodynamic strain, microtrauma, and intraluminal/intra-abdominal pressure fluctuations produced by truck vibrations are postulated as being at least partially responsible for the development of certain musculoskeletal, digestive, and circulatory disorders among interstate truck drivers [2]. The most pronounced long term effect of whole body vibration is damage to the spine, with health risks increasing with intensity and duration of exposure. [3, 4]. Whole body vibration (WBV) is a known leading risk factor for LBP among professional vehicle operators [1, 5–9]. Whole-body vibration occurs when a human is supported by a surface that is shaking and the vibration affects body parts remote from the site of exposure. When a forklift truck drives over a bumpy surface, vibration is

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transmitted through the vehicle to the seat and footrest, which are the surfaces that support the driver [10]. The long periods of operating off-road vehicles can result in the overuse and damage to the soft tissues in the low back and neck regions, which is a known precursor of musculoskeletal injuries [1, 11–13]. Numerous research studies have indicated that reducing WBV helps reduce discomfort and maintain vigilance, which may improve drivers' health and reduce the risk of truck collisions [14].

2 Method

(See Fig. 1).

Fig. 1. Phases of research project in truck drivers.

2.1 P1: Experimental Design

This was a cross-sectional study conducted during the Fall of 2019 on truck drivers of La Calera in Valparaíso province, Chile (Table 1).

Table 1. Description of truck evaluated for driver whole-body vibration exposure.

Truck	Year	Age (yrs)	Route
T-1	2011	8	Doñihue
T-2	2012	7	San Jorge
T-3	2012	7	Viña deí Mar
T-4	2015	4	La preferida
T-5	2019	0	San Pablo
T-6	2019	0	Walmart

The age is computed from vehicle year to date of latest data collection-2019.

2.2 P2: Measurement

All measurements were made with a Svantek 106 equipment, this equipment has an SV 39 A/L model seat accelerometer according to ISO 2631 and allows equivalent weighted acceleration values to be obtained, placing the instrument with filters weighting required for full body exposures. The measurements were made during a period of two weeks during the early morning. The measurements time was 30 min and was projected to 4 h, which corresponds to the daily driving time. (Random vibration). The participants signed an informed consent. We interviewed a tot al of 6 truck drivers in different routes.

$$\mathrm{TOT_{wRMS}}A(8) = \sqrt{(1.4\mathrm{wRMS}_y)^2 + (1.0\mathrm{wRMS}_z)^2} \tag{1}$$

Overall weighted total Root-Mean-Square (RMS) acceleration or vector sum normalized to an 8-h shift is obtained by Eq. (1).

Frequency-weighted RMS accelerations were then calculated using the appropriate weighting factors (x-axis = Wd; y-axis = Wd; z-axis = Wk) Scaling factors associated with the determination of health for seated exposure were also applied (x-axis, k = 1.4; y-axis, k = 1.4; z-axis, k = 1.0) [15].

According to 594 STD, the frequency-weighted acceleration values corresponding to the "x" and "y" and "z" axis of the health guidance caution zone (HGCZ) (for 4 h of exposure) are 0.71 m/s^2 and 1.09 m/s^2 respectively. According to the standard, health effects are not well documented for vibration exposure levels below the HGCZ. Exposures falling within the HGCZ should be viewed with caution in regards to health risks, while health risks are likely if the exposure is above the HGCZ.

2.3 P3 Analysis

Table 2. Vibration exposure time versus Max. limits.

Exposure Time (h)	Z- Axis	X-Axis	y-Axis
12	0,50	0,35	0,35
11	0,53	0,38	0,38
10	0,56	0,39	0,39
9	0,59	0,42	0,42
8	0,63	0,45	0,45
7	0,70	0,50	0,50
6	0,78	0,54	0,54
5	0,90	0,61	0,61
4	1,06	0,71	0,71
3	1,27	0,88	0,88
2	1,61	1,25	1,25
1	2,36	1,70	1,70
0,5	3,30	2,31	2,31

Daily vibration exposures were computed from weighted RMS accelerations for the different haul trucks and drivers using Eq. (1) (Table 2).

3 Results

Weighted acceleration levels for the total sample times were normalized to compare with the health guidance caution zone.

Table 3 shows truck driver WBV exposures in terms of wRMS accelerations for six trucks. All levels, normalized for an 4-h, were within the HGCZ for both ISO and 594 Chilean STD.

Table 3. Whole-body vibration exposures evaluated by weighted, root-mean-square (wRMS) accelerations for axis x, y, and z

Truck	Year	Route	A- TOT_{RMS}	Within HGCZ
T-1	2011	Doñihue	0,98	×
T-2	2012	San Jorge	0,53	×
T-3	2012	Viña del Mar	0,41	×
T-4	2015	La preferida	0,60	×
T-5	2019	San Pablo	0,41	×
T-6	2019	Walmart	0,35	×

4 Discussion

It is observed that there is a relationship between the year of the truck and the levels of exposure to vibrations, since it decreased when the truck is from 2015 onwards.

The X and Y axis measured are conditioned by the characteristics of the road, being mainly affected by three factors: route, truck age and traffic (Fig. 2).

Fig. 2. Route map used and result of A_{RMS} related with route within HGCZ

5 Conclusion

The levels of exposure to whole body vibrations are observed for each of the trucks used by the company, with favorable results since none of the trucks exceeds the limits established under Chilean regulations and ISO 2631-1. The farthest destination terminals had a higher level of exposure.

From this evaluation of the workstation it is concluded that the factors of exposure to mechanical vibrations are very determined by the type and state of conservation of the road through which they circulate, as well as the state of conservation of the truck, especially the damping system I have. The age of the vehicle also directly affects the level of mechanical vibrations.

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Social, Legal and Epistemology

The Impact of Social Media in Military Recruiting

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Abstract. Given the growing success and user base of Social Media websites and, specifically, Social Networks, over the last decade, businesses have transitioned from traditional advertising to digital platforms. Specifically, their audience targeting features make it very easy to promote products and services to defined groups of individuals with specific characteristics. As a result, in addition to standard advertising, organizations, including educational institutions, started using personal and professional Social Networks (e.g., Facebook, Instagram, and LinkedIn) as a recruiting tool for reaching potential candidates and interacting with them in a quick informal fashion.

In this paper, we explore the human factors in the use of Social Media in recruiting for the Army and we detail the results of a study in which we compared the perspective of recruiters and prospect cadets, especially in the context of initiatives, such as the Delayed Entry Program (DEP).

Keywords: Social Media · Recruiting · Military · Delayed Entry Program

1 Introduction

In the last decade, several Social Network (SN) websites have been developed to provide people worldwide with opportunities to connect with others, share different type of information, and stay informed, mostly for free. As a result, nowadays, the most popular platforms, that is, Facebook and Instagram, have more than 2 billion and 1 billion users, respectively. Traditional methods lack tools for quickly engaging in meaningful conversations between organizations and their audiences, whereas comments, messages, and notifications render Social Media more effective in creating a constant contact with a larger network of potential target users. Consequently, Social Media have been increasingly utilized by businesses as the predominant tool for communicating to their target audience and advertising their products and services to new groups of potential customers. On the one hand, this resulted in a major budget shift from traditional advertising to digital media; on the other hand, Social Networks are a marketing tool that any company can use to reach a broader audience [1].

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In addition to traditional advertising channels, recruiting agencies and human resource offices have increasingly started utilizing social media as a way to identify potential candidates and check their background, monitor employees and the appropriateness of their social media profile to the etiquette of the company, and promote the business itself using salient figures among their workforce as the face of the company, to advertise a healthy and productive work environment and, simultaneously, improve their brand reputation in order to recruit better talents. Following more traditional organizations, such as, education institutions, different military branches in the Army, such as, the Department of Defense and the Air Force, have attempted the use of Social Media to advertise their activities, recruit cadets, and engage youth in their programs.

In this paper, we focus on the use and impact of new forms of digital advertising on military recruiting and we present the results of a research study aimed at assessing the role of Social Networks, such as, Facebook and Instagram, in supporting traditional and non-conventional strategies for promoting enlisting in the army and military organizations. In our study, we specifically considered the Delayed Entry Program (DEP), which is designed to prepare civilians for basic military training, and we analyzed different strategies operated by recruiters, including traditional advertising and communication via personal and organization profiles. Moreover, we interviewed both recruiters and prospect cadets to compare their perspectives and expectations in terms of technology adoption, to highlight the role of human factors in influencing decisions to join the service, and to identify how Social Media changed recruiting practices. In addition to measuring the outcome in terms of successful applications, we describe current patterns and future trends in the context of recruiting for the military. Finally, we discuss how the results of our study can be applied in different types of hiring processes and how practices adopted by Army recruiters can offer insightful information for other organizations.

2 Related Work

According to a recent report [2] posting job vacancies and advertising them to potential candidates is among the compelling reasons for companies to use social media, because in addition to making it convenient to create job posts and specify a narrow target audience, communication tools, such as, instant messaging, increase engagement and, simultaneously, renders the recruiting process more informal. Also, as users can easily contact companies, Social Media enables job seekers to spontaneously apply, which helps organizations build a database of potential candidates for future consideration [3].

Specifically, research studies focusing on specific age groups found that users in the Millennials and Gen Z generation spend an average of 2 h and 43 min per day on Social Media, which makes SNs the primary channel they use to stay informed [4], despite the presence of potential risks [5]. As a result, higher education institutions have increasingly used SM to advertise their programs to future students, in the last decade, in addition to incorporating them as learning tools [6]. Also, applications can be built to acquire more information about the user, so that message can be customized accordingly [7]. Nowadays, most universities use SN websites to share information with students and their parents, and to recruit potential candidates. Moreover, as users tend to migrate from one Social Media to another [8], they simultaneously use multiple platforms. In longitudinal studies on the effectiveness of Social Networks as a recruitment tool [9, 10], the authors interviewed several institutions and measured their improvement over the course of four years. Moreover, they compared the Return on Investment of recruiting via Social Networks to the results obtained by several blogs maintained by the institutions and concluded that while the latter had little impact on enrollment, SN had a significant role in engaging students. Also, their findings showed an increasing trend in the numbers of schools that utilized SM.

While other types of organizations were faster in the adoption of SM technology, the Army did not adjust as quickly to leveraging the dynamics of Social Networks for recruiting. Although the Department of Defense (DOD) created a social media account almost a decade ago, over the last years cadets have been primarily contacted and managed using traditional methods and many recruiters in the United States have acknowledged the struggle to advertise the Army to Millennials and Generation Z. A few early adopters started using Instagram to post their daily operations in lieu of marketing events, others are broadcasting how the hiring process works, and others started using their feed to share motivational posts that can create awareness and aid their recruiting tasks. However, in addition to being a small group, the activity of the most innovative recruiters is the outcome of personal initiatives, rather than the application of a structured framework. Only recently, forced by decreasing budget availability, several branches, such as, the Air Force, started realizing that most recruiters are still relying on outdated procedures and they are not utilizing technology to its fullness, mainly due to security reasons or concerns that its use would invade on their personal time [11]. Therefore, nowadays there is a push towards modernized techniques and, specifically, to the adoption of Social Media as a platform for optimizing the recruitment process.

3 Study

As the purpose of our work is to evaluate the adoption of Social Media as an advertisement tool for the army, we designed a research study aimed on understanding recruiting from the perspective of recruiters and prospect cadets. Specifically, we focused on the Delayed Entry Program (DEP), which is designed to prepare civilians for basic military training. The DEP is one of the largest in terms of enrollment, because it is meant as a screening program for all individuals potentially going into active duty. Also, given the purpose and structure of the DEP, the program results in a higher dropout rate compared to further military training, as individuals can decide not to fulfill their active duty commitment while or after attending their training. This is especially interesting for the purpose of our research, as the dynamics of the DEP exactly mimic the inherent conversion funnel of products and services that involve potentially high churn rate.

A total of 73 subjects were selected for this study, 27 of them were recruiters (36.98%) and 46 (63.01%) were prospect cadets. Participants in the recruiters' group were all in the 28–32 age group, whereas the latter featured 30 individuals (65.2%) in the 17–21 age group, 9 (19.6%) who were 22–27, 4 (8.7%) aged 28–32, and 3 (6.5%)

in the 33–39 bracket, which reflects the distribution of applicants to the DEP. 45 of them had a social media account, whereas the remaining one was considered an outlier because they did not have any active profile on SN; as a result, their data were removed from the study.

In the group of recruiters, participants had different roles: 14 were actively involved in recruitment tasks, 6 were supervisors, 4 were responsible for the operations, and 3 were former recruiters or involved in other tasks of the DEP. Their experience ranged from 1 to 16 years with an average of approximately 5 years ±4 years; specifically, 11 of them (40.74%) had 1–2 years of practice in recruiting, 8 (29.62%) had 3–5 years, 8 (18.51%) had 6–10 years, and 3 (11.11%) had 10 years or more of experience.

We utilized two different questionnaires to collect responses about the perspective of recruiters and prospect cadets. As for recruiters, we also included questions that helped us capture their return on investment in the form of an average monthly conversion. The questionnaires were distributed to recruiters via e-mail, whereas they were administered to prospect cadets during events.

4 Results and Discussion

All the applicants were Social Media users, and many of them had multiple accounts: 82.2% were active on Instagram, 62.2% had a Facebook profile, 71.1% used Snapchat, 40% had Twitter, and 8.9% had an account on a different Social Network website. Although the majority of them (63%) reported that SM was the primary information channel for enlisting in the Air Force, 18 individuals decided to apply after a first contact via other sources. Specifically, responses from prospect cadets demonstrated that the organization website has still to be considered as one of the most relevant ways for generating leads; also, the data showed a long and fragmented tail of other methods, such as, word of mouth, personal networks (e.g., family and friends), and schools, which 20% of the applicants mentioned as the primary point of contact. Our findings are consistent with trends in other domains. However, surprisingly, age was not a factor in determining a prevalence for Social Media versus more traditional channels. With small fluctuations, approximately 63% of the individuals in each age group indicated SNs as the first point of contact.

As for recruiters, 85.2% of them utilized the Internet, and 74.1% particularly Social Networks, as a tool for advertising the DEP to prospect applicants. Other methods include the Radio (37%), Newspapers (29.6%), and personal contact or events (37%). Instagram and Facebook were indicated as the main platforms for generating leads, and they resulted in 85% and 80% of preference, respectively. On the contrary, websites, such as, Twitter and Snapchat, were not indicated as a recruitment tool at all. This is consistent with the use of Social Media among applicants, which indicates that recruiters are aware of the websites that are more effective in generating more leads. From our data, we can conclude that 80% of recruiters who rely on Social Networks tend to simultaneously use multiple platforms to contact potential applicants and communicate with them. Interestingly, the use of Social Media did not have any correlation with age, in contrast with published studies. On the contrary, expertise is a factor that influences the use of advertising tools: more senior recruiters (10+ years of experience) showed a tendency to diversify their strategy and communicate over multiple media, including Social Networks, whereas younger recruiters having 1–2 years of experience focused on one or two channels, only. Specifically, we found strong negative correlation ($r = -.86$) between seniority and media used, which were 1.18 ($\pm$0.98), 1.12 ($\pm$0.35), 1.6 ($\pm$1.35), and 2.66 ($\pm$0.57) for entry-level recruiters (1–2 years), junior (3–5 years) experienced (6–10 years), and recruiters (10+ years), respectively. Furthermore, the number of media utilized by air force personnel showed a very strong correlation ($r = 0.97$) with the average monthly leads, which demonstrates that diversifying their strategy enables them to obtain better results. Specifically, recruiters who did not utilize Social Media had an average of 2 leads, whereas the use of Social Networks in combination with other channels resulted in better performances and, particularly, using two, three, and four different types of media increased the average monthly leads to 5, 7, and 7.75, respectively (see Fig. 1). As we found no correlation between age or seniority level and the number of monthly leads ($r = -0.001$ and -0.13, respectively), we can conclude that although recruiters' experience might be relevant in the subsequent steps of the funnel (e.g., converting leads into enlisted cadets), the use of Social Media is a stronger factor for the lead generation phase.

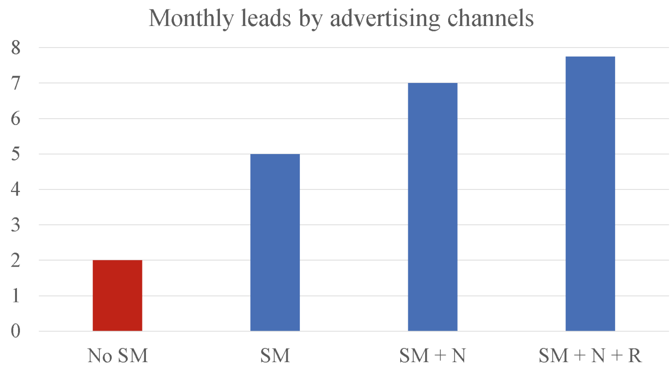

Fig. 1. Monthly leads generated by recruiters when using the Internet without Social Media (left), and when using SM combined with Newspapers (N) and with Radio (R).

5 Conclusions

In the last decade, Social Media gained increasing attention as the most prominent digital channel worldwide for connecting individuals and distributing information. In regard to the latter, most Social Networks offer the unprecedented opportunity of defining a variety of narrow audiences having very specify characteristics and targeting them accurately with promotional messages resulting in detailed statistics, higher conversion rates, and favorable Return on Investment. As a result, most digital advertising shifted to Social Networks, adapting to their mechanisms. Indeed, this resulted in new forms of promotion for businesses, products, and services: nowadays, brands adjusted their communication strategy and language to Social Media, such as, using influencers as testimonials, embedding their message in viral videos, and creating messages that leverage human factors to trigger social dynamics and generate organic trends.

In this paper, we presented the preliminary results of a study on the adoption of Social Media by military recruiters and potential cadets. We explored the human factors that determine the behavioral intention to use Social Networks with the aim of explaining the role played by aspects, such as, perceived usefulness, perceived effort, facilitating conditions, and personal motivation in the adoption of platforms, such as, Facebook, Instagram, and LinkedIn, for recruiting purposes. Also, we detailed how these tools are being incorporated in the daily duties of recruiters (e.g., to generate more leads or to manage communication with candidates) with the objective of sharing common practices and helping define guidelines. Indeed, despite the many benefits in utilizing social media, given the functioning mechanisms of the Army, it is important for high-ranking officials to advocate the use of social networks among all recruiters, and provide them with tools that facilitate their adoption.

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Improvement of Efficiency in the Productivity of an Aerospace, Maritime and Military Company in Tijuana, Baja California; Mexico

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Abstract. The interest of the present investigation was carried out along with an electronic branch that is a global leader in electronic engineering components, network solutions, marine telecommunication systems and consumer goods in the city of Tijuana, Baja California Mexico.

In a world where business is more competitive, organizations aim to increase their productivity at a lower cost, without affecting the quality of their products, or the health of their workers, so that the economic profit margin can be increased and be able to face the competition. Not only can new technologies improve quality and productivity, this can also be achieved by learning to use the machines at hand effectively. For this reason, in the company under study, the department of electrical connectors is intended to improve productivity with connector assembly machines that are in four parts.

In addition to the fact that there is a problem of absenteeism and rotation of the staff with those of entry-level recruits, for this reason the management of this department is analyzing the way to invest capital for the improvement of the connector assembly machines and increase the capacity, in such way to eliminate the night shift.

Therefore, the company's main objective is to increase production capacity and thereby improve the efficiency indicators of connector assembly machines in the department of electrical connectors by 25%. For this purpose, the 3 main approaches of the organization are covered, which are: safety, quality and service (for financial projects), using tools found in the plant, such as CNC, lathe and milling machines, statistical software, ergonomics, CAD and engineering work, to identify relevant information that improves the efficiency in the process of said machinery.

This project is an explanatory study, since it provides a profound response on the modification of the connector assembly machine. The method used is inductive since a working hypothesis was formulated and tested. Regarding data collection techniques, different methods were implemented, among which are: time-taking, route method, application of the 5s methodology and design of experiments.

According to the results, an increase in the capacity of connector assembly machines was achieved by up to 59%, that is, 500 more pieces per hour.

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Keywords: Efficiency · Productivity · Continuous improvement · Standardization

1 Introduction

History has shown that to be more competitive you have to make changes in the processes. A tangible example is undoubtedly the textile area that during the first industrial revolution ceased to be something handmade to become the central economic activity of the time [11]. Another outstanding example is the case of Henry Ford when he changed the way of assembling his cars, which positioned his company as a world-class company [12] therefore, it is suggested that with engineering work, and innovation in work teams, it is possible to unleash great advances in the productive capacity of companies.

Currently, the business world is increasingly competitive. The organizations aim to increase their productivity at a lower cost, without affecting the quality of their products, or the health of their workers, in such a way that the margin of economic utility can be increased and the competition can be tackled.

The present work projects the improvement of a machine with the objective of increasing productivity in an aerospace, maritime and military business in Tijuana, Baja California; Mexico. It consists of the realization of tests that allowed an increase in the productive capacity in the machines of assembly of connectors in the department of electrical connectors. The 3 main approaches that the organization has are covered: ***safety, quality and service***, using tools found in the plant, such as CNC, lathe and milling machines, statistical software, ergonomics, CAD and engineering work was achieved An excellent result.

This research work addresses a problem of absenteeism through the use of engineering tools that allow increasing the productivity of the machines. It has an introductory section, a brief description of the tools implemented in the analysis, the data and pilot tests section, and finally the conclusions.

The one in the development of this type of projects, an indispensable factor is the efficiency, since this term is a guide to reach the previously outlined aims (Cohen and Franco, 2006). The concept of efficiency is related to the economy of resources. It is common to define efficiency as the relationship between the results obtained (outputs) and the resources used. Since companies usually produce multiple outputs, the efficiency will be in any case the multidimensional magnitude. The efficiency shows the ability of the unit to obtain maximum output from the given set of inputs [6].

Another element of utmost importance is productivity, that is; the need to clean up productive processes in all spheres of economic activity has made productivity the focus of attention of the general public and of specialists in the field of competitiveness. However, at the company level there are not a few resistances when trying to incorporate certain innovations that involve increased productivity and cost savings. Despite this, productivity improvements seem to be the main remedy to increase yields, combat crises, performance, inflation and achieve highly competitive products [14].

Finally, standardization is an element to consider for continuous improvement. According to the International Organization for Standardization, the process that is carried out when a series of rules is applied to an ordered set of steps of a specific activity, without forgetting the functional characteristics and safety requirements is known as standardization; which is decisive for future development. To the extent that a process is executed consciously and in the same way improvements can be made more easily. Standardization is an engine for innovation and incentive for people facing a process to be more creative [4].

2 Paper Preparation

The present project generated high expectations when considering improvements and savings in a company of the aerospace, maritime and military business, in the department of electrical connectors; particularly in the area of four parts. This department has assembly machines and connectors, of which the production capacity was increased and along with it the efficiency, OEE and adhesion indicators were improved (according to the indicator tables reported daily by the company).

In the department of electrical connectors there is the problem of absenteeism and rotation of new staff, for this reason the management of this department analyzed the way to invest capital for the improvement of assembly machines and connectors and increase capacity, in such a way that it eliminates the night shift of said machines. Therefore, the following question was asked: What are the acceptable modifications in the assembly machine and connectors 1001 to generate an increase in its production capacity? Based on these modifications, what percentage is expected to increase the productivity of the assembly machine and connectors 1001?

Given that the main objective of the present work was to increase the production of the assembly machines and connectors of the four-part area, the following objectives were also proposed as specific: standardize the production process in the assembly machines and connectors in the area of four parts, increase the existence of mandrels and washers for the department of electrical connectors, analyze the factors that impact the transformation process when making these modifications to the machines; and optimize the workstation to make it more pleasant for the area worker.

The hypothesis proposed with the improvement of the machines is that the production capacity of the assembly machines and connectors will increase by a minimum range of 25% from the modification of the open to closed bases, in addition to an increase in stock of washers and mandrels.

This project is an explanatory study, since it provides a profound response on the modification of the assembly machine and connectors 1001. The method used is inductive since a working hypothesis was formulated and approved. Regarding data collection techniques, different methods were implemented, among which are:

Time taking: A time was taken on the assembly machine and connectors 1001, since it was the only machine that had the capacity of 50 mandrels, divided into 25 for round mandrels and 25 for tip mandrels; This time was taken with the objective of having the current state of the capacity of the machine (production per hour), and thus obtain a future comparison of the changes that will be made. The time-taking methodology with chronometer was implemented. A full hour of production was taken randomly during the workday of the employees and at the end of the hour the result of the production (finish good) was taken giving the quantity 680 pieces.

Rula Method: An ergonomic analysis was implemented with the Rula method to the operator of the assembly machine and connectors 1001, said analysis evaluated the risk factors of posture that the worker has when performing his daily task, with this evaluation it is planned to avoid risks futures. An ergonomics program conducted by "Ergonomics Quantification and Improvement Process Tool (EQuIP ™ Tool)" was used for due method analysis.

Technical Drawing: An inventory was made of the existing mandrels and washers that are used in the current production of the assembly machine and connectors 1001, in order to know the quantity of pieces that are going to be required in the Machine shop area. The existing drawings corresponding to each mandrel and washer that are required to be machined were located in the Tooling area. It was detected that said technical drawing did not exist for certain models of mandrels and/or washers, so the mandrels and missing washers were drawn in tooling, respecting the client's measurements and requirements, ensuring the distances between insert and weld, between insert and insert, and from the bottom edge to insert (poka yoke system).

Once the drawings and drawings approved by engineering were obtained, the steel was transformed to mandrels and washers, this based on the missing inventory previously recorded.

For this transformation the CNC machine (computer numerical control) was used in which the specifications of the technical drawing corresponding to the mandrels and/or washers were made with the Master Cam software version 2019, the cutting and revolutions parameters were entered. All this data entered in the software was stored in an external memory to later enter that data to the CNC machine center where the part modeling was performed. Once the pieces were made, the tempering process was carried out in another area within the machining department, as follows:

1. The Master Cam 2019 icon was opened with the purpose of placing the cutting measures according to the technical drawing.
2. Once you opened the program start window, it was verified that in the lower right you will find a small box with the same measures as the technical drawing. Otherwise, the following should be done:
   a) Click on "File" in the upper left of the screen
   b) In the toolbox that slides in the last line, click on "configuration"
   c) Press Click to "Star up"
   d) Enter the measures in which you want to work the drawing and finally click on the green popcorn when finished.
3. The longitudinal and radial lines that were taken as the basis for starting the design were made.
4. Click on the "WIREFRAME" tab then "LINE endpoints", these points are the beginning and end of the cutting piece.
5. In the same tab you can find the "Trim Break Extend icon", click on it to form the Angle of the piece and in the same way the measurements were transcribed in the window that appears after clicking.

6. In the toolbox, the “SOLIDS” tab was clicked and then clicked on the “Revolve” icon that was used to create the body solid.
7. In the File tab 3 icons appeared among them are “FACE”, “ROUGH” and “FINISH”.
8. In the “FACE” icon, the Endorsement and fairing” was performed, that is, the roughness of the saw cut. Then “Rough” was used for the roughing of the piece that specified the height that the insert will fall and it stopped at the point where it began to fall and finally “Finish” served to finish the piece, that is, the contour and remove excess material. All these 3 icons have their own measurement tab that must be added according to the technical drawing.
9. Once the design is finished; It was stored in a USB to take it to the CNC machining center, for this, the material of the piece was previously determined, in this case it was Steel 01 which, due to its properties, makes it optimal for the work they will perform in the future.
10. Then the USB was placed on the CNC machine and the file with the arrows on the machine keyboard was chosen on the screen of the machine.
11. The file was opened and only the steel bar in the CNC was missing so that it could start the machining.

As a final product the piece of Fig. 1 was obtained, the measurements of the metal bar were used to make 2 pieces and there is no scrap.

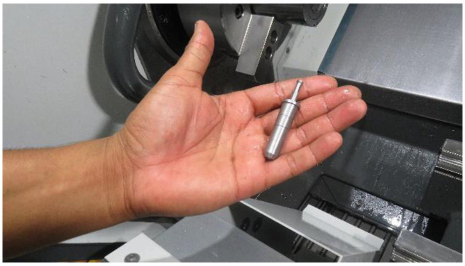


Fig. 1. Final piece

Lathe: Mandrels with a larger diameter were manufactured due to the low variability generated by the devastation in this type of piece (few vibrations and no rounding).

a. Once the technical drawing is made, the material is taken to rough it. The material that was chosen for the piece is Steel 01. Then the Jaw is taken which together with some keys is adjusted to keep it stable and without movement for a good cut.
b. Then with the indicator clock the centrality was measured with the objective that the piece has the measures set in the technical drawing. It was done in the following way: Since the indicator clock is magnetized, it “sticks” to the lathe and, together with the magnetic arm, approaches the jaw area and when the clock has set zero it is already centered (see Fig. 2) .

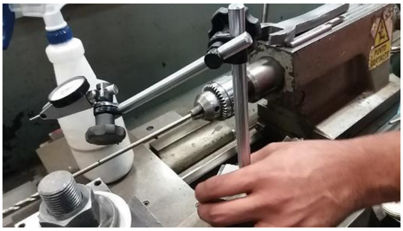


Fig. 2. Lathe positioning

a. After the other side of the jaw, the center drill bit that served as a guide at the time of cutting was adjusted.
b. The chisel was chosen to make the cut of the piece, so it had to be adjusted along with some keys to the lathe machine. In order to choose it, the hardness of the material is taken into account. In this case, one with the Carbide tip was chosen.
c. An adjustment was made in the grades for the cut made by the donkey.
d. The machine was adjusted to the depth of the cut in thousandths.
e. The crank was adjusted to adjust the depth (x axis).
f. Finally, the roughing is carried out at 350 revolutions by approaching the crank (z axis).

Milling Machine: It was used to modify the supports of the new installation of the visual system.

Tempering: Once the piece was made, the tempering process was done in another area within the machining department.

Application of 5S: In the RT's there was a deficiency in the organization of the work area, for this reason it was forced to make changes using the 5S tool to justify the ordering and changes in said station, giving a better visual and operational aspect, having as a more spacious and safer result.

a) **Standardization:** To ensure the standardization of the process of assembling the RT machines, it was decided to use a visual system (Digital Work Instructions, VKS) showing each operator the correct way of how to perform the work.
b) **Marking of Parts:** On a laser printer (Laser Marker 49073) The marking for mandrels and washers was carried out in order to identify the model and integrate them and update the corresponding tooling inventory. The procedure was as follows:
c) **Design of Experiments:** An experiment design was carried out with the purpose of verifying the factors that cause noise in the RT 1001 machine process, taking into account the factors temperature, motor speed and mandrel speed, that the Operators can move these ranges. The minimum and maximum ranges were found to be able to create a parameter in which an optimum recommendation of the desired length in our piece is given.

Data and Analysis

The data obtained in the application of the tests are presented below (Table 1).

Table 1. Tests

Pilot run on assembly machine and connectors 1001	*[a]Date: 8/28/2019 Turn: 1 Part number: B76114-111 Description: T311-4-11 Batch: 31132161493 Chucks: 13-519 Rondana: LFQ-436-86 Type base: M.W. (25 PZ)
Test 1. Normal Production	*Parameters* Chuck speed: 369–371 Temperature: 500 °C Amount of Chuck: 25 Cycle: 97″ Takt Time: 3.9″ *Results* Production: 690 Pz × Hr Quality Review: Accepted
Test 2. Speed 1	*Parameters* Chuck speed: 311–321 Temperature: 400 °C Amount of Chuck: 50 Cycle: 159″ Takt Time: 3.2″ *Results* Production: 780 Pz × Hr Quality Review: Accepted
Test 3. Speed 2	*Parameters* Chuck speed: 311–321 Temperature: 400 °C Amount of Chuck: 50 Cycle: 159″ Takt Time: Takt Time: 3.2″ *Results* Production: 780 Pz × Hr Quality Review: Accepted
Test 4. Speed 3	*Parameters* Chuck speed: 329–321 Temperature: 400 °C Amount of Chuck: 50 Cycle: Takt Time: 106″ Takt Time: Takt Time: 2.12″ *Results* Production: 1080 Pz × Hr Quality Review: Accepted

[a]Note: The numbering was changed in order to protect industrial secrecy

5S: When making a safety tour (gemba) several risk situations were noted for the operators of the electrical connectors' area four-part section (Table 2).

Table 2. 5's

Free space	Problem: Little space between the PR3 machine and the FILOMAT machine table	Observation: Modify the size of the table, and thus relocate to a place that does not hinder the passage of the operators and be able to free up space avoiding hitting when passing
Pneumatic tube and power cable	Problem: The pneumatic outlet pipe is located exactly above where the collaborator of the area sits, being a very high risk of a possible accident. The power connector is in a rather awkward position for the area	Observation: Change the position of the pneumatic tube and the power connector, eliminating this risk
PR3 edges	Risk: Hitting the edge of the PR3 machine, since it is without edge protection	Observation: Put a rubber protector on the PR3 machine

Standardization of the Process: Generation of instructions. The objective of the technical instructions is to provide a detailed description of how an operation should be performed [9]. Later, the work instructions were written in a physical document, which commonly causes a waste of time to look for the folder and consult it. For this reason, the idea of digitally documenting the operating instructions was raised, so that the worker has access to this system and can locate in an easy, fast and uncomplicated way. For this, the Vks system of digital work instructions was used, which will be supported with 2 tablets per workstation and the instructions will be divided by sequences of which the operator performs.

2D and 3D drawings of Chucks and Rondanas: When not finding the drawings of the pieces (01-060, 02-402, 12-050, Mep-325-75, Mep-419, Mep-420, Mep-854) we proceed to make the drawings of said mandrels and washers to later analyze that the measurements coincided with the specifications of the product. The pieces that were not certain that they fulfilled this specification proceeded to be printed in 3D. To create the drawings, the CREO Parametric CAD was used, in order to make the work order in the machine shop department, since this order occupies an attached drawing with the measurement specifications of the piece to be machined. (it seems that this section is out of place).

CNC Machining: Steel 01 was chosen to make the pieces because it has adequate physical properties (high temperature support) for application in assembly machines and connectors. The machining of the pieces was done at 350 revolutions and finally the tempering of the finished parts was performed.

Design of Experiments: During the design of experiments the factors temperature, motor speed and mandrel speed were taken into account, this taking into account that they are variables that generate noise in the assembly machine process and connectors 1001.

Subsequently, the measuring ranges for the factors shown below were found (Table 3):

Table 3. Factors for tests

Ranges of the corresponding factors		
Factor	Low range	High range
Temperature	220	390
Motor speed	222	495
Chuck Speed	22	44

When the ranges of the factors were found, the design of experiments was generated, for this the MINITAB software was used to perform the order of the randomized experiment.

These results represent the total length of the connectors, that is; The measure falls within the range where the connectors do not lose their physical properties, both at the minimum and maximum points. Therefore at the minimum point is where the piece begins to form and the maximum point where it is reduced, and thus it is difficult to separate from the mandrel.

Ergonomics According to the Method of Rula: Previously the workers presented different physical discomforts, pain in the neck, back, and fatigue in general. The cause of the problems perceived by the operators was investigated, and Rula's ergonomic method was considered, which also supported the generation of data and background. This method evaluates the postures of the body and allows to detect the level of risk in the neck, shoulders, back, arms and elbows, wrists, legs and static postures.

To implement the Rula method, initially a safety tour was carried out in the four-part area where it was determined that the position of the operators is incorrect; In addition to finding possible musculoskeletal risks that can cause injuries. Based on these findings, the "Ergonomics Quantification and Improvement Process Tool (EQuIP ™ Tool)" program was used. As a result, a Gemba sheet was obtained for the solution of ergonomic problems, which is presented below (Fig. 3).

AON	Gemba - Hoja de Solución de Problemas Ergonómicos	
Parte del Cuerpo	**Factores de Riesgo Ergonómicos**	**Causa Raíz**
Cuello	Dobles de cuello	Al estar a una en una postura más alta que la mesa, hace que su cuello tenga que doblarlo para así poder agachar la mirada y ver lo que tiene frente de ella
Hombros	Abertura de hombros incesesarios	La mesa al tener un ángulo muy abierto respecto donde el trabajador descansa su antebrazo, esto provoca que el busque el poder recargarse provocando así que abra sus hombros de más.
Espalda	Dolor de espalda	El trabajador se inclina hacia la mesa de trabajo y olvidándose que cuenta con un respaldo de la silla, haciendo que no descanse correctamente su postura y se sobre esfuerce previamente antes de que se encorve.
Brazos y Codos	Cansasio	Al estar en una posición alta el trabajador no apoya sus antebrazos en las recargaderas
Muñecas		
Manos y Dedos		
Piernas		
Posturas Estáticas	Dolor de espalda	El trabajador se inclina hacia la mesa de trabajo y olvidándose que cuenta con un respaldo de la silla para recargar su peso.

Fig. 3. Gemba sheet for ergonomic problems

3 Results

Pilot Run on Assembly Machine and Connectors 1001 (Table 4 and Fig. 4).

Table 4. Test result

Test	Production per Hour	Percentage difference
Test 1	680	0%
Test 2	0	−100%
Test 3	770	13%
Test 4	1080	59%

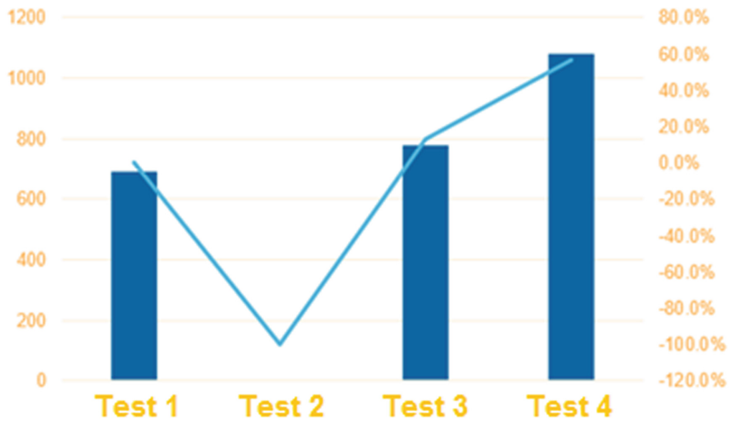


Fig. 4. Percentage differential chart

5S: After making the safety tour in the area of assembly machines and connectors, and observe problems and needs; Work was done on the liberation of space and improvement in terms of security (Table 5).

Table 5. Aplication 5's

Change	Action
FILOMAT machine table	• Change table for a smaller one: change from 2.5 m * 1.25 m to 1 m * 0.8 m • Change of position
Change of position of the pneumatic air tube and electrical connection	The pneumatic air tube and the electrical connection attached to the wall were moved as it was in the middle The edge of the PR3 machine was covered because it represented a risk of injury in the area

Standardization of the Process: Generation of instructions: With the new design of visual instructions of digital work, the operator has at all times the necessary instructions for the operation on the tablet with the Vks program that is in his workstation. Thanks to visual work methods, higher quality results are obtained by presenting fewer errors.

Change of Mandrels: The changes of the bases were necessary because with the LU type inserts used in the pilot run the height of the mandrels were not uniform.

Design of Experiments: The result to consider is $P < 0.05$, in this it is observed that the significant factors are temperature and motor speed, and the significant interaction is the temperature * motor speed. The value of R-quad is also considered, since this represents the factors covered in 99.33% of the variability in the process (Figs. 5 and 6).

Regresión factorial: Resultado vs. temperatura, Velocidad ... d mandrill

Análisis de Varianza

Fuente	GL	SC Ajust.	MC Ajust.	Valor F
Modelo	7	71.7288	10.2470	169.18
Lineal	3	60.3439	20.1146	332.10
temperatura	1	46.8198	46.8198	773.00
Velocidad de motor	1	13.5240	13.5240	223.28
Velocidad mandrill	1	0.0001	0.0001	0.00
Interacciones de 2 términos	3	11.2387	3.7462	61.85
temperatura*Velocidad de motor	1	10.8406	10.8406	178.98
temperatura*Velocidad mandrill	1	0.0588	0.0588	0.97
Velocidad de motor*Velocidad mandrill	1	0.3393	0.3393	5.60
Interacciones de 3 términos	1	0.1463	0.1463	2.42
temperatura*Velocidad de motor*Velocidad mandrill	1	0.1463	0.1463	2.42
Error	8	0.4846	0.0606	
Total	15	72.2134		

Fuente	Valor p
Modelo	0.000
Lineal	0.000
temperatura	0.000
Velocidad de motor	0.000
Velocidad mandrill	0.976
Interacciones de 2 términos	0.000
temperatura*Velocidad de motor	0.000
temperatura*Velocidad mandrill	0.353
Velocidad de motor*Velocidad mandrill	0.045
Interacciones de 3 términos	0.159
temperatura*Velocidad de motor*Velocidad mandrill	0.159
Error	
Total	

Resumen del modelo

S	R-cuad.	R-cuad. (ajustado)	R-cuad. (pred)
0.246107	99.33%	98.74%	97.32%

Coeficientes codificados

Término	Efecto	Coef	EE del coef.	Valor T	Valor p
Constante		27.6756	0.0615	449.81	0.000
temperatura	-3.4212	-1.7106	0.0615	-27.80	0.000
Velocidad de motor	1.8388	0.9194	0.0615	14.94	0.000
Velocidad mandrill	-0.0037	-0.0019	0.0615	-0.03	0.976
temperatura*Velocidad de motor	1.6463	0.8231	0.0615	13.38	0.000
temperatura*Velocidad mandrill	-0.1213	-0.0606	0.0615	-0.99	0.353
Velocidad de motor*Velocidad mandrill	-0.2912	-0.1456	0.0615	-2.37	0.045
temperatura*Velocidad de motor*Velocidad mandrill	0.1912	0.0956	0.0615	1.55	0.159

Término	FIV
Constante	
temperatura	1.00
Velocidad de motor	1.00
Velocidad mandrill	1.00
temperatura*Velocidad de motor	1.00
temperatura*Velocidad mandrill	1.00
Velocidad de motor*Velocidad mandrill	1.00
temperatura*Velocidad de motor*Velocidad mandrill	1.00

Fig. 5. Noise factors and their interactions.

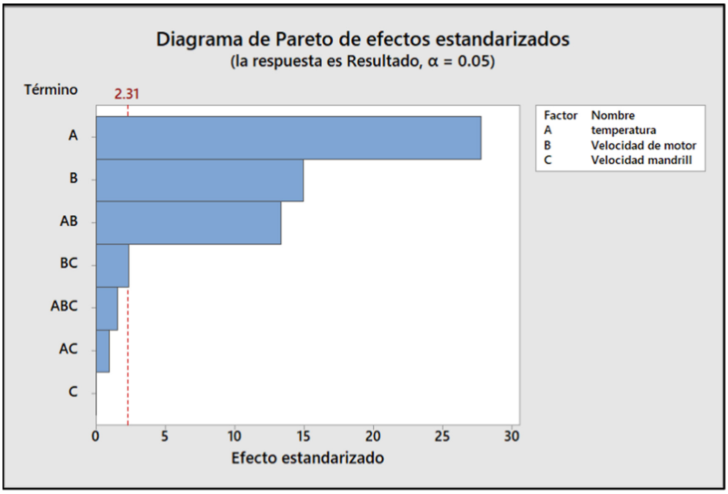


Fig. 6. Highest impact factors

Figure 7 is the interaction representation of the temperature with respect to the motor speed, in this graph it indicates that there is indeed an interaction between both factors. And in the graph of effects in the temperature section, the lower the temperature, the longer the connectors and the higher the temperature, the shorter the connectors.

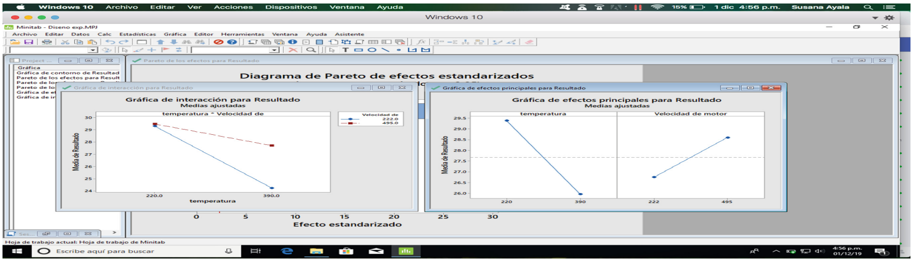


Fig. 7. Interaction graph for the results.

The results contour Fig. 8 will help to define the margin window to obtain an optimal result in this regard to obtain the ideal length of the connectors and establish a parameter between temperature and motor speed.

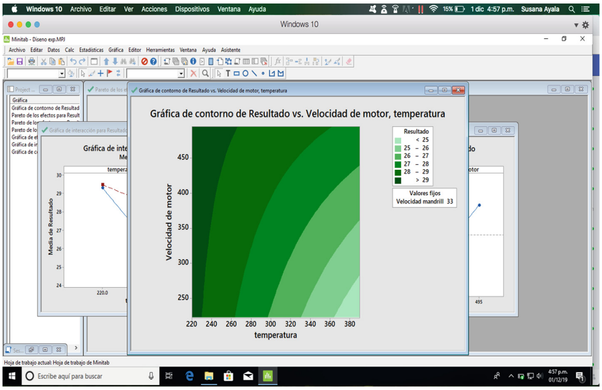
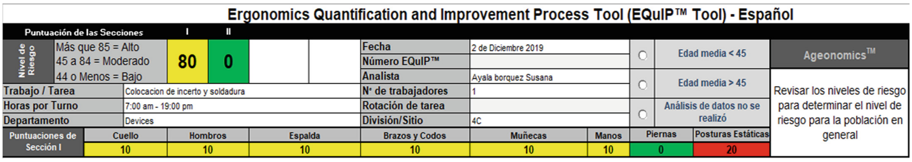


Fig. 8. Contour plot

Ergonomics according to Rula's method: According to the information that the route through the work areas and the Gemba sheet showed, the positions adopted by the workers were observed; and as a result, the following analysis was carried out

Figure 9 shows the general data of the area to be evaluated, but the point to highlight in the image is a risk level of 80, the result as such is classified as "Moderate", this risk requires a level of action necessary for homework



Ergonomics Quantification and Improvement Process Tool (EQuIP™ Tool) - Español

Puntuación de las Secciones		I	II					
Nivel de Riesgo	Más que 85 = Alto 45 a 84 = Moderado 44 o Menos = Bajo	80	0	Fecha	2 de Diciembre 2019	Edad media < 45	Ageonomics™	
				Número EQuIP™				
				Analista	Ayala borquez Susana	Edad media > 45	Revisar los niveles de riesgo para determinar el nivel de riesgo para la población en general	
Trabajo / Tarea	Colocacion de incerto y soldadura			N° de trabajadores	1			
Horas por Turno	7:00 am - 19:00 pm			Rotación de tarea		Análisis de datos no se realizó		
Departamento	Devices			División/Sitio	4C			

Puntuaciones de Sección I	Cuello	Hombros	Espalda	Brazos y Codos	Muñecas	Manos	Piernas	Posturas Estáticas
	10	10	10	10	10	10	0	20

Fig. 9. Work area to evaluate and risk levels.

Based on these observations, it was detected that the worker needs to lower the viewing angle, which results in poor neck posture with moderate risk when considering that he maintains this position during the full day.

As for the shoulder area, a moderate risk was detected with high frequency since there is a greater than natural distance between the body and the body, this due to the condition of the dough with respect to its workstation.

Finally, there is the area of static postures that represents a high-risk level because the back area is tilted, and this is added that the movement is performed while the operator is sitting. These movements have a high frequency since it is the activity that they carry out throughout the working day.

4 Final Result

All of the above was carried out with the objective of increasing the processing capacity of assembly machines and connectors in the four-part area of the electrical connector department of an aerospace, maritime and military business. The initial proposal was to increase the capacity of the process by a minimum of 25%, however the results obtained exceeded the approach by registering an increase of 59% per hour, which translates into a 57% increase in productivity

With the completion of this research project, it is possible to conclude that improvements in assembly machines and connectors have effectively resulted in increased productivity, exceeding the percentage proposed in the problem statement; therefore, the hypothesis is accepted.

5 Recommendations

Design of experiments: With Fig. 10, of contours with respect to temperature versus motor speed, it has been defined that the best definition of the parameter window will be that the motor speed is maintained with a minimum of 250 reference and a maximum of 300 reference, and for temperature with a minimum of 280 °C and a maximum of 300 °C, this so that the connectors are in a range of 27 and 28 mm in length.

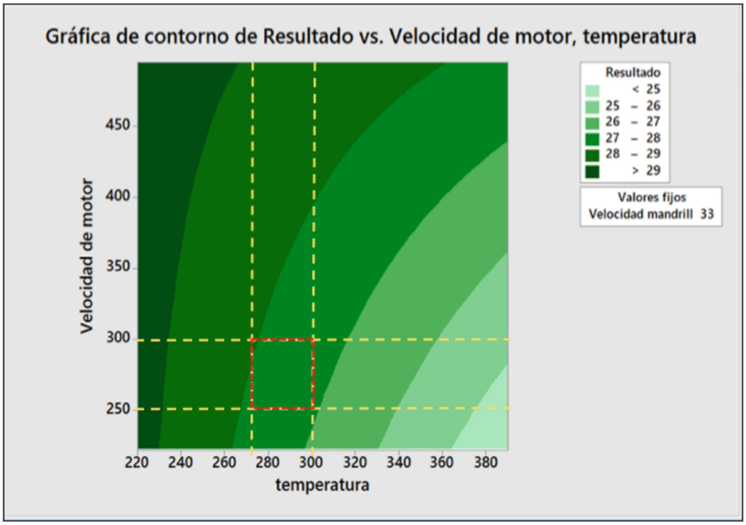


Fig. 10. Parameter of outline scope

Ergonomics According to the Method of Rula: As a recommendation for the workstation of the assembly machine and connectors 1001, regarding the risks obtained previously, it has been decided to make a new table, this will have new angles to favor the correct posture of the workers (see Fig. 11).

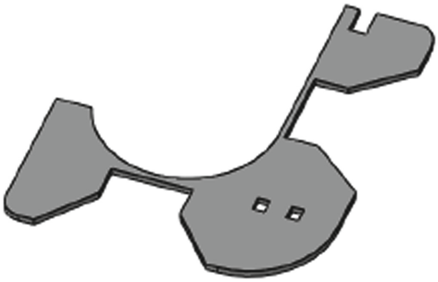


Fig. 11. Proposal for changing the workstation

It is also recommended to purchase chairs adjustable to the correct position and with back support. This will help prevent erroneous postures and at the same time prevent occupational diseases or injuries. Additionally, it is recommended to provide safety and hygiene training for the correct use of the materials and infrastructure required to perform work activities optimally. This recommendation has the objective of establishing the basic forms for the design of work systems, defining the relevant terms and at the same time addressing the principles of the design of the tasks regarding UNE-EN ISO 6385: 2004 and NOM-036-1- STPS-2018.

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Impact of Pre-professional Practices on the Excessive Mental Workload of University Engineering Students

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Abstract. The excessive mental workload in university students of Engineering careers is an important factor that affects their performance and their health and that, therefore, it is necessary to investigate. The purpose of this study was to examine the academic performance of students who develop their pre-professional practices, to see the impact of time dedication to work in companies and the excessive mental workload resulting in this dedicated time. For this, the industrial engineering students of a Peruvian university were taken as a study sample, focusing on determining the mental workload in university students, and how this influences their academic performance. This is evident when the students, in addition to carrying out their regular studies, must develop their pre-professional practices in companies in the industrial sector, for an average of two to three months, with a dedication of at least 30 h per week, with the expected consequences in their academic performance. For this, the impact of the practice was identified in a group of students attending the seventh and eighth academic semester during the period between 2018 and 2019. Subsequently, the number of credits carried by the students who do not develop pre practices is analyzed. professionals and a student who does carry professional practices and how this influence, in the variables of average grades, in the standardized coefficient of performance and in their cognitive abilities. Finally, the application of a mental workload assessment tool was included, which validated the hypothesis of the excessive mental workload that students have during that period and the negative impact it has on the performance of the majority of students involved. These results can be used to better balance the academic load of the students, so that they do not affect their studies as is the case so far.

Keywords: Human factors · Mental workload · Stress

1 Introduction

In Peru, approximately 35.8% of young people have a higher education, of which only 21.5% have a university education [1]. During the last decade the total university population has increased by 40%. Being an obligation on the part of the educational entities to improve their teaching quality. In 2014, Law No. 30220 - “University Law” was declared, with the purpose of regulating the creation, operation, supervision and

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closing of universities. The purpose of this law is to improve the quality of services provided by universities (institutions essential for national development). To regulate this law, the National Superintendence of Higher University Education (SUNEDU) was created as an agency attached to the Ministry of Education [2].

However, the search for quality in education often generates a collateral impact on the level of mental load in university students, particularly in engineering specialties. Engineering careers have a mental burden that can be excessive. However, there is a small number of researches conducted in Peruvian universities on the subject. Within the most visible expressions of this mental burden is stress. Stress is usually classified, according to its source, into the categories of academic stress and work stress, academic stress is defined as a reaction of physiological, emotional, cognitive and behavioral activation to stimuli and academic events [3]. Knowing that stress is understood as a crisis or lifestyle variation [4] that affects anyone regardless of their stage of development or socio-economic level [5], it is clear that engineering university students can be being affected, for a long time, by a stress that could be very strong, and this is corroborated by the statistics published by the National Crime Records Bureau, which indicate that a student commits suicide every hour [6]. However, students tend to think that this mental load is normal, by the mere fact of studying engineering, without being able to detail that this is harming their health. There are statistics that registered that 1.8% of students who committed suicide due to lack of exams and an 80% increase in suicide rates during a period of academic semesters. Academic stress has been identified as the main cause of these alarming figures [7].

On the other hand, the university phase is usually accompanied by physiological and psychological changes associated with late adolescence and emerging adulthood [8]. In addition, Arnett et al. reinforces this statement by establishing that young adults suffer from physiological, sociological and cultural changes, derived from abandonment of the family home and the influences of peer groups in this period, which may be related to unhealthy habits that affect the health [9]. Depression, anxiety, behavioral problems, irritability, anger, alteration of diet, loneliness, etc. These are some of the problems reported in students with high academic stress [10, 11]. Although certain levels of stress push students towards optimal performance, when not handled efficiently due to inadequate resources to cope with stress, it can have dire consequences for the student and the institution, resulting in for example that the pressure faced by these students to perform is so severe that it results in a fivefold increase in suicide attempts [7], damage to health, or instead of having high academic competitiveness, they end up having a very poor level competitions.

These differences would be seen in the causes, sources and consequences of stressors. Some of the common stressors presented in the academic environment include excessive homework, poor time management and social skills, peer competition, soft skills, etc. [7]. Academic overloads, complicated courses, inadequate time to study, workload each semester, difficult exams, low motivation and high family expectations generated moderate stress among students and that fear of failure is the main source of stress among undergraduate students [12]. On the other hand, there are investigations that determined that higher levels of stress are notorious during work exposures, academic overload, lack of time and exams [13]. It can also be said that the exams make up to a certain extent one of the fundamental academic stressors in student life, with sensitive effects at the behavioral, cognitive and physiological-emotional level [14]. Among the causes that have not been considered in academic stress researches, are the internships that students must perform in a company in a complementary manner, while they continue their university studies. Internships were designed to be carried out during the months in which classes were not scheduled (January to March). However, for many years now, companies do not take these periods into account and students develop these practices in parallel with their university studies, which increases the mental load and therefore the stress linked to the requirement Academic of engineering studies.

2 Methodology

2.1 Stress Test

The SISCO Inventory of Academic Stress was used for the study [15]. Barraza built the inventory to recognize the characteristics of stress that usually accompanies students of different levels of education [16]. The questionnaire used was designed based on the study variables related to stress: level of self-perceived stress, stressors, symptoms and coping strategies. The indicators proposed in the Barraza questionnaire were derived from the variables. The questionnaire is presented in Table 1. To calculate the stress level, the sum of the scores obtained in the surveys will be carried out. If the score is in the range of 10 to 39, the stress level is low; if the score is in the range of 40 to 79, the stress level is medium; and if the stress level is in the range of 80 to 110, the stress level is high [16].

Table 1. Variables to determine academic stress

Physical reactions	**ID**	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Almost always (4)**	**Forever (5)**
Sleep disorders	PhR_sleep					
Chronic fatigue	PhR_fatigue					
Headaches	PhR_head					
Digestion problems, abdominal pain	PhR_dig					
Scratching, biting nails, etc.	PhR_scratch					
Sleepiness or increased need for sleep	PhR_somnolence					
Psychological reactions	**ID**	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Almost always (4)**	**Forever (5)**
Restlessness (inability to relax and be calm	PsR_quiet					
Feelings of depression and sadness (decayed)	PsR_depression					
Anxiety, anguish or despair	PsR_ansiety					
Concentration problems	PsR_concentration					
Feeling of aggressiveness or increased irritability	PsR_aggressiveness					

(*continued*)

Table 1. (*continued*)

Behavioral reactions	**ID**	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Almost always (4)**	**Forever (5)**
Conflicts or tendency to argue	R_conflicts					
Isolation from others	R_isolation					
Reluctance to perform university work	R_reluctance					
Increase or reduction of food consumption	R_foods					
In classes	**ID**	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Almost always (4)**	**Forever (5)**
Competition with classmates	IC_competence					
Academic homework overload	IC_overload					
The personality and character of the teacher	IC_personality					
Teacher evaluations (exams, homework or homework, etc.)	IC_evaluations					
The type of work that professors ask you for	IC_tasks					
Do not understand the issues addressed in the class	IC_ understand					
Participation in class (answer questions, presentations, etc.)	IC_participation					
Little time to do the work	IC_time					
Strategies	**ID**	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Almost always (4)**	**Forever (5)**
Assertive skill.	STR_assive					
Preparation of a plan and execution of its tasks	STR_plan					
Praise yourself	STR_praise					
Religiosity (prayers)	**STR_religiosity**					
Search for information about my situation	STR_information					
Ventilation and confidences (verbalization)	STR_ventilation					
Score	**Score**	**Never**	**Rarely**	**Sometimes**	**Almost always**	**Forever**
CRAEST during the internship	VCraest					
Regarding the number of credits	VNCredits					

2.2 Population Data and Determination of the Number of Samples

The research focuses on the industrial engineering students of the selected university, whose curriculum requires students to develop two pre-professional practices. Around 1750 students are enrolled in this university during the academic semester of 2019. Subsequently, the number of samples is determined according to the formula described in Eq. (1). To prepare the sample, the number of students required is 75 (n = 74.52). However, 15% of additional surveys will be developed to strengthen the analysis, therefore, the number of surveys will be 87 students.

$$n = \frac{Z_1 - \frac{a^2}{2} N\sigma^2}{(N-1)E^2 + Z_1 - \frac{a^2}{2}\sigma^2} \tag{1}$$

Where:

$n =$ Number of students needed.
$\sigma =$ Standard deviation (4.5 students).
$N =$ Total of Industrial Engineering students (1750 students).
$Z =$ Confidence level 95% $=$ 1.959963 $(95\% + \frac{\alpha}{2})$
$E =$ Permissible error (1 student).

Once the sample was defined, the survey was applied virtually (https://forms.gle/mSSVAjZ9pr3sdExf6). Additionally, two very important factors were considered, not contemplated in the original instrument: the variation in academic performance during the development of their practices (CRAEST) and the variation in the number of credits taken during that same period.

3 Results

Figure 1 shows two important results of the study, the first three graphs present the results of 3 of the 29 criteria studied, in addition to the CRAEST and Credits: Increase or reduction of food consumption (food), the type of work that professors ask you for (tasks) and sleepiness or increased need for sleep (somnolence). It can be noted that in these three cases, the negative effect among students is quite high, which is what happens with many of these criteria. The last graph in Fig. 1 presents the overall result of stress among students, so it can be seen that almost 80% of them have high stress.

Additionally almost 15% have a very high stress. On the other hand, one of the main concerns of the student is the evolution of his weighted performance. In the university a similar indicator called 'CRAEST' is used that normalizes the grade of a single student with respect to that of the entire classroom. In Fig. 2 we can see that 80% of the students of the 7th semester reduced their "CRAEST", while the percentage of students older than 8th semester was 50% on average and some even increased (approximately 5%). The tenth semester students had the best results; however, on average, students fell 0.6 points, the most affected being those of the seventh semester with an average reduction of 1.2 points.

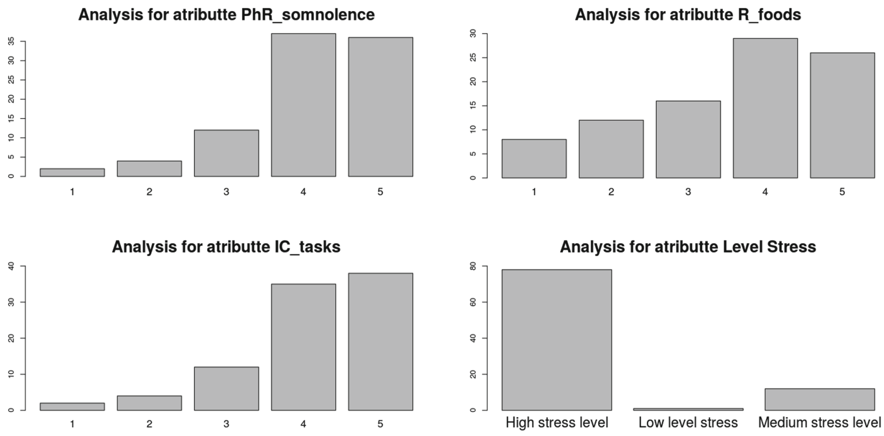

Fig. 1. Survey summary

Another impact detected in students is that the internships influence the number of credits in which they enroll per semester. According to the curriculum, each semester has an average of 23 programmed credits, but the student is free to enroll in the amount he wishes. As we can see in the results of Fig. 3, 80% of the youngest students reduced the number of credits enrolled in the semester and none increased.

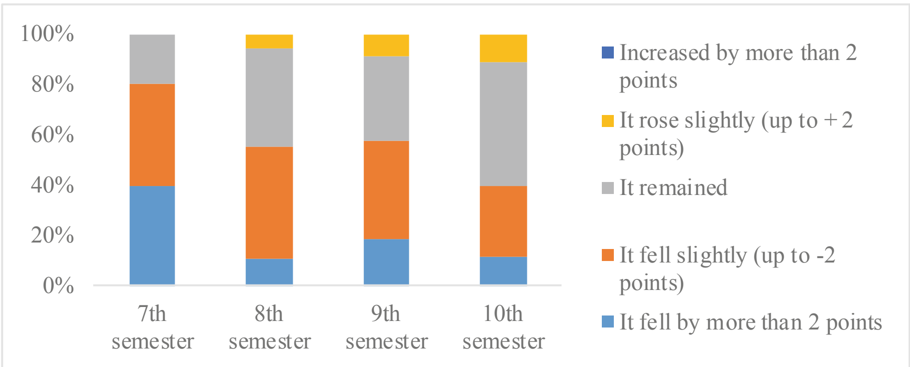

Fig. 2. Variation in the number of credits enrolled per semester

On the other hand, this decreases in the students of higher semesters since 50% reduced the number of credits enrolled, while approximately 20% increased the amount enrolled. This could be explained because the youngest students might not be prepared yet for the work, and in order not to risk oversaturation, they enroll in fewer credits. Secondly, higher semester students already have more experience and they may be looking to graduate soon to advance in their companies so they accelerate their career by enrolling in more credits.

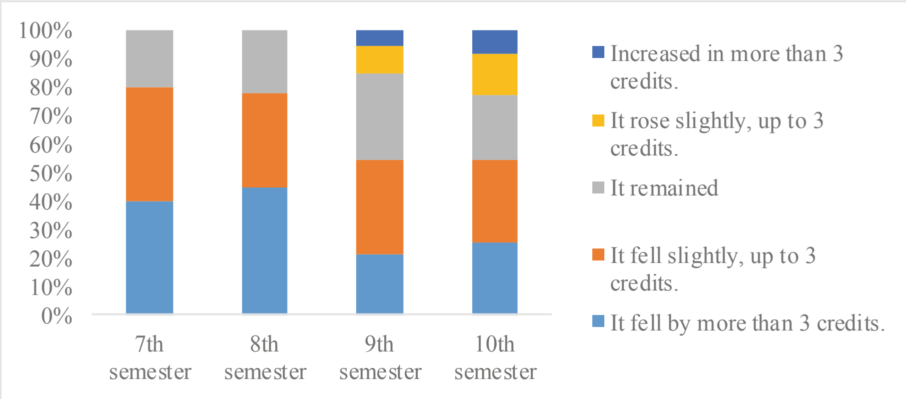

Fig. 3. Variation in the number of credits enrolled per semester

4 Conclusions

In the present research it was determined that currently the quality of education is sacrificing the health of the students, which in the long term will not only provide a student with a very high level of stress, but also a student with a low academic performance. Of the total surveys we have that 0% have low stress, 14.29% have medium stress, 70.33% have high stress, and 15.38% of students have a stress level much higher than normal measurement values, which it is alarming. That is why it is proposed to change the approach of internships (complement of what was learned in the classroom) and the number of hours required (only a 300-h internship).

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Communication of Legal Epistemology Applied to Law

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Abstract. In Ecuador, criminal justice has taken an unprecedented role. It is the scene of a policy and institutionalism mired in crisis, the reasons from the right are several. Two of those reasons are exposed by Luigy Ferrajoly [1] as the main ones according to his book Law and Reason. Theory of Criminal Guarantee. The first reason is the expansion of illegality in public life that includes political parties, public administration, businessmen, banks and the entire population linked to the world of politics by dense client relationships and involved in different ways, for convenience or even just for resignation, in the practice of corruption.

Keywords: Communication · Legal epistemology · Law

1 Introduction

Behind the facade of the Rule of Law a clandestine state has developed with its own codes and its own taxes, organized in hidden power centers and often in coexistence with the mafia powers, and, by algorithms, in contradiction with all the principles of democracy. The second reason is the social demand for legality. Politicians have lost all political legitimacy and cannot respond to this demand. What is institutionalized is a growing anatomy of the contemporary State, the massive expansion of its functions in economic and social life and in a regulatory incapacity of right-inadequacy, the lack of dynamics and the tendency of political power to release legal controls.

This crisis of law is aggravated by "legislative legislation" and the development of an emergency criminal law, reducing the guarantees of due process. Luigy Ferrajoly's theoretical hypothesis is the existence of an indissoluble link between guarantee of fundamental rights, division of powers and democracy, the quality shared by the authors of the present investigation and is summarized in that "Only a criminal law directly led to functions of guardianship of assets and fundamental rights can, in effect, combine legal guarantee and efficiency".

A criminal system is closer to the minimum criminal law guarantee model, but it is in a position to meet the general principles that are suitable for serving as pragmatic criteria for acceptance or rejection of the decisions of the judiciary. Guaranteeism has

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nothing to do with legalism and literalism. On the contrary, it criticizes the mechanistic ideology of law enforcement.

2 Criminal Law as a Rule Regulates Conflicts Between the Parties

In the criminal world the injury is suffered by the lord (State, republic, monarch, the one in charge) and the victim is only a fact, a test, that if it does not agree to be it is forced and coerced even with the same treatment as your offender In summary, the offender is not the person who offended but a builder of the alchemical retort of criminal law, and the victim is not the offended person, but a fact that must be contributed to the process; the victim is not a person, it is a test [2].

Criminal Law as a rule regulates interparty conflicts; thus, the victim and the offender emerge with the typical adaptation of a behavior to a behavioral hypothesis provided by law. Notwithstanding that there are cases in which those offended, according to the legal good protected, are corporations or public entities, in most cases they are faced with two individuals who are linked by the affectation of the rights of one by of the other.

Given the existence of a conflict, the law tries to propose solutions to terminate it and return things to their previous natural state. Many times solutions are reached without the intervention of the criminal procedure system, simply with the help of other conflict resolution methods such as Mediation and Arbitration, which is currently one of the best alternatives that the parties have, to put an end to litigation, as long as it concerns transigid matters [3]; other times the administration of justice is the ideal way. Thus, any justice system that corresponds to the parameters that the rule of law imposes, upon the proven denunciation of a conflict, the repair of the injured offender.

In the old criminal justice, the victim had a preponderant role in substantiating the causes and when he decided to launch the collective conflict resolution bodies, his opinion traced the way of reparation. However, the appearance of public or state criminal prosecution in the thirteenth century caused the exclusion of one of the protagonists of the conflict: the victim lives a marginal role, confined to a timely consideration as a material object of the crime. It is that the modern criminal law has generated the neutralization of the victim [4], at the moment in which the satisfaction of the injured subject is replaced by the retribution of an unjust fact.

3 The Sentence Does Not Fall on the Act

We do not punish drug use, contempt for national symbols or obscene exhibits because they cause damage. We pursue these actions because they constitute symptoms of evil spirits, of sinful attitudes. The sentence does not fall on the act, it falls on the disobedient person. It follows from this premise that the victim is unimportant; The offender does not act against his fellows but disobeys God. This forgetfulness of the one who suffers the damage deprives the right of the mission to dignify the victim through the condemnation of the transgressor. If the Criminal Law is useful for something in a secular society, this something consists in preventing damages and, in the event of damages, in giving people the respect required to be full moral subjects.

The blackmailed, the violated and the person transformed into something by violence deserve a re dignifying institutional remedy. This remedy is the criminal conviction achieved through the participation of the offended party in the process. I call this version of law; perfectionist does not fulfill this mission.

Since the Inquisition, the conflict ceased to be parallel, to have two parts to become a triangle, based on the victim, who was clouded by the dust caused by the search for truth between the other two parties that would be the perpetrator and the sovereign or state. That search for truth was also affected in the way it was obtained; even before the configuration of the triangle, the fight or dispute between the victim and the perpetrator, was the paradigm, afterwards, it was the investigation or inquiry carried out by the sovereign or his representatives.

The inquisition in the procedural field and as a method of knowledge was first installed in the bureaucratization of the Church, when it was hierarchized as a result of its romanization; In the following centuries, the authority of the bureaucracy with respect to the rest of the believers was accentuated, until culminating in a total seizure of knowledge and power by the same, which exercised controlling any heterodoxy (heresy) through the Holy Office. In this way I inaugurate a method of knowledge and power of a corporate and hierarchical society that, from then until now, will be assumed by all those who exercise or intend to exercise power within any society with these characteristics [5].

4 Confiscation is Unilateral and Does Not Involve Public Compensation

Thus, the struggle or dispute ceases in the thirteenth century, to give way to the inquisition or investigation, whose main characteristic was the confiscation of the conflict to the victim. The conflict is subject to a state confiscation, from which the victim loses all decision-making capacity. Confiscation is unilateral and does not involve public compensation. It is not an expropriation, where the State cancels the fair price of the good whose private domain extinguishes. On the contrary, this confiscation not only does not eliminate the conflict, maintains it or even enlarges it, and constitutes the cause of new related conflicts or derived from the original conflict between the victim and third parties, sometimes with the same offender, when the accused threatens or mandates the offended to withdraw his complaint or not give his incriminating testimony.

The victim as being offended or injured in their rights disappears to become an excuse for the sovereign (and then for the State) to exercise their power at discretion. Important distinction between our Ecuadorian criminal procedure system, even after the accusatory reforms and the US adversarial system, … “the public criminal prosecution in Anglo-Saxon law” [6], is found that the victim determines, in most of the cases, if the criminal process is going to be launched. Although a possibly punishable act comes to the State's knowledge even without the existence of a complaint by the victim, it can influence the process in different ways, for example, by the decision not to make the particular accusation, or, more Go ahead, for the decision not to testify.

While it is true, that in our adversarial justice system, except in exceptional cases, the victim has no obligation to report, he does have the obligation to appear before the corresponding court or tribunal to be interrogated by the parties. However, it is well known by litigating lawyers that there is no worse witness than him who does not want to go to render version.

5 The Increase in Penalties

Initial-based cheeks, errors of appreciation or mental gaps, can completely destabilize the theory of the Prosecutor's case. Unfortunately, in spite of the fact that the trial as a procedural stage is, or should be, the center of the criminal process, and therefore, all the probative decisions regarding the elements of conviction received or not received by the Public Ministry, prior to the trial. They should be weighted in their future impact within it, this does not happen in the majority fiscal practice, with their exceptions that confirm the rule. The exception confirms the rule, the particularity corroborates the generality.

A prosecutor with a victim who does not collaborate must be very clear that he risks a potential acquittal. Perhaps the unquestionable performance of courts and criminal courts in which they fill the investigative deficiencies of the Judicial Police and the Prosecutor's Office, through preventive prisons, appeals for trial and convictions of null, little or erroneous motivation, affects the relaxation current prosecutors in weighing their true probative potentials in the trial hearing. When the holders of criminal courts assume the challenge of sticking exclusively to their role as judges, the balance of sentencing statistics will have a real counterweight.

The increase in penalties for crimes that affect citizen security is detrimental to human dignity, without neglecting that the honorable members of the National Assembly crystallized our vindictive desires, however, criminal statistics show that the most serious crime does not fall by raise the punitive response of the State, this dichotomy does not allow the correct weighting of the most fundamental legal rights and rights of the human being.

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Human Factors in Ecuadorian Institutions of Higher Education and Their Control Agencies

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Abstract. Universities must take advantage of their status as generators of scientific knowledge and resort to communication as an ally. The endogenous knowledge process is a path for the development of the identity of higher education institutions, which with responsibility, seek to find new communication alternatives from within, in a feedback process, between local and international, to generate processes of increase.

Keywords: Human factors · Higher education · Control agencies

1 Introduction

The media can be strategic alternatives that well used give good results. Faced with this need for communication and the maintenance of a good institutional image, departments or areas of communication arise, which cease to function only in advertising campaigns, to make a comprehensive communication.

Integral communication in the university code is a concept that refers to a social process of production, processing and exchange of information, which has the determination to generate interactions between qualified actors in four aspects: internal communication, institutional communication, marketing communication and administrative communication [1].

These communication dimensions are present interacting automatically with each other, seeking the participation of all the actors, to order their productive, sustainable and socially responsible activities [2]. University communication specializes in the work on the image of the University, to offer legitimacy to its students; make the strategic planning of the institution visible; monitor compliance; and seek to exchange the generated products. Its products are knowledge, patents, publications, discoveries, future graduates, etc. [3]. Universities, to face this challenge, look for that finding that differentiates that element from others, and they know how to communicate it to their students [4].

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2 Image Before Interested Audiences

Currently, Ecuadorian universities begin to worry about the image that the interested public has of them, so it is necessary to create structured communication areas and chaired by an expert in the field of communication, to advise the main authorities, called guiding, general secretaries or directors, and coordinate the necessary communication processes, which achieve the construction and maintenance in time of a close relationship with stakeholders. That is, a communication professional must be responsible for managing an optimal institutional image, with rigorous academic training, information and communication skills, and a solid knowledge of current communication trends [5].

In this same scenario, the control agencies do not depart from the reality of universities in communication issues, since their role through the evaluation and accreditation of Ecuadorian institutions of higher education, relates them to the dissemination of their research, project advice, knowledge transfer, interinstitutional relations, etc. The communication of these actions of the agencies is transcendental in the development of higher education in Ecuador, because they need to communicate messages that transfer knowledge to society.

To achieve this objective, it is necessary the role of a communication director who directs the processes, which proposes strategies, that transfers information from universities and their agencies to interested parties. The university world and the current processes, dynamic and competitive, require professionals with a solid knowledge of the various areas of management and administration, with personal skills such as versatility, adaptation, reflection, resolution, creativity and, above all, communication skills [6].

3 Value Creators for Their Stakeholders

Faced with the reality of a technologically developed and globalized world, universities and their control agencies have gone from generating services and products to creating value for their stakeholders. For this reason, the need arises to create communication departments within the organizational charts of these institutions, which allow obtaining an effective management of their relations with their internal and external audiences, information and communication means to guarantee the efficiency of the processes carried out within and outside the institution [7].

Communication has become a key piece in the generation of intangible values, such as institutional reputation. It is here that the importance of the role of a communication director, who chairs this type of process, provides effective communication strategies, transfers information from universities and their agencies to interested parties, and is an advisor to the rectors, deans, directors or General Secretaries [8].

Communication in organizations, whether educational or not, has become a strategic tool to address stakeholders and the agency, an institutional image and an excellent social reputation. Organizational communication is a discipline that studies internal and external communication, intangible values and the organization's environment; institutional relations; the speeches, and within them, ethics; useful, complete and truthful information; It is the one that integrates the facts in the actions of the organizations [9].

Organizational communication has several historical backgrounds, but as a science, it was consolidated in the mid-twentieth century, when the need arises to communicate massively, to the actors and to the qualified public, about the products or services of the organizations.

4 The Person in Charge of the Communication

The person responsible for communication is transcendental within any organization. After the manager, president or rector, the person responsible for the communication is the subsidiary of the execution, monitoring and evaluation of the communication policies. Its main function is to be the custodian of the organizational image.

Likewise, the communication departments are the result of a process of evolution of the traditional press offices, which previously were only limited to everything related to information relations, that is, they related to the community through the media Communication outside the institution. In this way, the tendency was to consider communication as an entity to manage relations with its different audiences, including normative communication, linked only to human talent, and commercial ones, linked to the areas of marketing and advertising [10].

The Communication Department must depend on the senior management of the organization and must remain with the executive director, in this case, the rector. It must occupy a horizontal level, maintaining contact with all areas of the organization and coordinating all communication processes. The Communication Department must be literally at the top of the organizational pyramid, with great freedom of action, along with the main leaders, and very close to the Human Talent and Marketing and Advertising team.

5 Director of Communication

The Director of Communication, based on the objectives, vision, mission and values of the university, is the one who assumes the responsibility of defining and concretizing the Corporate Communication policy. It is also who must guarantee the capital increase of intangible assets: corporate visibility, brand, image and reputation. Information is a very important asset in universities, which collaborates in obtaining data, facilitates compliance with quality indicators [11] and provides communication channels in the improvement of organizational processes [12]. Its objective should be to specify the concepts of values and antivalores to recognize them in society, through the analysis of the different media and the reality that surrounds us, so that we have a clear idea of the hierarchy of values of society and promote be a change agent willing to improve it [13].

The communication department must be the figure that exercises control over the new online channels, considered essential vehicles for the diffusion of the brand and the organizational project, not only externally, but also internally, involving and aligning the professionals of a university with the culture and the corporate market. Also, very important is the establishment of two-way conversation channels, to develop in the user a positive feeling towards the service [14]. For this purpose, new technologies should be used, creating favorable university environments for communication between teachers, students and staff. Even today, not all the potential that technology can offer in university institutions is exploited [15].

The Director of Communication, regardless of his training, assumes the functions of Public Relations because he is the one who defines the university's communication policy, strategic planning, culture management, identity, image and corporate reputation, relationship with the media, institutions, public administrations, social responsibility and communication management in crisis situations and maintain lines of communication, acceptance and mutual cooperation between an organization and its public [17].

On the other hand, Juan Manuel Mora [18], in relation to the communication professional, points out that there are no basic notions of the administration, stating that the communicators are not prepared to understand the logic of the management tasks, or to collaborate in the governance of institutions. In view of these challenges, the possibility of improving the governance conditions of the higher education system requires, as a starting point, to recognize its complexity and heterogeneity, as well as the diversity of roles and functions that Universities play in response to demands of its surroundings [19].

Some manuals indicate that the profile of the Director of Communication requires a certain degree of journalism, but that this is not strictly necessary, since most journalists are unaware of issues such as internal and external communication, aspects that are key to success in their job. However, many universities focus their activity on the management of informational relations, confusing press offices with communication cabinets and placing experts in journalism at the head of the communication department. Currently, the main function of a communication department is to improve the image and reputation of the institution [20].

At the same time, marketing does not depart from the reality of the Director of Communication. For the American Marketing Association (AMA), marketing is an organizational function and a set of processes to generate, communicate and deliver value to consumers, as well as to manage relationships with the latter, so that the organization and its shareholders obtain a benefit.

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Epistemological Fundamentals of the Conditioned Constitutionality

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Abstract. The action of unconstitutionality, in its legal context, is public and participatory because it is expressly linked to the right of every citizen to participate in the formation, exercise and control of political power. With that purpose, the citizen is granted the power to file public actions in defense of the Constitution and the validity of the law, the validity of which is conformed to the constitutional contents. The importance of the action of unconstitutionality, as a means of constitutional control, is evident; one of the characteristics that adds importance is that it is a means of control within the reach of State bodies, without limiting its origin or invasion of areas of competence, as is the case of the constitutional controversy. In these terms, the action of unconstitutionality may not only address violations of the organic part of the Constitution but may also address violations of guarantees or individual or collective rights, according to the case.

Keywords: Unconstitutionality · Constitution · Constitutional control

1 Introduction

Conditional constitutionality indicates that the norm fulfills relevant constitutional functions, such as constitutional, legal and regulatory rights, which must be applied under equal conditions and adhered to the Constitution, in a uniform manner for all factual and legal subjects, applying the recognition of rights issued by the corresponding agencies.

The plaintiff starts from an inadequate interpretation of the jurisprudential precedent theory. This is because there is no legal basis to lead the contentious jurisprudence to oppose the constitutional Conditional constitutionality is an alternative which is partially applied by the justice operators, thus violating the constitutional right of freedom, of people who should access because they are framed to what is referred to in law.

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2 Paper Preparation

Currently, Conditional constitutionality is the development and application of jurisprudential precedents based on triple repetition rulings issued by the Specialize Chambers of the National Court of Justice, who affirm (reiterate) on three occasions the same opinion on a point of law; and that after the analysis of the Plenary of the Court, it discard or ratifies them, that if they are ratified they will be constituted in obligatory jurisprudence and published in the Official Registry so that it has mandatory effect, until the National Assembly regulates it definitively, created by the Specialized Chambers of the National Court of Justice applied by the judges.

3 LNCS Online

The written process suffers from being bureaucratic, slow, delegable (many procedural activities are not carried out by the judge but other judicial savants), incidentalist (the interposition of an incident in the process can delay indefinite times), but above all, the lack is evidenced immediately (the judge is not close to the process, is close to a file). On the other hand, the oral process guarantees immediacy since the judge resolves in oral hearing all disputes that may arise, allowing the parties to present the allegations and the evidence. Based on this contradiction and the guarantee of due process, the judge must make his decision, and the incidents that may be generated in the process are also attended at the hearing. The decrease in the resolution times of non-criminal cases is one of the main advantages that motivates the adoption of the oral process, as well as the quality and transparency in the administration of justice. However, the characteristics of this regulatory body cannot be ignored, such as: It applies to all non-criminal matters. That is, Procedural Law in non-criminal matters is regulated in a single Code. Unify procedural avenues, avoiding normative dispersion.

The four processes foreseen in the COGEP are: Ordinary, Summary, Executive and Monitory. The substantiation of process is carried out through hearings, which must necessarily contain a resolution or decision of the judge. The use of technology is potentiated throughout the substantiation of the case, with technological tools such as electronic files and judicial auctions.

Alternative methods of conflict resolution are strengthened: judges have the possibility of deriving a mediation lawsuit and have the obligation to propose settlement formulas. That is, mediation is strengthened and stimulates reconciliation between the parties.

Finally, it is important to mention that procedural orality strengthens independence is not a privilege of judges, it is a right of citizens [1, 2].

4 Critical Analysis of Topic

The action of unconstitutionality, in its legal context, is public and participatory because it is expressly linked to the right of every citizen to participate in the formation exercise and control of political power. With that purpose, the citizen is granted the power to file public actions in defense of the Constitution and the validity of the law, the validity of which is conformed to the constitutional contents.

The importance of the action of unconstitutionality, as a means of constitutional control, is evident; one of the characteristics that adds importance is that it is a means of control within the reach of State organs, without limiting its origin or invasion of areas of competence, as is the case of the constitutional controversy. In these terms, the action of unconstitutionality may not only address violations of the organic part of the Constitution (which occurs in the case of the constitutional dispute), but may also address violations of guarantees or individual or collective rights, according to the case [1, 2].

It is the development and application of jurisprudential precedents base on triple repetition rulings issued by the Specialized Chambers of the National Court of Justice, who affirm (reiterate) on three occasions the same opinion on a point of law; and that after the analysis of the Plenary of the Court, it discard or ratifies them, that if they are ratified they will be continued in obligatory jurisprudence and published in the Official Registry so that it has mandatory effect, until the National Assembly regulates it definitively.

Taking into account the functionality of the judgment analyzed, with respect to the family issue, specifically in terms of food, it is possible to establish with strict precision the absolute competence and relative discretion of the judges, who seek that the parties find a midpoint through conciliation when it comes to securities owed; since, this favors the debtors of alimony, in this case considering that in merit of the principle of good faith they look for way to achieve the cancellation of unpaid assets, thus treating the judge to protect the effective judicial protection in proportion to equal justice.

The shareholders requested that the relevance of unconstitutionality be declared through Public Action of Unconstitutionality, Mr. Arturo Alberto Zelaya Gamboa, in the case signed with No. 0026-10-IN; Marcel René Ramírez Rhor, who represents the Parents Foundation forever, in the case signed with No. 0026-10-N; and, Javier Renán Donoso Saldarriaga, in the case signed with No. 0052-16-IN (Sentencia No.012-17—SIN-CC 2017) [3].

It is imperative to carry out a general analysis of the tradition and scope of human rights, including the right to freedom, since their application in society to maintain their supremacy is complicated, because people have a tendency to contravene the law and the norm.

The application of alternative measures to people who are immersed in judicial problems, gives the possibility to respect their right to freedom. The Specialized Chambers of the National Court of Justice through the issuance of triple repetition rulings on norms accused of unconstitutional protect this right.

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Social and Occupational Ergonomics

Is Sick Building Syndrome Existing in Thailand?

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Abstract. Sick building syndrome (SBS) is a group of illnesses associated with the building. From the standard comparison, all standards are aware of Carbon Monoxide, Nitrogen dioxide, and Ozone. The Ministry of Public Health of Thailand has established the air quality standards in Thailand based on Singapore. But after that, Singapore standards adjusted PM 2.5 down, but Thailand still uses Singapore's old standard. So, the PM 2.5 value of Thailand is higher than every standard. There are many studies, which study the prevalence, factors, and symptoms of sick building syndrome. They have different results because of different environments. Thai people are not aware of the sick building syndrome, although it is very close to them. Because in the past, Thai people lived in houses with space under houses, providing good ventilation. But nowadays, Thai people have changed to live in the building. They are increasingly exposed to sick building syndrome. Sick building syndrome protection can do in various ways.

Keywords: Sick building syndrome · Indoor air quality · Ventilation

1 Introduction

A human spends up to 80% of their life inside the workplace or home [1]. The progress of science and technology makes the lifestyle of Thai people has changed. In particular, the design of buildings built in a modern western style. These buildings are designed to prevent pollution from the outside. These buildings have many facilities such as computers, photocopiers, and air conditioners. So, employees are comfortable but at the same time, these buildings may cause Sick Building Syndrome.

The research of the International Labour Organization (ILO) found that 20% of respondents had symptoms related to air quality and these symptoms are defined as Sick Building Syndrome (SBS) [1]. In recent years it has become apparent that occupants of buildings suffer illnesses in which there is no apparent cause, yet it has been established that these are caused in some way by the building [2]. World Health

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Organization (WHO) reported that 30% of new, remodeled or renovated buildings had occupants with SBS. SBS may occur in most kinds of building: offices, apartment houses, and schools. It causes reduced work performance and increased absenteeism [3]. Therefore, the researcher is interested in studying sick building syndrome. This research covers the definition, causes, effect, and prevention of the disease. The main objective is to compare certified standards and researches of other countries about sick building syndrome.

2 Sick Building Syndrome Review

2.1 Definition of Sick Building Syndrome

A building is constructed to protect people and/or objects from the outdoor climate. Buildings cannot have ill health, but the indoor environment enclosed space can have airborne contaminants that cause ill health to the people who live in the building [4]. The term "Sick Building Syndrome" was coined by WHO in 1982 [2]. It has been used to describe the situation in which building occupants express their dissatisfaction with the building environment. The symptoms tend to increase with the time people spend in the building and disappear when people are away from the building [4].

2.2 Cause of Sick Building Syndrome

NIOSH research [5] broke down sources of sick building syndrome as follows, inadequate ventilation 52%, contamination from inside building 16%, contamination from outside building 10%, microbial contamination 5%, contamination from building materials and equipment 4%, unknown sources 13%.

Poor ventilation causes carbon dioxide, carbon monoxide or other gasses and pollutants that were circulated by the air conditioning system [5]. Most contamination comes from sources inside the building [4]. For example, adhesives, cleaning agents, pesticides. The outdoor air that enters a building can be a source of indoor air pollution. For example, pollutants from motor vehicle exhausts [3]. The biological contaminants include bacteria, viruses, fungi, etc. These contaminants can breed in stagnant water that has accumulated in drainpipes and ceiling tiles, carpets, and upholstery. Insect and bird droppings can also be a source of biological contamination [4]. A variety of materials and equipment used in the work environment have been implicated as potential risk factors for illness symptoms [4]. More research focused on floor coverings, particularly textile materials, and their potential for contributing to Sick Building Syndrome [5]. Other inappropriate environments include light, temperature, humidity, building odors, and noise in the building.

2.3 Effects of Sick Building Syndrome

Sick building syndrome causes many symptoms. Symptoms of sick building syndrome are shown in Table 1.

Table 1. Health effects of sick building syndrome

System	Symptom
Respiratory	Runny nose [1, 2, 5], sneezing [1], sore throat [2, 5], nose bleeds [2, 5], rhinitis [4], colds [4], throat irritation [3, 5]
Eye	Eye dryness [2, 5], itching of the eyes [1], tearing of the eyes [2], burning of the eyes [2, 5], visual disturbances and light sensitivity [4]
Skin	Skin rashes [1, 5], itchy skin [2, 3], dry skin [2, 5], redness [5], irritation [2], and dryness of the lips and urticaria [4]
Nervous	Dizziness [5], headache [1, 2, 3], migraine headache [4], mental confusion [4], lethargy [2, 5], irritability and poor concentration [1, 2]
Another symptom	Gastrointestinal symptoms [4, 5], exacerbation of pre-existing illnesses such as asthma [1], sinusitis or eczema [4]

2.4 Prevention of Sick Building Syndrome

Ventilation, if you have equipment that releases air contaminants, you must install air cleaners or filters [4, 6]. Open windows to provide natural ventilation but do not open windows that face high-traffic areas or areas that leave them vulnerable to wet weather [6]. If you have a large area, installing high-volume low-speed fans will provide more effective ventilation [4]. If the ventilation system is turned off during weekends, ensure that the system is on so that contaminant concentrations are sufficiently diluted prior to occupancy [4]. Material, choose facilities that are easy to clean [4]. Choose furniture made from natural materials or that do not have noxious chemicals [6]. Look for paints with low VOC ratings [4]. Cleaning, people should follow the guidelines for cleaning operations such as clean ventilation systems, grills, humidifiers annually, clean windows and light fittings every month or 3 months, clean the floor, carpet, and furniture including desks and chairs daily [6]. Cleaning should do in the evening rather than in the early morning, it will prevent odors from bins which can cause a continuing problem the following day [4]. Other, the light should utilize natural light [4]. Planting plants to absorb toxins [4]. Good communication and good relationships between management and staff will be important ingredients in helping to know staff concerns [4]. Standards, international organizations use IAQ standards to prevent the prevalence of SBS. Indoor Air Quality (IAQ) is a function of many parameters, including outdoor air quality in the vicinity of the building [7]. The summary of international standards is shown in Table 2.

3 Discussion

Indoor air quality standards of many countries specify indoor air pollutants that affect health, the initial symptoms caused by these pollutants relate with symptoms of sick building syndrome as follows: Carbon dioxide (CO2) indicates the efficiency of the building's ventilation [1]. When people received in large quantities will cause headaches, confusion, dizziness [7]. Poor ventilation will cause the accumulation of carbon

Table 2. Comparison of international standards (acceptable/recommended value)

List	NAAQS[a]	OSHA[b]	ASHRAE[c]	NIOSH[d]	ACGIH[e]	WHO[f]	Hong Kong[g]	Singapore[h]	Thai[i]	Unit
CO_2	–	5,000	1000	5,000	5,000	–	800–1,000	700	700	ppm
CO	9	50	9	35	9	10	1.7–8.7	9	9	ppm
Formaldehyde	–	0.75	0.08 [30 min]	0.016	0.3 [C]	0.081 [30 min]	(0.3–1) x 10^{-4}	0.1	0.1	ppm
NO_2	0.05 [1 year]	5 [C]	1×10^{-4}	1 [15 min]	3	0.1 [1 h]	0.021–0.080	1×10^{-4}	1×10^{-4}	ppm
O_3	0.08	0.1	0.05	0.1 [C]	0.05	0.064	0.025–0.061	0.1	0.1	ppm
PM 2.5	35 [24 h]	5,000	15	–	3,000 [C]	25 [24 h]	–	37.5 [24 h]	50 [24 h]	μg/m^3
PM 10	150 [24 h]	–	150 [24 h]	–	10,000 [C]	–	20–180	50	50 [1 h]	μg/m^3
Radon	148 [1 year]	–	148 [1 h]	–	–	100 [1 year]	150–200	150	150	Bq/m^3
SO_2	0.14 [24 h]	5	8 x 10^{-5}	2	2	0.048 [24 h]	–	–	–	ppm
Total particles	0.26 [24 h]	15	–	–	–	–	–	–	–	mg/m^3
Total VOCs	–	–	–	–	–	–	$(2–6) \times 10^{-4}$	3	3	ppm
Air movement	–	–	–	–	–	–	0.2–0.3	0.1–0.3	0.1–0.3	m/s
Temperature	–	–	–	–	–	–	20–25.5	24–26	24–26	°C
Relative Humidity	–	–	30–60	–	–	–	40–70	65–70	65–70	%
Total Bacteria	–	–	–	–	–	500	500–1000	500	500	CFU/m^3
Total Fungal	–	–	–	–	–	500	–	500	500	CFU/m^3

Description. [] refer to compare with time in []. C = Maximum ceiling value. - = No data. If not specified, it will be compared to 8 h. min = Minute. hr = Hour. ppm = Part per million. mg/m^3 = Milligram per cubic meter. μg/m^3 = Micrograms per cubic meter. Bq/m^3 = Becquerels per cubic metre. °C = Celsius. m/s = Meter per second. CFU/m^3 = Colony Forming Units per cubic meter

[a] National Ambient Air Quality Standards (NAAQS) [8]
[b] Occupational Safety and Health Administration (OSHA) [7]
[c] American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) [9]
[d] National Institute for Occupational Safety and Health (NIOSH) [10]
[e] Association advancing occupational and environmental health (ACGIH) [11]
[f] World Health Organization (WHO) [4]
[g] Hong Kong standard [12]
[h] Singapore standard [13]
[i] Thailand standard [14]

monoxide (CO) in the air. When it accumulates in the body, it will bind to hemoglobin in the blood and will impact on important organs of the body. These effects will result in drowsiness, nausea, vomiting, fatigue, confusion.

Parking in the building [7], building near the road with heavy traffic, buildings near the industrial area [1] will have a high risk of carbon monoxide. Formaldehyde (CH2O) often found in wooden furniture, office equipment, paints, wallpapers. It is released when high temperatures and high humidity [15]. It causes irritation to the respiratory system, skin and nervous system [5]. Upon people's exposure to nitrogen dioxide (NO2), this will cause irritation to the area of exposure such as skin, mucous membranes, nose, neck and will have chest pain, cough, and decreased respiratory diseases' immunity [4]. Ozone caused by the reaction between oxide of nitrogen and volatile organic compounds with sunlight as a catalyst. Ozone causes irritating to eyes and the respiratory system [12]. PM2.5 refers to atmospheric particulate matter (PM) that has a diameter smaller than 2.5 μm. PM10 is particulate matter 10 μm or fewer in diameter [12]. PM2.5 and PM10 affect the respiratory system and stimulate asthma [4]. Radon causes dizziness and directly affect tissues within the respiratory system. Radon gas often enters the building while the pressure has a difference. When the indoor air pressure is lower than the external pressure, air from outside and air from the underground will be pulled to the building The low indoor air pressure is caused by many reasons such as walls that are thicker cause temperature differences between inside and outside the building. In addition, it can enter the building via leak holes and cracks of the building [16]. Sulfur dioxide can combine with other pollutants and form small dust particles. It causes irritation to the lining of the eyes, skin and respiratory system [4]. Total particles have main sources such as a heater, fireplace, and contamination from outside the building. They cause irritation to the respiratory system and stimulate allergies and asthma [6]. Total volatile organic compounds (VOC) are a chemical that is in the cleaning agent for house [11], paint, and dry-cleaning solution. When entering the body will cause problems to the immune system, nervous system and will cause dizziness, burning eyes, difficulty breathing [12]. Air movement, temperature, and relative humidity is a factor that affects the feeling of comfort in the building. If the humidity is high, people will feel uncomfortable. If the humidity is low, it will make eyes, the respiratory, skin dryness, and irritation [5, 12]. Bacteria and fungi are associated with temperature, humidity, and ventilation [1]. They are originated from building materials, walls, ceilings, carpets, and air conditioners. The illness appears to correlate with the type of bacteria and fungi [4]. The mentioned symptoms are only the initial symptoms associated with sick building syndrome. Some pollution may cause cancer or death if people receive high amounts. So, we should control these pollutants base on the standard.

NAAQS standards can be used both inside and outside the building. It is created for people who are sensitive to air quality such as children. OSHA sets standards covering the general and industrial environment. WHO standard is the European standard base on Denmark. It can be used both inside and outside the building but does not cover the industrial environment. NIOSH standard has recommended values for occupational exposure. ACGIH is the recommended value for the industrial environment. Hong Kong standard has two levels that can apply in office and public places. Table 2 shows that all standards emphasize with Carbon Monoxide, Nitrogen dioxide, and Ozone.

They are basic air pollutants released directly from the source and effect of human health. NAAQS, OSHA, and ACGIH clearly identify air quality values but don't specify details about bacteria and fungi. WHO, Hong Kong and Singapore standards clearly specify temperature, humidity, air movement, VOCs and the number of bacteria and fungi. Due to these standards were created for their country directly and considered specific climate, unlike other standards that were created to be an overall standard. In the part of Thailand, the Ministry of Public Health of Thailand has established the air quality standards in Thailand based on Singapore. But after that, Singapore standards adjusted PM2.5 microns down. Singapore is trying to adjust standard again in the future, but Thailand still uses Singapore's old standard. So, the PM2.5 value of Thailand is higher than every standard.

In China [17], there is a study of sick building syndrome in crowded buildings. It was found that 98.7% of the respondents had sick building syndrome. Most symptoms were dizziness. Symptoms occurred in the afternoon more than the morning. Measuring the amount of carbon dioxide and radon was found that the daytime more over the morning as well. In Canada [4], the prevalence of sick building syndrome of office workers before improving the ventilation system (1991) and after 6 months (1992) and 3 years (1995) of improvement, They concluded that carbon dioxide concentration and humidity are associated with the prevalence of sick building syndrome. For Thailand, there are studies about sick building syndrome in a hospital and office building. The comparison of prevalence, the most symptom group, and the factor of sick building syndrome in hospitals and offices in Thailand show in Table 3.

Table 3. The comparison of researches in Thailand

List	In hospital [18]	In-office [19]
Prevalence	26.01%	37.4%
The most symptom	Eyes (17.94%)	Nervous (24.9%)
Factor	1. Dust more than 0.1 mg/m 2. Work more than 5 days/week 3. Using a printer 4. Poor ventilation 5. Noise 6. Dirt	1. Severe stress 2. Using a computer at more than 8 h/day 3. PVC or plastic floor 4. Volatile substances such as glue, correcting fluid

Many Thai people don't know about sick building syndrome, although it is very close to them. In the past, Thai people lived in houses with space under houses, providing good ventilation. But nowadays, Thai people have changed to live in the building. They are increasingly exposed to sick building syndrome.

4 Conclusion

Sick building syndrome is a group of symptoms. It occurs when people stay in the building for a long time and disappear when leaving the building. Thai people are not aware of the sick building syndrome, although it is very close to them. Sick building syndrome protection can do in various ways such as manage air ventilation, choose facilities that are easy to clean, regularly clean the inside of the building, and choose to use appropriate standards and control the indoor air quality to meet the standards.

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Proposal for Integration of Urban Planning with the Environment in Daule - Ecuador

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Abstract. Since the 1990s, the extension of urban land in Latin America and the Caribbean has increased considerably, in Ecuador it has doubled, due to a migration from the countryside to the city that generates disorderly settlements causing the use of fruitful soils; consumption of natural resources; environmental damage and alteration of ecosystems. The canton Daule is considered the fourth largest and most populous city in the province of Guayas with an uncontrolled growth of the urban area. Next, we develop the Territorial Economic Development methodology applied to one of the sectors of the Daule canton, where several articulated analyzes are carried out with the actors involved and landscape improvement plans conceived under a systemic approach are proposed. The objective of the work is to preserve the natural heritage of the city, improve the image of the landscape with inclusive designs oriented towards sustainable urban development.

Keywords: Daule · Ecological corridor · Human factors · Sustainable urban planning · Infrastructure

1 Introduction

Several investigations argue that Latin America and the Caribbean are the most urbanized regions in the world and also the most unequal [1]. Since the 90s, the extension of urban land in Ecuador has doubled with respect to the population [2], the canton Daule is considered the fourth largest and most populated city in the province of Guayas and its cantonal head is no exception, since its growth in the urban area presents a rural – urban inequality, a persistent migration to the city from the countryside, which causes disorderly settlements, consuming fruitful soil, accelerating resource consumption, affecting the environment and altering ecosystems [3].

In addition, the lack of democratic governance in the city has hindered the planning and decision - making on strategic issues such as land use and management, mobility and trade. This is a reflection on the need to plan, avoiding uncontrolled urban expansion, promoting sustainable urban development in natural areas in an orderly manner, making the city more equitable, productive and sustainable, emphasizing governance including the participation of all main actors of territorial development [4].

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From the social point of view, an increase in green areas and spaces in general allow several actions, facilitating the grouping of children, adults and young people, using public spaces in different ways [5].

Natural spaces should not be isolated, must be integrated as a system to generate urban comfort, where all scales interact, using Green infraestructure (IV) as a comprehensive planning strategy in which land can be managed natural with the landscape and open spaces, to conserve the values and functions of the ecosystems providing better quality of life to the population [6]. This is a reflection on the need to plan, avoiding uncontrolled urban expansion, promoting sustainable urban development in natural areas in an orderly manner, making the city more equitable, productive and sustainable, and emphasizing governance including the participation of all the main actors of territorial development [7].

The benefit that motivates this article is to change it would be the proposal of a system to improve the urban image, preserve the architectural heritage and the free movement of citizens in the Cantonal Headquarters of Daule, adjusting in a process organized in a spatial, inclusive and functional way within a territory, eliminating barriers that prevent personal autonomy, to potentiate it with various zones of use, accessibility and land use; with a focus on environmental comfort guidelines oriented to the visual quality of the urban landscape; identifying the main components that make it up, with factors inherent to the ecological, aesthetic and cultural dimensions, and thus improving the visual quality of the informal urban landscape, results of results that help to preserve or improve it, creating capacities from designs with inclusive systems. Using the DET (Territorial Economic Development) methodology; This constant two-phase methodology: First phase, Mapping and identification of productive systems, which establishes a convenient articulation between positive participation with a commitment of consensual responses from the actors involved, stories such as public or private institutions, social or cultural groups or movements. and inclusive, and the effectiveness of the technical developments that support the proposal; and as the second phase the Plans for landscape improvement and competitive inclusiveness, identifying it in three dimensions; the ecological and territorial scope, the aesthetic and visual dimension oriented towards the capacity of perception of the observer and the culture of the landscape.

2 Materials and Methods

2.1 Delimitation of the Study Area

Daule is located at −1.8667 South latitude, −79.9833 West longitude at the foot of the Andes, between 15 and 58 m above sea level. It is the rice capital of the country, with a population of 120326 inhabitants (INEC, 2010) and in the cantonal head 65145 inhabitants (INEC, 2010) and an average density of 253.32 inhabitants/ km^2. It is divided into 6 parishes [8].

It is characterized by a warm and dry climate, which corresponds to the climatic subtype of tropical savanna., With winter rainfall and prolonged dry season. The annual average precipitation is 1007 mm, with marked interannual oscillations [9]. These climatic characteristics are extraordinarily relevant for the design and maintenance of green areas and urban parks. An area located northwest of the urban area of the cantonal capital. See Fig. 1.

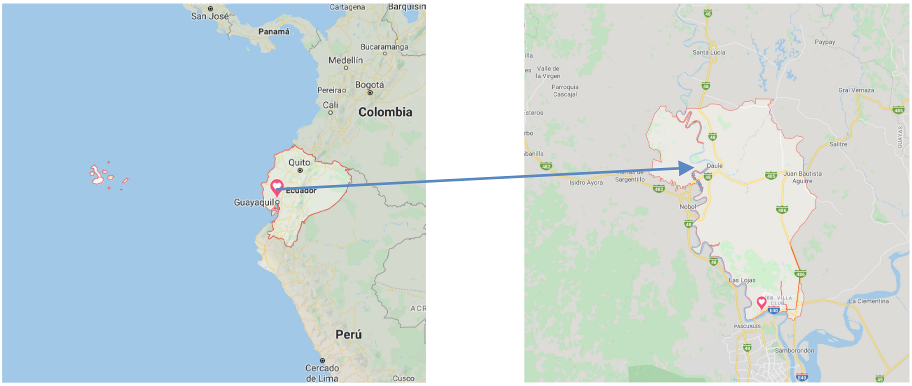

Fig. 1. Map of Daule. Source: Google Maps. Own elaboration.

Daule is within the analysis of the Urban Green Index with a rate of 1.49 m^2 per inhabitant. Considered as low, although 80% of its area is agricultural, this area is not considered in the IVU. Source (Census of Economic Environmental Information in Autonomous Municipal Decentralized Governments - 2012 INEC) For this category, parks, plazas, gardens, flower beds, banks, stadiums, sports fields, green areas (cemeteries, vacant lots, etc.) were considered. According to WHO, the amount of green spaces in a city should be between 9 and 15 square meters per person [10].

2.2 Methodology

According to Vásquez et al. (2010), the urban riverbanks in Santiago have failed to escape the urbanization process and are often found occupied by residential sectors. In the case of the urban waterfront of the Daule River in the sector of the cantonal headland, although it is true there is something more than 50% of the area occupied by residential sectors, and urban avenues, there are still similar proportions of green and open spaces along the river corridor, but these sections do not reach high levels of spatial connectivity. It is important to mention that the collaboration and participation of the population, as well as other stakeholders, the main actors, is a decisive factor for the success of the Sustainable Urban Planning Process [8].

In order to obtain an inventory of existing assets in the study sector, the qualitative, quantitative and participatory exploratory method will be used. For the inventory with specific characteristics there are three tables (Tables 1, 2 and 3):

- Urban sets
- Public spaces
- Funeral equipment

Table 1. Inventory of assets (Urban sets) Source: Own elaboration.

Name	Construction time	Assessment	State
Farmhouse of the century of the 20th century Opposite banks	1930	Antiquity, Historical - Testimonial - Symbolic	Bad
Traditional style house of the 20th century Padre Aguirre	1940	Antiquity, Historical - Testimonial - Symbolic	Regular
Coastal style house Padre Aguirre	1940	Antiquity, Historical - Testimonial - Symbolic	Regular

Table 2. Inventory of assets (Public spaces) Source: Own elaboration.

Name	Construction time	State	Construction (m^2)
River Daule – canoe ride	N/A	Moderately contaminates	N/A
Lord of miracles church	1650	Good	3356.16
Santa Clara church	1621	Regular	956.48
Palace municipal	1820	Good	4504.10
Santa Clara park	2004	In makeover	2838.26
Mother of park	2005	Regular	2133.06
November 26 boardwalk	2017	In makeover	82496.91
Triumph park	2018	Good	9341.74
San Francisco park	2019	Good	2496.95
Water park	2019	Good	2571.14

Table 3. Inventory of assets (Funeral equipment) Source: Own elaboration.

Name	Construction time	State	Construction (m^2)
General cemetery	1862	Regular	58955.55

In addition, a survey was carried out in the sector with the following questions: What is your gender?, What age range are you in?, How to mobilize daily?, Why do you think the migration from rural to urban areas in generated?, What is the advantage of living in the urban area?, What problems do you face daily living in the city?, Would you like to live in an ecological sustainable city? It is the one that offers quality of life to its inhabitants without putting natural resources at risk, because it ensures the welfare of future humanity and seeks social justice., Which of the natural and cultural heritage that exists in the city, visits more frequently?, If you have a recreation or cultural area near your home, If you had an acological corridor to guide you to recreation and culture points (Ecological corridor: road or connectivity between several areas, spaces with landscape, ecosystem and natural or cultural habitats) How often would you use it?, With the implementation of the new projects of the Decentralized Autonomous Government Daule; boardwalk, pedestrian bridge and water park, You would like the environment of the riverside to stop having a rural environment and increase the urban environment?.

The survey was conducted by 388 people, shows that it was obtained through the QuestionPro page using a 95% confidence level, margin of error of 5 and a population of 37,000 inhabitants (Fig. 2).

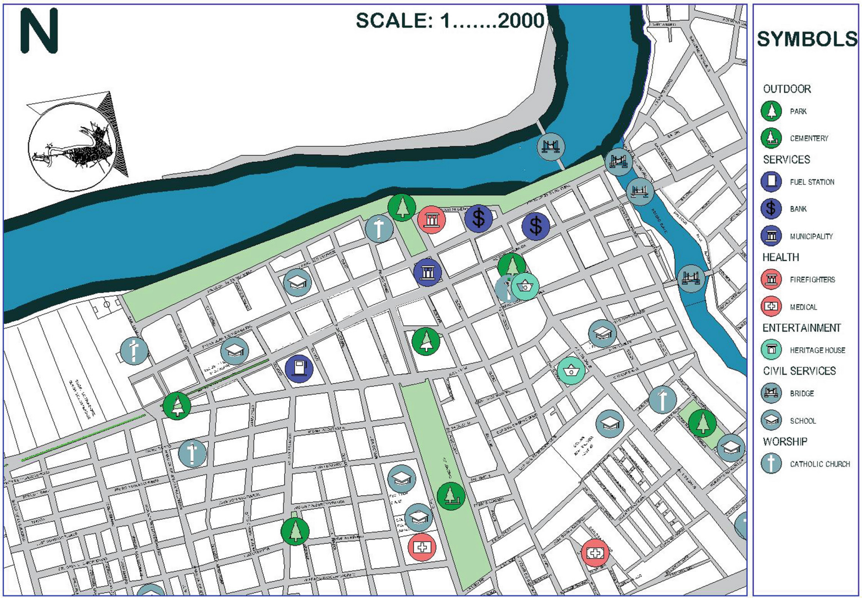

Fig. 2. Current map of the cantonal header of Daule. Source: Own elaboration.

3 Proposal

The proposal for the integration of urban planning with the environment in Daule – Ecuador is composed of an ecological corridor, with which it is desired to obtain connectivity between the areas of cultural and natural heritage, to counteract the fragmentation of green areas, and the heritage houses.

Ecological corridors and buffer zones were designed according to location. It should be noted that an ecological corridor is defined as an elongated connector that fulfills the functions of restoring terri-torial couplings to increase access to resources. Ecological corridors can be of various types: linear, landscape corrridors or step corridors. So we will achieve some buffer zones, areas designed by strips of vegetation that are incorporated into the surrounding landscape, and fulfill the functions of increasing habitat; intervene in ecological terms; provide services to more population [11]. For which it was necessary to design an urban regeneration on the sidewalks of the central avenues, implementing gardens and access for pedestrians in addition to designing linear park. Contemplating an intervention of 5567.50 linear meters (Fig. 3).

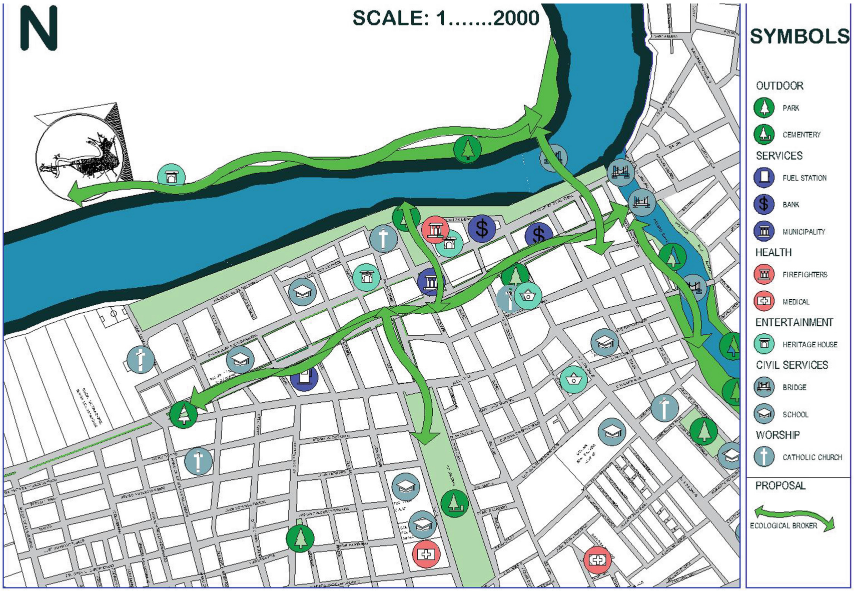

Fig. 3. Proposed map of the ecological corridor in the cantonal header of Daule. Source: Own elaboration.

4 Results

With the proposal of the integration of urban planning with the environment in Daule – Ecuador through a corridor ecologic, results in the implementation of 5567.50 linear meters of green areas and access to pedestrians. The presence of trees in the area is minimal and its variety depends on the location, in the parks they are mostly shrubs and near the riverbank they are mainly fruit trees, fruits that are used by the community for sale. The flora in the parks is in good condition. With respect to the heritage houses, these are in a regular state, and talking with the current owners wish to make an intervention through an agreement between the public – private.

With the results obtained through the survey, it was determined that the inhabitants of this sector agree with the implementation of an ecological corridor that guides them to recreation and culture points.

5 Conclusions

With the implementation of the ecological corridor, the urban green index increases from 1.49 m^2/ room to 2.44 m^2/ room, a value that is below the recommendation of the World Health Organization (WHO) of 9 m^2/room.

When planting trees of different species, the necessary connectivity is made, to obtain the ecological corridor and pedestrian access, improving the habitat.

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Corporate Mental Health Program

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Abstract. This study presents a proposal for a Mental Health Program, as part of ergonomic management within an organization. The program has three stages of intervention. The primary consists of Assessments, both in Ergonomic Analyzes and in Occupational Medical Examinations, of aspects related to mental health. From the data found in this first phase, it is possible to preventively identify possible psychosocial factors. As a result, we can instruct to participate in the secondary intervention stage, called "Mental Health Tips", which consists of actions of orientation and awareness of aspects focused on mental or emotional aspects. Finally, there is the tertiary intervention, if worrying psychosocial factors are identified, a multidisciplinary committee will act as support. The program is contributing to the emotional well-being of its employees, who are able to deal with emotions better, focus their attention on the present moment and report feeling much happier and lighter.

Keywords: Cognitive ergonomics · Mental Health · Mindfullness

1 Introduction

According to the International Ergonomics Association, IEA, ergonomics (or human factors) is the scientific discipline concerned with understanding the interactions between human beings and other elements of a system, being a multidisciplinary, user-centered integrating science. This science takes into account physical, cognitive, socio-technical, organizational, environmental and other relevant factors, as well as the complex interactions between humans and other humans, the environment, tools, products, equipment and technology [1].

Among these factors considered relevant in the man - work interaction, there are the psychosocial factors, which according to the International Labor Organization (ILO) definition, constitute the interactions between and among work environment, job content, organizational conditions and workers' capacities, needs, culture, personal extra-job considerations that may, through perceptions and experience, influence health, work performance and job satisfaction [2].

In the 1980s, the ILO mentions the growing concern about these psychosocial factors, warning about their intensification. Thereby, the ILO addresses the importance of prevention and highlights the need for interventions not only at the individual, but also at the collective level. In this sense, it recommends actions to employers that

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include improving work conditions and organization (ergonomics measures and improvements, job redesign), information on work processes, workers' participation as regards organizational measures, appropriate training and education, helping workers to cope with stress; provision of psychological first aid, among others [2].

All of these recommendations remain valid and relevant, since the psychosocial aspects at work have assumed relevance and are identified as the main emerging risks in European Union countries, according to Lucca and Sobral [3]. In their research, they states that the number of studies on the negative impact of psychosocial factors in triggering occupational stress on the health and well-being of workers is increasing in the scientific literature.

Given this scenario, the interest in quality of life programs in organizations is growing. Corporations are beginning to take an active role in building the well-being of their employees, seeking to keep them healthy, motivated and productive. As a result, they have sought to implement quality of life actions and programs [4].

1.1 Objective

The objective of this work is to present the structure of a mental health program that has been developed by the company Samsung, in Campinas (Brazil). The company has an Ergonomics Management System, one of the pillars of which is quality of life at work.

The "FullMind Program" appeared at the end of 2019 to complement the management system and has as its main objective, to promote actions in mental health, from the evaluation stage (both in ergonomic analysis, as in medical examinations), to the stage of practical actions, such as campaigns, classes with meditation techniques, relaxation, breathing and, in more specific cases, care with a multidisciplinary committee.

2 Samsung Mental Health Program

Since 2009, Samsung Campinas started an Ergonomics Program, the main actions of which were to carry out Ergonomic Work Analysis, training and partnership with the medical clinic to monitor employees who had any difficulty with their work activity. At that time, the company already had labor gymnastic services in all sectors of the factory, every day. Over the years, the ergonomics program became robust, until it became a Management System, even certified by the national certification body (ABNT), being the first Brazilian company to have this certification.

In 2016, Samsung Campinas has a space dedicated to Quality of Life at Work, called Ergonomics Center, in which activities are carried out so that employees can take care of their health. At the beginning, the focus of activities was physical health, with activities such as stretching, strengthening, postural education and Pilates. However, in September 2019, we started activities focused on mental health, with breathing, relaxation and mindfulness techniques.

The objective of the classes focused on mental health was to present techniques that help people to:

- Be well with yourself and with others;
- Knowing how to deal with emotions, whether they are good or unpleasant;
- Recognize your limits and seek help when needed;
- Turn your attention to the present moment.

Seeing the importance of the subject and having a good return from the participants of the classes, we decided to create a program called “PlenaMente Program”, in English, “FullMind Program”, focused on mental health and structure it, in a way that helps the well-being of our employees even more.

The program has three stages of intervention, the primary, secondary and tertiary. The primary consists of Assessments, both in Ergonomic Analyzes and in occupational medical examinations, of aspects related to mental health. From the data found in this first phase, it is possible to preventively identify possible psychosocial factors. As a result, we can instruct to participate in the secondary intervention stage, called “Mental Health Tips”, which consists in some actions, like:

– Classes on Ergonomics Center, twice a week in that space focused on Quality of Life at Work. These meetings are held with health professionals who address topics focused on mental or emotional aspects, such as meditation (body scanning, mindfulness of breath, mindfulness of sounds, breathing by counting), self love; pillars of pleasant personality; techniques of dealing with problems; remembering a happy childhood moment; remembering a loved one who hasn’t spoken for a long time; Image and Action Game - Non-Verbal Communication and the power of the word (Fig. 1);

Fig. 1. Relaxation and Mindfullness classes at the Ergonomics Center.

– Auriculotherapy and Quick Massage on Ergonomics Center, interspersed every 15 days, which consist of techniques that act on the central nervous system, bringing relaxation and acting in a positive way in reactions and emotional memories (Fig. 2);
– Lectures/Training/Informative: sporadically information, tips and texts are released on the subject of mental and emotional health;

Fig. 2. Quick Massage.

– Campaigns: in January 2020, the "White January" is celebrated, a Ministry of Health campaign on mental health. For this event, we did a campaign and special action at the factory, with an external relaxation class and with employees wearing white (Fig. 3).

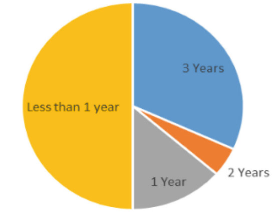
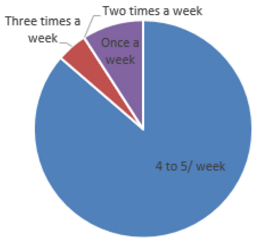
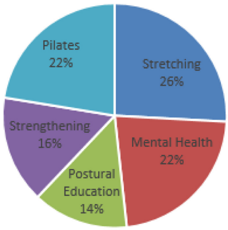
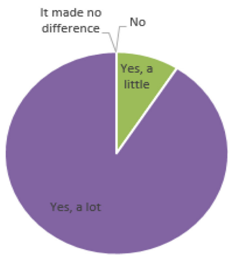
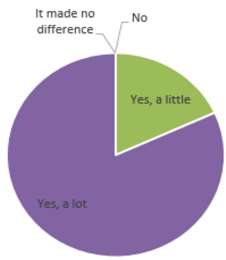
Fig. 3. External Mindfullness class in the "White January" campaign.

And finally, there is the tertiary intervention, if worrying psychosocial factors are identified, a multidisciplinary group will act as support. This group is made up of company professionals from different sectors such as occupational doctor, occupational nurse, ergonomist, social worker and human resources.

3 Results

After 2 months of the program's start, a perception questionnaire was applied to participants in the ergonomics center classes who attend the room more frequently. There were 22 people who answered a brief questionnaire, with some personal data such as time in the company, administrative or operational position, age and sex. Next, there were 5 questions about the classes (types of classes, contributions of classes to people's health) and space for comments and suggestions (Table 1).

Table 1. Perception Questionnaire Results about people's opinion.

Perception Questionnaire Results	
1. How long have you been attending the ergonomics center?	
2. How many times a week do you attend the ergonomics center?	
3. Of the activities carried out at the ergonomic center, which one (s) do you like best?	
4. With regard to physical health (muscle stretching, conditioning, strength), do you think the Ergonomics Center contributed?	
5. Regarding mental or emotional health, do you think the Ergonomics Center contributed?	

In view of the results presented, it is possible to observe that mental health classes are in second place in the preferences of participants in the ergonomics center. In addition, 100% of the participants affirm that these classes have contributed to their mental health, with 18% stating that they contribute a little and 82% stating that they contribute a lot.

The program is contributing to the emotional well-being of its employees, who are able to deal with emotions better, focus their attention on the present moment and report feeling much happier and lighter.

4 Conclusion

Psychosocial factors have been increasingly present in work processes and relevant to workers' health. It is interesting that organizations seek programs that aim at the early detection of the factors that can be considered at risk and act to mitigate these factors.

The program presented in this work has shown only positive results and has brought greater employee satisfaction. and the employer only receives good results from motivated workers.

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Looking Toward the Future of Mental Workload Research Through the Past: A Bibliometric Analysis of 1990–2020

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Abstract. This article aims to conduct a bibliometric analysis of mental workload from 1990 to 2020. Publication source, publication organization, authors, country, citation of articles, citation of country and organization were recorded and analyzed. Bibliometric maps of authorship, citation, co-citation and network of co-occurrence of keywords are drawn. 11,157 articles and 461,366 cited references were analyzed. The USA dominates the publications (4748, 42.56%) and citations (159434 times). George Mason University (36) is the most productive organization. Murai (59) is the most productive author. *Ergonomics* is the top journal with the most papers about mental workload. Hart and Staveland's paper (1988) is the most co-cited. The latest burst keyword analysis shows that "machine learning", "classification", "automation", "physiology" and "mental health" have and burst end time of 2020. As for researchers and practitioners, this paper suggests an analysis of integrated visualization based on the area of mental workload in human factors and ergonomics.

Keywords: Mental workload · Task load · Bibliometric analysis · Citespace

1 Introduction

Mental workload has become a popular topic for ergonomics, psychology, safety, human computer interaction, and organizational behavior-related studies since its birth [1, 2]. Two representative publications of [3] and [4] during the 1980s proclaimed the study of mental workload as a topic within ergonomics. At its origins, mental workload (otherwise referred to as cognitive workload or mental effort is grounded in Baddeley's well-established model of working memory [5]. According to this theory and Limited Resource Model [6], the mental workload is defined as "the rare at which information is processed by the human operators, and the rare at which decisions are made and the difficulty of making the decisions" [4]. Different definitions of mental workload are promoted based on Cognitive Load Theory [7], Multiple Resource Model [8], etc. Now with the rapidly evolving electronic display-control system in this Intelligent era, we face some interesting and exciting but broad and difficult challenges. As the nature of

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work has changed dramatically shifting the focus from physical to cognitive demands [2, 9], how human cognitive systems interact with computer systems has become a matter of concern.

In the last half-century, there have been hundreds of studies of mental workload. There are mainly three issues in this area from the general evolution of research in mental workload: how to measure it, how to define and model it, and how to apply it [2]. Firstly, although mental workload is a peculiar, it is also one of the most nebulous concepts, and remains surprisingly difficult to define [2, 9]. Secondly, the measurement methods of mental workload can be divided into three categories: operator's performance, subjective experience, and physiological consequences [2, 3, 10]. However, there appears no consensus on their validity of measuring mental workload, especially for physiological measures [11, 12], even multimodal measurement is encouraged but some of these methods can provide diverging information [9]. Thirdly, the application of mental workload has spread from job design to driving, system monitoring, teaching, military, user experience, etc. [2]. The studies always conducted in a simulated environment, which is far away from the real condition.

Since mental workload has attracted the attention of many disciplines, this field has accumulated numerous research outcomes. Therefore, it is important and timely to make a systematic and comprehensive evaluation of the research output of mental workload over the last decades. There are many review articles in this field, such as [11–15]. Although these reviews have been proposed on mental workload, they mainly focus on one aspect of mental workload and separately analyzed with other disciplines. In our review, to characterize the mental workload specialty, it is important to determine the forces that have shaped its evolution over the years. [16] has suggested that these forces include impactful research trends, influential researchers, publications, and research outlets.

Therefore, we use the bibliometric analysis method to achieve this objective. The bibliometric analysis method can be used to investigate the quantity and quality of a research discipline [17] and to indicate the frontiers of scientific research, and has advantages on handling a large number of articles compared to traditional literature review method. Hence, it serves as an ideal method in comprehending the status quo of a research discipline [18]. Albeit two studies have bibliometrically evaluated the discipline of mental workload, these studies have some limitations, such as with limited publications and out of date (i.e., published 30 years ago). Thus, this article aims to delve into providing a comprehensive and objective analysis of mental workload under different perspectives in the past three decades.

2 Methodology

As our search result of WoS returned a smaller sample (3834 publications), we decided to adopt the database from Scopus. Cognitive load is different from mental workload, the former mainly represents the load that performing a particular task imposes on the learner's cognitive system, while the latter mainly originates from the interaction between task and subject characteristics [7]. Therefore, the search code used was "(TITLE-ABS-

KEY (mental AND workload) OR TITLE-ABS-KEY (mental AND load) OR TITLE-ABS-KEY (mental AND task AND load) OR TITLE-ABS-KEY (mental AND effort)) AND PUBYEAR > 1989". All data is available online from January 1990 to February 2020. Journal articles, reviews, book reviews as well as conference proceedings have already been recorded. In the period from 1990 to 2020, there were 11,157 articles downloaded and recorded from the databases.

There are many methods to conduct a bibliometric analysis. Co-occurring subject words/keywords and citation analysis are two most frequently used methods [19, 20]. Co-occurring subject words/keywords analysis can be used to obtain the internal relations and scientific structure of works of literature and reflect the current research hotspots [20]. We can objectively find the current research hotspots for mental workload by co-occurring cluster analysis of high-frequency words. Citations can reflect the citation of journals, authors, papers, organizations, and countries, and reveal quantitative characteristics and internal laws [19]. The direct citation and co-citation were used to find the impactful journals, papers, authors, and organizations, and reveal the hotspots and major research trends by co-occurrence keywords. There are many bibliometric mapping software tools to conduct the above questions, such as Citespace, VOSViewer, CiteSpace, HistCite, SciMAT, Sci2, etc, which have pros and cons (Van Eck and Waltman, 2014). Here, Citespace and VOSViewer were used to conduct the bibliometric analysis.

3 Results and Discussion

3.1 Number of Publications and Journal Source

Figure 1 shows the descriptive statistics of annual publications related to mental workload in Scopus during 1990–2020. Psychology (38.4%), social sciences (35.6%), computer sciences (20.9%), engineering (15.9%), and neuroscience (14.1%) consist of the top 5 disciplines with the highest application of mental workload. By contrast, environmental science (0.8%), multidisciplinary sciences (0.8%), decision science (0.9%), economics (0.9%), and business, management and accounting (2.6%) form the bottom 5 disciplines. The count of publications in this field has increased constantly.

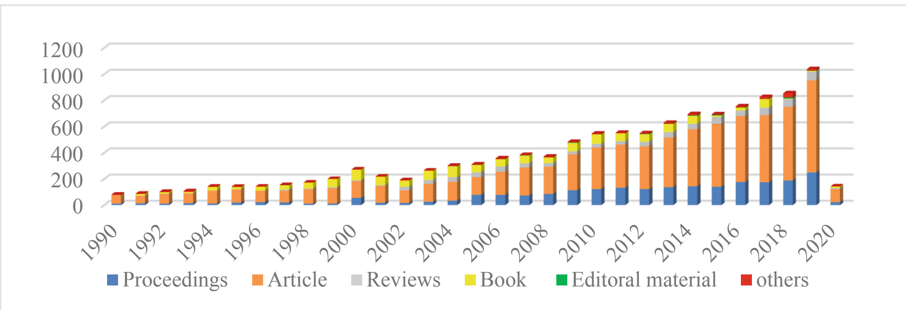

Fig. 1. The numbers of annual publications in mental workload during 1990–2020.

Lecture Note in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (338 publications) ranks the top one, which is a distinguish conference proceeding published the latest research developments in all areas of computer science. Proceedings of the Human Factors and Ergonomics Society (224) ranks the second, which is the annual meeting of human factors and ergonomics. Ergonomics ranked the top one among the journals with 162 publications, it is a journal with a strong focus on work, leisure and other aspects of our daily lives, with a 60-year tradition of publishing high-quality research in physical, cognitive, organizational and environmental ergonomics. Then Social Science and Medicine (144 publications) and Human Factors (138 publications) occupy the next two pistons. Social Science and Medicine publishes material relevant to any aspect of health. Human Factors published its first issue in 1958 and publishes studies in human factors/ergonomics.

3.2 Co-authorship Analysis

We then investigated the most productive countries. USA (4748), UK (912), Germany (777), Canada (648), and Netherlands (501) are the top 5 productive countries, followed by Japan (498), Australia (494), China (471), France (297), and Italy (282). USA dominant this field, and the publication count far exceeds the sum of other countries. The citation of countries can show the quality of publications of each country. And the results show that the top 5 cited countries are USA (159434 times), UK (33772 times), Netherlands (24442 times), Germany (20698 times), and Canada (14666 times), which are the sources of high-quality publications. In summary, the geographical distribution of the literature is uneven.

More than 6000 institutions have done research related to mental workload. The most productive organization is George Mason University with 36 publications, followed by UCLA (32 publications), University of Central (29 publications), University of Cincinnati (26 publications), University of Michigan (21 publications), etc. UCLA ranked first with citation frequency of papers for 4591 times, followed by University of New South Wales (2273 times), UCLA (1944 times), University of Cincinnati (1273 times), UCSB (1182 times), etc, which means that high-quality papers were mostly from these organizations. Among these organizations, the air force research laboratory of Wright-Patterson Air Force Base is the only non-institutional research organization and only two organizations are not from the USA.

We have further analyzed the co-authorship at the author level. Figure 2 displays the co-authorship network of productive authors by using VOSviewer. The minimum number of documents of an author was set 5, of the 27994 authors, 249 met the threshold. The 249 points represent the 249 authors. Different colors of points divided the authors into different clusters. The size of a point represents the number of publications. The line between two points represents that there exists co-authorship between each author. The distance between two circles is conversely corresponding to the collaboration between each author. Table 1 gives the top twenty most productive authors. Murai is the most productive author with 59 publications, who mainly investigate mental workload measurement of navigators, students, athletes and so on by using physiological signals. Among Murai's cooperative relationships, Hayashi, Kitamura, Wakida, Fukushi, Mitomo et al. are the core authors. Paas is the core authors in another research cluster, who mainly studies cognitive load theory and measurement, the relationship between mental effort and performance of students, and instruction design. Parasuraman is the core authors in the third large cluster, who researches mental workload in automation from psychophysiological measurement, especially neuroergonomics. More than one thousand journals accept and publish articles or conference papers related to mental workload, and we find that the authors are from 95 countries, which indicates that the study of mental workload has enough worldwide popularization. Certainly, the count of publication cannot indicate the influence of each author. Also, some names' frequencies are virtual because of the abbreviation phenomenon [20]. Therefore, we will reveal key authors and their work by co-citation analysis in the following section.

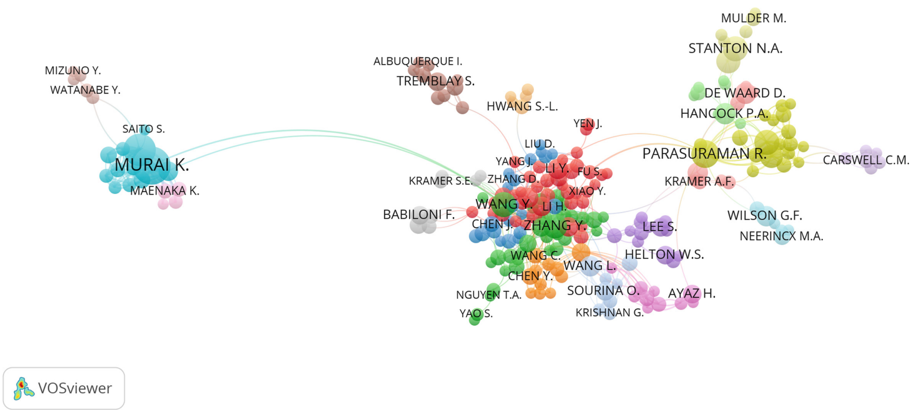

Fig. 2. Mapping on co-authorship of studies related to mental workload.

Table 1. The top 20 most productive authors.

Total publications	Author	Total publications	Institutes
59	Murai, K.	20	Wilson, G.F.
43	Hayashi, Y.	20	Zhang, J.
32	Paas, F.	19	Wickens, C.D.
32	Parasuraman, R.	18	Longo, L.
27	Stanton, N.A.	17	Sweller, J.
25	Matthews, G.	16	Kitamura, K.
25	Warm, J.S.	16	Liu, Y.
24	Young, M.S.	15	Ayaz, H.
21	Hancock, P.A.	15	Sourina, O.
20	Gendolla, G.H.E.	15	Tremblay, S.

3.3 Co-citation Network

9177 articles, 363210 references in Scopus. We analyzed a co-citation network (Fig. 3) of mental workload by retrieving records between 1990 and 2020 from Scopus. After selecting the top 50 cited articles each year, we got a total number of 11,157 publications with 461,366 references. Citespace was used to generate the co-citation network. The valid reference is 363,210 (78.725%), and the other 98,156 references are invalid for repeated or incomplete information. We constructed the network by using time-slicing and give a systematic review of relevant documents. The first paper with the strongest frequency was written by Hart in 1988. The second and third papers were [8] and [21], respectively.

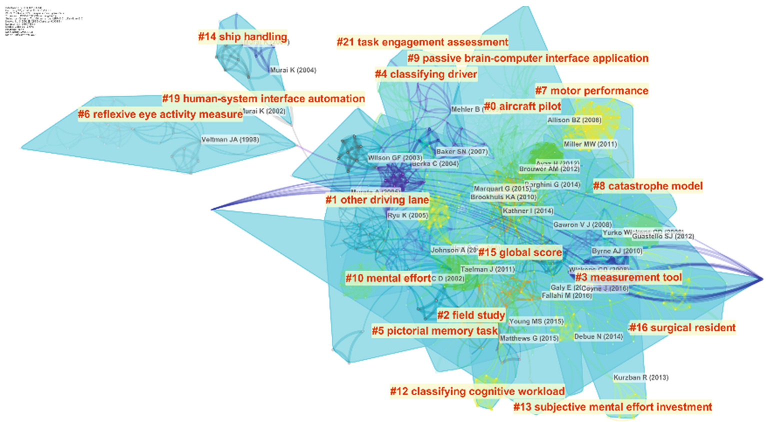

Fig. 3. Co-citation and cluster analysis.

The top-ranked paper by co-citation count is written by [22], a chapter in "human mental workload" [3], this article promoted one of the most outstanding subjective measures, i.e., NASA-TLX (Task Load Index). [21] gave a computational rendering of multiple resource model. [8] summarized the discoveries and developments of multiple resource theory in mental workload. [6] elaborated the capacity theory and identified attention with a general pool of limited capacity. [23] testified the reliability of the psychophysiological measures of mental workload in pilots. [25] addressed the four aspects of human use of automation and factors associated with them. [25] proposed a dynamic model addressing the effects of stress on vigilance and performance tasks. [26] summarized the studies using NASA-TLX. [27] proved the effectiveness of subjective measures of mental workload. [28] tested the sensitivity of physiological measures to mental workload in a flight simulator. [29] proposed the malleable attentional resources theory and suggested designers should pay attention to the driver support system.

3.4 Research Trends Analysis

Burst detection is adapted to identify emergent research-front concepts [30]. Table 2 shows the top 20 papers with the strongest burst of the 90 references with burst. Six articles have the strongest burst and with the ending year of 2020. Young et al.

Table 2. Top 20 references with the strongest citation burst.

Author	Burst	Begin	End	1990-2020
Ryu	7.5611	2007	2013	
Young	7.4702	2017	2020	
Wickens	7.2998	2005	2010	
Brouwer	6.479	2016	2017	
Wickens	6.4142	2004	2008	
Rubio	6.1611	2006	2010	
Matthews	6.0382	2015	2020	
Berka	5.9965	2011	2015	
Hart	5.9572	2012	2014	
Wickens	5.4597	2012	2016	
Hart	5.3546	1992	1994	
Miyake	5.1641	2007	2009	
Hogervorst	4.6892	2017	2020	
Miller	4.6152	2014	2017	
Herff	4.5664	2016	2017	
Borghini	4.5639	2017	2020	
Horrey	4.4316	2010	2011	
Wang	4.0989	2017	2020	
Fallahi	4.0989	2017	2020	
Wilson	4.0137	2014	2015	

(2015) reviewed the definition, measurement, and application of mental workload, which also indicate that this review was highly rated by peers. [10] tested the sensitivity of multiple workload indices to differing mental workload. [31] found that EEG performs best followed by eye related measures and peripheral physiology in workload assessment. [32] used neurophysiological measures to detect mental state of aircraft pilots and car drivers. [33] used Wireless EEG Signals and pattern recognition techniques to identify mental workload. [34] used multiple measurements to evaluate operators' mental workload in real traffic density monitoring condition. Also, the latest burst keywords showed that "machine learning", "classification", "automation", "physiology", and "mental health" may be the new research hotspot in this field, which have an ending year of 2020.

4 Conclusion

This study uses a quantitative and visual method to evaluate the history, current, and future of publications regarding mental. Although relatively objective and comprehensive, there are some limitations in this study. First, extensive databases containing other languages should be considered. Second, predefined terms are used which may make some publications ruled out. Third, bibliometric data are dynamic, but this analysis is based on a static data. Hence, some newly published and outstanding articles may not be cited many times but with a rapid increase. In this condition, a bibliometric analysis may not reflect the truth. This bibliometric analysis showed a visual and scientometrics review of false information in detail by collecting every related paper from Scopus from 1990 to 2020. The USA dominates the publications (4748, 42.56%) and citations (159434 times). George Mason University (36) is the most productive organization. Murai (59) is the most productive author. Ergonomics is the top journal with the most papers about mental workload. Hart and Staveland's paper (1988) is the most co-cited. "Machine learning", "classification", "automation", "physiology" and "mental health" may be the new research hotspot in this field. All the summarization of this study mainly depends on databases from Scopus, extensive literature should be collected. Few conclusions may be one-sided. Hence, the study should be updated in the future.

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Quality of Work Life and Burnout in Workers of a Health Institution in Guadalajara, México

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Abstract. The aim of the present study was to establish the relationship between Quality of Work Life (QWL) and Burnout Syndrome in workers of a health institution in Guadalajara, Mexico. Analytical study was carried out; the study population consisted of 5351 workers. All workers in grassroots positions who answered the questionnaire voluntarily were included.

For this study three questionnaires were considered: the first one collected sociodemographic and labor data; the second was the "CVT-GOHISALO" for the identification of the level of QWL in seven dimensions and finally the "Maslach Burnout Inventory (MBI-HSS)" scale for the evaluation of Burnout Syndrome in three dimensions.

The analyzes were descriptive and inferential. The descriptive analysis was used both in the socio-demographic and labor data, satisfaction of QWL and Burnout Syndrome. The association between them was established with Chi square, considering the association if p was lesser than 0.05. For the calculation of Odds Ratio (OR), the low and medium levels of the QWL dimensions were grouped as non-satisfaction and the high level was considered as satisfaction and, for the dimensions of Burnout were handled as absent (low-null) and present (medium and high).

Of 5351 workers included in the study, 68.2% were female; the average age being 38.6 years, 31.2% were graduated with a degree. The seniority in the position varied from less than a year to 37 years, being 11.7 years old average.

Regarding the evaluation of perceived QWL, 27.6% described as "low", 43.8% as "average" and 28.5% as "high". As for the dimensions of Burnout, we found that 30.3% presented "lack of personal realization" 16.5% presented "emotional exhaustion" and 13.5% presented "depersonalization".

Unsatisfaction with QWL in all its dimensions, showed a consistent association with the dimensions of Burnout Syndrome, showing values of risk factor in all cases. As can be seen, the non-satisfaction with the QWL is consistently a risk factor for Burnout Syndrome, being especially high in the dimension of emotional exhaustion.

Keywords: Quality of work life · Burnout Syndrome · Health institution workers

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1 Introduction

The concept of QWL is not new, but it is a term that has peculiar characteristics such as subjectivity and multidimensionality; besides being tinged in great part of the values and beliefs of the individuals in their determined historical moment, and implies the objective and subjective valuation of the different dimensions of the human needs. It has also been coined as a product of the evolution of the concept of quality of life (QL), which has gradually been related to health and work [1].

Thus, the QWL "explains the way in which work experience is produced, both in its objective conditions (safety, hygiene, salary, etc.) and subjective (the way in which it is lived by the worker). It is, therefore, a multidimensional concept formed by objective and subjective indicators that consider the individual and the context in which it develops" [2].

The objectives of the QWL are to achieve a greater humanization of work, focusing on numerous elements such as the development of the worker, high motivation, adequate performance of their functions, greater satisfaction, better use of free time, better social support systems, etc.

On the other hand, it is important to recognize that the health context has very particular characteristics, different from those of other types of organizations; they are highly complex and demanding environments, on a physical, psychological and social level [3].

To the above we must add characteristics of health care work, which further complicate the environment; professionals in health centers must face pain, death, terminal illness, as a high content of psychic burden of their work [4]. Aggregating an all that health institutions are usually bureaucratized organizations, highly hierarchical and very departmentalized [5].

The development of QWL indicators in health institutions is expected to lead to workers' health benefits ranging from accident prevention to stress reduction or the presence of Burnout Syndrome.

This syndrome, which in recent decades has been the subject of numerous studies because of the effects it has on both the mental health of the worker and the environment of the company.

The concept was mentioned for the first time since the work of the psychiatrist Herbert Freudenberger in 1974 [6], to refer to the lack of motivation and lack of interest they had after 2 or 3 years of work, those volunteers working in their Free Clinic.

Later, Maslach's conceptions are presented as a response to chronic labor stress, and manifested in a three-dimensional way with: emotional exhaustion, depersonalization and lack of personal fulfillment at work [7].

In previous studies, the presence of Burnout Syndrome in health workers is widely recognized [8–10].

However, prevalence seems to vary significantly according to different working conditions, the prevalence of Burnout Syndrome seems to be more frequent and intense in emergency departments [11], the educational level of workers seems being associated with the high levels of Burnout dimensions, as well as the monotony of activities, reduced responsibility and lack of decision-making possibilities, which occurs in public health centers [12].

And there have been approximations to support a relationship between the QWL and the presence of the syndrome [2].

2 Aim

The aim of the present study was to establish the relationship between the QWL and Burnout Syndrome in workers of a health institution in Guadalajara, Mexico.

3 Methodology

A descriptive, analytical and comparative study was carried out. The study population consisted of 5351 workers from the Mexican Social Security Institute in the State of Jalisco, Mexico. All workers in grassroots positions who answered the questionnaire voluntarily were included.

For this study three questionnaires were considered: the first one collected sociodemographic and labor data with items such as gender, marital status, age, educational level, presence or not of children, current position, work shift, seniority in the current position and in the institution, as well as weekly hours; the second was the "CVT-GOHISALO" for the identification of the level of QWL and finally the "Maslach Burnout Inventory (MBI-HSS)" scale for the evaluation of Burnout Syndrome.

The CVT-GOHISALO, consisting of 74 items with Likert responses of 5 options, was elaborated and validated in the Mexican population and has validation of content, criteria and construct [14], has a reliability of 0.9523 with Alpha de Crombach and measures the QWL in seven dimensions: (1) Institutional work support, (2) Job reliability, (3) Integration to the job, (4) Satisfaction with the work, (5) Well-being obtained through the job, (6) Worker's personal development and (7) Free time administration.

The "Maslach Burnout Inventory (MBI-HSS)" rating scale, used to evaluate Burnout or Burnout Syndrome, consists of 22 items with three dimensions, using a Likert scale with options ranging from "never" to "every day". It evaluates the three dimensions already mentioned: 1) Emotional exhaustion, 2) Depersonalization and 3) Lack of personal realization. Each of the items is added according to the dimension and the scores are placed at a high, medium or low-grade level.

The instrument has shown alpha values of Cronbach $\alpha = .90$ for emotional exhaustion, $\alpha = .79$ for depersonalization and $\alpha = .71$ for lack of personal fulfillment in the work [15].

The analyzes were descriptive and inferential. The descriptive analysis (frequencies and averages) was used both in the socio-demographic and labor data for the knowledge of the population and in each one of the instruments applied to obtain the prevalence of both psychosocial factors and social support and Burnout.

For the inferential analysis of data the low-null, medium and high levels were established for each of the dimensions of Burnout Syndrome and those of QWL, establishing the association between them with Chi square, considering significant the association if p was less than 0.05, and for the calculation of OR, the levels of Burnout dimensions were grouped into absent (low-null) and present (medium and high) and the values of the dimensions of QLW, considering the valid OR when it is greater than 1, reliability levels do not include the unit and there is an association value according to the established ($p < 0.05$).

4 Results

The study involved 5351 workers from the Jalisco Delegation of the Mexican Social Security Institute, of which 68.2% were female; the age ranged from 18 to 66 years, with the average age being 38.6 years.

In terms of marital status, 30.4% are singles and 55.9% are married, the rest are divided among widows, separated and divorced.

In terms of schooling, 31.2% graduated with a degree, followed by 30.8% with a technical career and 18.2% with some form of postgraduate studies.

The type of basic recruitment predominated with 94%; that work 45.4% in morning shift, 30.7% in evening, 12.8% in night and the rest in different forms of continuous hours or accumulated days. The seniority in the position varied from less than a year to 37 years, being 11.7 years old average.

Regarding the evaluation of perceived QWL, 27.6% described as “low”, 43.8% as “average” and 28.5% as “high”.

The dimensions or scales with the worst qualifications were “ Well-being obtained through the job “ with 67.1% rated “low” and “Satisfaction with the work” with 54.8% also in the “low” level. While the best qualified would be the “Institutional work support” with 57.5% in “high” level and “Job reliability” with 56.3% in the same level (see Table 1).

Table 1. Percentage of satisfaction with the Quality of work life by dimensions

Dimensions	Levels		
	Low	Medium	High
Institutional work support	21.3%	21.2%	57.5%
Job reliability	9.7%	34%	56.3%
Integration to the job	43.7%	36.7%	19.6%
Satisfaction with the work	54.8%	24.2%	21%
Well-being obtained through the job	67.1%	13.6%	19.3%
Worker’s personal development	26.9%	48.5%	24.6%
Free time administration	44%	37.3%	18.7%

As for the dimensions of Burnout, we found that 30.3% presented “Lack of personal realization” (18.6% at high level and 11.7% at medium level), 16.5% presented “Emotional exhaustion” (5.4% at high level and 11.1% in the middle level) and 13.5% presented “Depersonalization” (5.4% high level and 9.1% average level) (see Table 2).

Table 2. Presence of Burnout Syndrome by dimensions (percentages)

Dimensions	Levels		
	Low	Medium	High
Emotional exhaustion	21.3	21.2	57.5
Lack of personal realization	9.7	34	56.3
Depersonalization	43.7	36.7	19.6

QWL, as well as all its dimensions, showed a consistent association with the dimensions of Burnout Syndrome, showing values of risk factor in all cases.

The values of risk of the QWL in global were of OR = 4.41 for the emotional exhaustion, OR = 2.04 for the depersonalization and of OR = 1.62 for the lack of personal fulfillment.

Analyzed by dimensions, the highest risk factors for Emotional exhaustion were "Integration to the job" with an OR = 4.04 and "Worker's personal development" with an OR = 4.03; while for the Lack of personal realization, the highest risk factors were "Well-being obtained through the job" with OR = 1.95 and "Satisfaction with the work" with OR = 1.89; For the dimension of Depersonalization, the highest were "Integration to the job" with OR = 2.22 and "Free time administration" with OR = 2.20 (see Table 3).

Table 3. Association between the Quality of Work Life and Burnout Syndrome by dimensions

Quality of Work Life Dimensions	Burnout Syndrome Dimensions		
	Emotional exhaustion	Lack of personal realization	Depersonalization
Institutional work support	OR = 3.35 I.C. = 2.87–3.92 p = .000	OR= 1.42 I.C. = 1.23–1.63 p = .000	OR = 1.85 I.C. = 1.56–2.19 p = .000
Job reliability	OR = 4.67 I.C. = 3.85–5.66 p = .000	OR = 1.50 I.C. = 1.24–1.81 p = .000	OR = 2.02 I.C. = 1.62–2.51 p = .000
Integration to the job	OR = 4.04 I.C. = 3.45–4.73 p = .000	OR = 1.77 I.C. = 1.57–1.99 p = .000	OR = 2.22 I.C. = 1.90–2.59 p = .000
Satisfaction with the work	OR = 2.89 I.C. = 2.45–3.40 p = .000	OR = 1.89 I.C. = 1.67—2.13 p = .000	OR = 1.53 I.C. = 1.30–1.79 p = .000
Well-being obtained through the job	OR = 2.48 I.C. = 2.07–2.97 p = .000	OR = 1.95 I.C. = 1.71–2.23 p = .000	OR = 1.62 I.C. = 1.36–1.94 p = .000
Worker's personal development	OR = 4.03 I.C. = 3.47–4.68 p = .000	OR = 1.84 I.C. = 1.62–2.09 p = .000	OR = 2.07 I.C. = 1.76–2.42 p = .000
Free time administration	OR = 2.62 I.C. = 2.26–3.04 p = .000	OR = 1.38 I.C. = 1.23–1.56 p = .000	OR = 2.20 I.C. = 1.88–2.57 p = .000

5 Discussion

In the last 10 years there are many studies of Burnout Syndrome in health workers, the prevalence of the three dimensions show a great variety, but all higher than those reported in our study. Some studies show prevalence of emotional exhaustion ranging from 42.3%, where 16.5% is at high level and 25.8% at medium level, found in specialist doctors throughout the Spanish State (n = 1021) [16]; up to 83.2% (40.6% in high level and 42.6% in medium level) reported in nursing professionals in Gran Canaria (n = 101) [3]. Our study showed a prevalence of 16.5% (5.4% in high level and 11.1 in middle level) to consider that our study is in Mexican population, with all types of health workers, not only nurses or specialist doctors and a large population (n = 5351) from a single public health institution.

The values found for Lack of personal realization vary from 31.3% (14.1% high level and 17.2% average level) reported by Ávila [17] in a population of health professionals from two private clinics in the city of Montería, Colombia (N = 99) to 61.4% (29.7% high and 31.7%) in the study by Farrerons [3] with nursing professionals in Gran Canaria (n = 101). While our data show 30.3% (18.6% and 11.7% in high and medium respectively), drawing attention to the closeness with the Colombian population, although Ávila's study [17] refers to private clinic workers and ours to a public institution.

On the other hand, data related to depersonalization in different studies tend to be the highest prevalences [18, 17, 2], contrary to what was found in our study, which were the lowest. Prevalences may exceed 70%, as in studies of Flores [2], which report 74.9%, Scribe [16] with 73.0% and Farrerons [3] with 71.3%; while the workers in our study reported only 14.5% (5.4% in high level and 9.1% in medium level).

The dimensions of Burnout Syndrome have been associated with various organizational and/or psychosocial factors of work; the type of contract, satisfaction and monotonous work [3], with the performance of guards [19], with contact with suffering and death, work overload, and professional seniority [16]. For our part, the seven dimensions of QWL showed a solid consistency in their relation with the Burnout Syndrome, since all of them qualified as risk factor for the three dimensions of Burnout.

6 Conclusions

As can be seen, QWL is consistently a risk factor for Burnout Syndrome, being especially high in the dimension of emotional exhaustion.

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Cross-Cultural Decision Making Focus

Comparative Analysis of Website Usability Between United States and Japan

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Abstract. The aim of this study is to reveal differences of web design from the viewpoint of usability between United States and Japan that have different cultures and design preferences. Nine companies that had websites for their local offices in both United States and Japan were selected for the survey of this study. To compare the usability between United States and Japanese websites, heuristics evaluation was performed by the authors. The authors attempted to find the usability drawbacks from four to six pages including the top page in each company's website. The total number of usability drawbacks that was identified in the United States and Japanese websites was compared. As the result of the *t*-test, the usability drawbacks that were observed in the Japanese websites were more than those in the United States websites. The ratio of each of the ten usability heuristics was compared between the United States and Japanese websites. Compared with the United States websites, the Japanese websites had more "aesthetic and minimalist design" drawbacks.

Keywords: Web design · Cultural difference · Web usability · Usability heuristics · Heuristics evaluation

1 Introduction

Because the number of global internet users is large and they have diverse cultures, web design localization has been accelerated to adapt to specific languages, cultures, and preferences. In such circumstances, web designers must consider cultural aspects to enhance website usability and user satisfaction. According to Petrie et al. [1], the approach to develop accessible and usable designs will be different based on different cultural contexts. With respect to web design, the cultural viewpoint of web usability has been discussed by several researchers.

With respect to design characteristics in different cultures, Cyr and Trevor-Smith [2] and Doi and Murata [3] investigated the differences of web design characteristics among several countries to examine the design direction considered for the localized websites. They reported that the websites of these countries had statistically significant different characteristics from several viewpoints. Barber and Badre [4] and Marcus and Gould [5] reported that several different characteristics of the user-interface design existed among countries that had different cultural characteristics. Alexander et al. [6, 7] tried to

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develop cross-cultural web design guidelines based on the findings of cultural differences among some countries.

Several studies exist with respect to the usability assessment considering the cultural differences. Becker and Mottay [8] summarized the global perspective on websites usability. Zhou and DeSantis [9] and Fang and Rau [10] performed usability evaluations of websites associated with countries that had different cultural backgrounds and compared the results. They showed that usability drawbacks associated with cultural differences existed.

As described above, different countries have different design preferences as well as characteristics of web designs. However, the findings, from the viewpoint of usability to design websites, have been limited. To expand on the previous studies, a survey was conducted to grasp the cultural differences of website usability. The aim of this study is to reveal differences of web design from the viewpoint of usability between United States and Japan that have different cultures and design preferences. This study will contribute to understanding characteristics of web designs associated with countries that have different cultural background and enhance usability by taking into account cultural differences.

2 Cultural Differences Associated with Web Designs Between United States and Japan

2.1 High-Context and Low-Context Cultures

High-context and low-context cultures were proposed by E.T. Hall as classifications for linguistic communication [11]. These classifications help to understand the communication style of different countries and regions. High-context cultures are communication cultures that frequently use non-linguistic communication and do not require strict linguistic expression in their communication. In contrast, low-context cultures are communication cultures that use strict and concrete linguistic expression and emphasize linguistic communication. United States is classified as a low-context culture, while Japan is classified as a high-context culture.

2.2 Color

The meaning of and/or preference for colors are different among countries that have different cultures and customs. Therefore, the color designs of websites tend to differ between United States and Japan. Russo and Boor [12] showed some of the different meanings among several countries. Table 1 shows the differences between Japan and United States based on their findings.

With respect to the trend of web design, according to Doi and Murata [3], United States websites tend to use deep colors compared with Japanese websites. Moreover, Japanese websites tend to use white as a background color.

Table 1. Cultural differences in the meaning of colors between Japan and United States [12].

	Red	Blue	Green	Yellow	White
Japan	Anger, Danger	Villainy	Future, Youth, Energy	Grace, Nobility	Death
United States	Danger, Stop	Masculine	Safety, Go	Cowardice, Temporary	Purity

2.3 Appearance

The visual characteristics of both United States and Japanese websites can be summarized as follows based on the findings of Cyr and Trevor-Smith [2] and Doi and Murata [3]. Japanese sites tend to use considerable text and have few blank spaces. Additionally, the point form is frequently used to list many items. Moreover, in Japanese sites, the 3 columns layout is frequently used, while the footer navigation is not frequently used in Japanese site. Moreover, many banners feature on the top page. The frequent use of the banners is considered a unique feature of Japanese sites.

The United States sites typically tend to have less information per page. Because the amount of text is small, headings and the point form are not frequently used to organize text information. Moreover, the United States sites used the 1 column grid layout and a large photograph features as a headline image in many web sites.

3 Method

3.1 Analyzed Websites

Nine companies that had websites of their local offices in both the United States and Japan were selected for the survey; therefore, 18 websites were investigated (9 companies $\times$ 2 countries). Table 2 shows the list of the analyzed websites.

Table 2. List of the analyzed websites.

Company	Japan	United States
Yahoo!	https://www.yahoo.co.jp/	https://www.yahoo.com/
Godiva	https://www.godiva.co.jp/	https://www.godiva.com/
Uniqlo	https://www.uniqlo.com/jp/	https://www.uniqlo.com/us/en/home/
P&G	https://jp.pg.com/	https://us.pg.com/
Diseny	https://www.disney.co.jp/	https://www.disney.com/?intoverride=true
Coca cola	https://www.cocacola.jp/	https://us.coca-cola.com/
Caterpillar	https://www.nipponcat.co.jp/	https://www.cat.com/en_US/products/new/parts/reman.html
Starbucks	https://www.starbacks.co.jp/	https://www.starbucks.com/
Toyota	https://toyota.jp/index.html	https://www.toyota.com/

3.2 Usability Evaluation

To compare the usability between the United States and Japanese websites, heuristics evaluation [13] was performed by the authors. Heuristics evaluation is the one of the methods of usability inspection to find usability drawbacks in each page and/or task through the reviews from the viewpoint of Nielsen's ten usability heuristics: (#1) visibility of system status, (#2) match between system and the real world, (#3) user control and freedom, (#4) consistency and standards, (#5) error prevention, (#6) recognition rather than recall, (#7) flexibility and efficiency of use, (#8) aesthetic and minimalist design, (#9) help users recognize, diagnose, and recover from errors, and (#10) help and documentation. The authors attempted to find the usability drawbacks from four to six pages including the top page in each company's website. Each usability drawback was associated with the ten usability heuristics.

3.3 Analysis

The total number of the usability drawbacks that was identified in the United States and Japanese websites was compared. The paired *t*-test was performed to statistically compare the total number of the usability drawbacks. Moreover, the usability drawbacks were broken down to the ten usability heuristics, and the ratio of each of the ten usability heuristics was compared between the United States and Japanese websites. To compare the ratio of each item for all the usability drawbacks identified for the websites of each country, the two-proportions *Z*-test was performed for each of the ten usability heuristics between the United States and Japanese websites.

4 Results

The mean number of usability drawbacks in each country is shown in Fig. 1. As the results of the *t*-test indicate, the usability drawbacks that were observed in the Japanese websites were more than those in United States websites ($t(8) = 2.45$, $p < 0.05$).

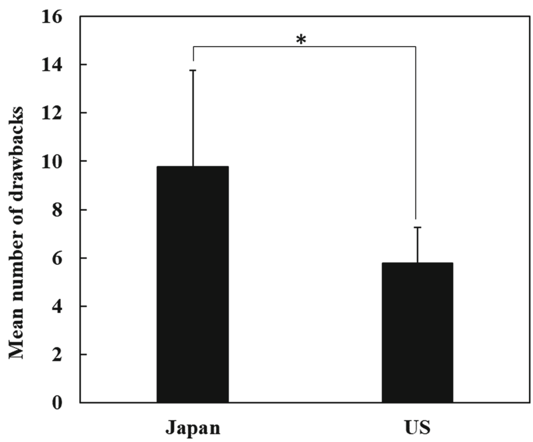

Fig. 1. Mean number of usability drawbacks in each country's website (Error bar shows the standard deviation. *: $p < 0.05$).

The ratio of the drawbacks for each of the ten usability heuristics is shown in Fig. 2 (top: Japan, bottom: United States). As per the results of the two-proportions Z-test, the "aesthetic and minimalist design (#8 of 10 usability heuristics)" drawbacks of the Japanese websites are significantly more than those of the United States websites ($Z = 1.89$, $p < 0.05$). For the other ten usability heuristics, no significant differences were observed between the Japanese and the United States websites.

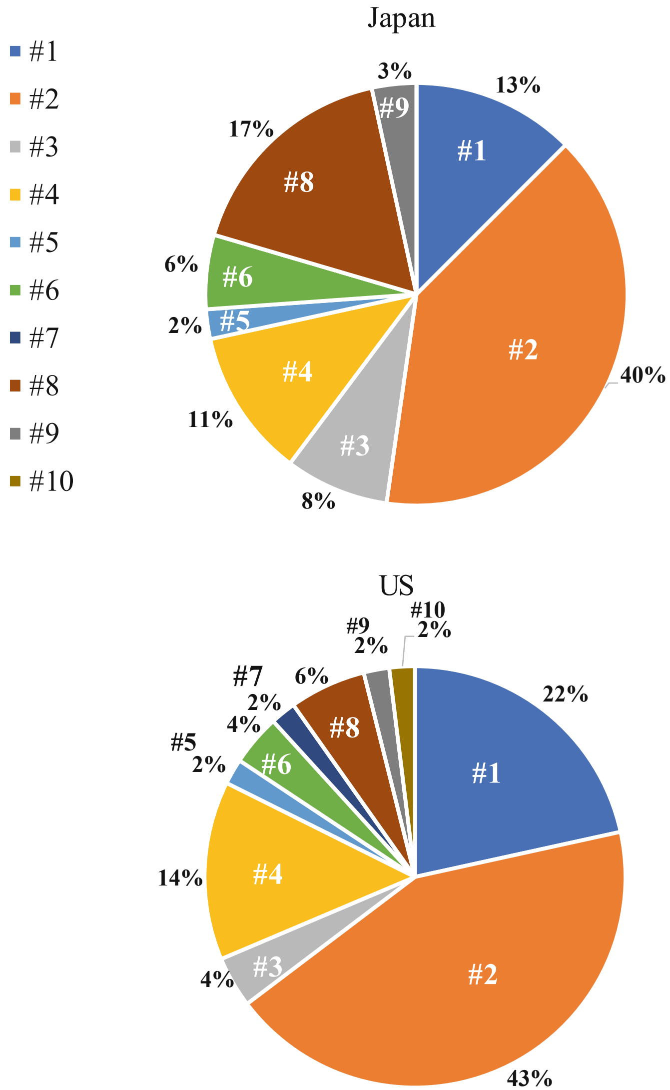

Fig. 2. Composition ratio of the ten usability heuristics (top: Japan, bottom: United States).

5 Discussion

As shown in Fig. 1, the number of usability drawbacks in the Japanese websites was significantly more than that in the United States websites. This means that even if the contents of a website are nearly identical, the usability of Japanese websites is poorer than that that of the Unites States websites.

To understand the features of the usability drawbacks in greater detail, the usability drawbacks were categorized using the ten usability heuristics, as shown in Fig. 2. In both the countries, the drawbacks with “match between system and the real world (#2)” were the most frequent. In contrast, there were few drawbacks with “error prevention (#5),” “help users recognize, diagnose, and recover from errors (#9),” and “help and documentation (#10)” in this survey. These characteristics seem to be common usability drawbacks in the both the countries.

As per the results of the two-proportions Z-test that was used to statistically compare the ratio of the usability drawbacks of the ten usability heuristics between both the countries, the “aesthetic and minimalist design (#8)” drawbacks in the Japanese websites were significantly more than those in United States websites. The Japanese websites tend to include considerable information per page and have few blank spaces. Because users cannot understand where to look first, they may face difficulties in searching for specific information. In contrast, the United States websites tend to have less information per page and are organized well.

The above-mentioned characteristic of website usability in both Japan and United States matches the differences of web designs associated with cultural differences that were reported by Doi and Murata [3]. The previous study also showed that Japanese websites had a tendency to include considerable information (text, banners, etc.) with few blank spaces. The consideration can be made that the design characteristics affect the above-mentioned usability drawbacks. On the other hand, the previous study showed the United States websites had a tendency to adopt simpler layouts with less information. Therefore, information could be organized in a much easier manner in the United States websites.

One of the causes of the above-mentioned difference between the United States and Japanese websites may be the high- and low-context cultures. As previously mentioned, Japan is classified as a high-context culture and the United States is classified as a low-context culture. High-context cultures do not depend on linguistic communication and can guess the message of a speaker (or writer) well. Therefore, the consideration can be made that because Japan has a high-context culture, even though considerable information is included per page on Japanese websites and it not organized well, readers of the websites can still guess the contents.

The future work related to this study that needs to be undertaken is discussed. In this study, only heuristics evaluation, which is one of the expert review methods, was adopted. However, user testing was not performed. To obtain even more detailed findings, user testing comprising users from several countries should be performed. Subsequently, user preference and performance associated with each website can be discussed to understand how cultural differences influence web designs.

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Attitude Toward Long Working Hours from the Perspectives of Cross-Cultural Difference of Viewing Things and Scarcity-Slack Relation

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Abstract. Cross-cultural differences between Japan and US contributed to the attitude toward long working hours, that is, the acceptance of the reduction of working hours. US people seem to be more acceptable to the reduction of long working hours than Japanese people, although both countries have gradually accepted and recognized that the reduction of working hours will eventually lead to high efficiency. Based on scarcity and slack relation, it is reasonable to think that scarce state with less slack in workplaces is not necessarily resolved by increasing manpower or working hour of each worker. This scarcity and slack relationship is more acceptable to US people who tend to be more tolerant to the reduction of working hours.

Keywords: Long working hours · Cross-cultural difference · Way of thinking · Scarcity-slack relation · Productivity · Working hours-productivity relation · Harmony

1 Introduction

The problem of long working hours is an important ergonomics issue, because long working hours affect the productivity (efficiency) [1] and the safety measures such as human errors or the number of defective products manufactured. According to Nisbett [2], the way of thinking of Western people is characterized by the following properties. Western people cannot see the forests for the trees. This generally means that they cannot review the overall situation before discussing the details. Western people also seem to infer causes based on effects. They are good at purpose-oriented inferences, prefer simplicity, are apt to ignore the role of context, tend to over evaluate the competence of humans' predictability of behavior, and are vulnerable to fundamental attribution error. Contrary to the properties of Western people, Eastern people are said that they cannot see the trees for the forests, assume more complexity than Western people, and tend to have comprehensive belief (therefore, judge that we cannot know trees without seeing forests). This study based on such a difference of way of thinking, and compared and discussed the attitude toward long working hours among US and Japan.

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As well as the different way of thinking between US and Japan, long working hours based on scarcity and slack relation [3] are discussed as follows. Mullainathan and Shafir [3] assumed that the waste of time and fund should be viewed as not scarcity but slack for creative activity. Although taking extra time and learning knowledge that is seemingly unrelated to the task that we engage in at present seems to be wasteful, this is helpful for us someday. However, it must be noted that this waste of time or fund might create nothing. Such a case, in particular, must be dominantly observed for routine works. We must, therefore, wisely differentiate the two types of waste, that is, the waste that works for creating slack and the waste that doesn't. The concept of scarcity and slack relation must be more and more useful even in addressing the issue on the relationship between working hour and humans' performance such as productivity.

In case of Ford motors, stopping long hours of work and shortening hours of work led to the increase of production efficiency and the decrease of workers' human errors. This must mean that long hours of work do not necessarily increase the slack (or compensate for scarcity) for enhancing competence and efficiency of workers and consequently increase the processing capacity of each worker. In short, hours of work are not proportionally related to processing capacity and do not increase slack and make it possible to resolve scarcity issues of workplaces. There are many cases where longer working hours to compensate for scarcity do not work for achieving a goal or objective. Therefore, we always need to quest for the condition to increase slack (decrease scarcity) for effective work performance.

Japanese companies or organizations are in particular apt to misunderstand that longer working or training hours lead to enhanced achievements. This must be attributed to Japanese way of thinking to see the forests (organization as a whole) for the trees (individual workers), assume more complexity than Western people, and have comprehensive belief that leads to judging that trees (individual workers) cannot be understood without seeing forests (company or organization as a whole). It is reasonable to ponder that such properties to prefer an organization to an individual are based on the spirit of "Wa" widespread among Japanese people [4–7]. Such a way of thinking does not make an organization or company notice that optimum workload of each individual supported by shorter working hours works for the compensation of scarcity that hinders work efficiency and increase slack to increase work efficiency. On the other hand, Western style to pay more importance on the trees (individual workers) than on the forests (organizations or companies) enable people to recognize that achieving moderate workload for each workers at the sacrifice of longer working hours eventually leads to the elimination of scarcity to attain a goal or aim and the increase of slack. Therefore, it is speculated that Ford motors succeeded in shortening hours of work and increasing the production efficiency and workplace safety.

The aim of this study is to discuss the difference of working hours between US and Japan from the following viewpoints of cross-cultural difference, mindset of Japanese people who base their behavior on harmony "Wa", and the relationship between scarcity and slack.

2 Cross-Cultural Difference of Viewing Things or Way of Thinking Between West and East

2.1 How Western and Eastern People Think Differently [2]

The way of thinking of Western people are characterized by the following properties. They cannot see the forests for the trees. This generally means that Western people cannot review the overall situation before discussing the details. Western people also seem to infer causes based on effects. They are good at purpose-oriented inferences, prefer simplicity, are apt to ignore the role of context, tend to over-evaluate the competence of humans' predictability of behavior, and are vulnerable to fundamental attribution error.

Contrary to this, it is said that Eastern people cannot see the trees for the forests, assume more complexity to interpret or view things than Western people, and tend to judge that we cannot know trees without seeing forests. This study is based on such a different way of thinking or viewing things, and compared and discussed the attitude toward long working hours between US and Japan.

2.2 Group Harmony ("Wa") Peculiar to Japanese

Whiting [6, 7] discussed group harmony in Japanese baseball including high school and professional baseball league, which emphasizes the importance of group harmony and is opposite to MLB that gives priority to concentration and individualism. Such a cultural difference is reflected in the difference of training hours and spiritualism toward baseball. Japanese high school baseball players don't mind at all to play at a stadium under poor environment such as severe heat. US baseball coaches never make their players play under such fierce heat. Comparing training hours in spring training between MLB and NPB, long training duration is apparently more dominant in Japan. Long training hours must come from the harmony-based way of thinking. There are a lot of NPB players from US who feel that such long training hours do not fit them.

In US, throwing restriction of a pitcher is strictly enforced. The number of pitches, for high school students of 17–18 years old is restricted to 105 pitches. Moreover, they are forbidden to pitch for four days after they pitch more than 80. On the other hand, Japanese high school baseball players frequently pitch more than 300 (at the worst case, pitches more than 500) for four or five days without throwing restriction. Japanese baseball is rather non-scientific and players are required to pitch with spirit and grit even if they are exhausted and feel pain in their shoulder. In Whiting [6, 7], he sounded a warning to no restriction of pitches. Although there is some trend to restrict the number of pitches recently in Japan, the strict throwing restriction system has not been established especially in Japanese high school baseball. The tendency of long working hours is also reflected in such a tendency of long training hours and no restriction of pitches.

The properties mentioned above are all based on Japanese spiritualism "Wa", and a mindset not to complain even if players feel that the playing environment is very tough. Such a complaint is regarded as a behavior that is not based on harmony "Wa" which Japanese people traditionally cherish and value. Thus, Japanese people are more tolerable to long training or working hours than people in US. They can pitch more than 300 for four days without complaints even if they feel a pain in their shoulder.

3 Scarcity-Slack Relation

In order to understand scarcity-slack relation, it is necessary to differentiate between waste and slack. Waste is interpreted as follows. Even if the blank is compensated for by the increase of work hours, this never leads to the increase of processing competence. The longer work hours are never helpful for enhancing the processing competence individually or as a whole organization. The concept of slack regards the blank not as waste but as absolutely essential for enhancing processing competence of jobs at workplaces.

Forcing workers to work for long hours to meet the deadline of delivering products give rise to more errors, and adversely reduce efficiency. This corresponds to tunneling in the concept of scarcity and slack relationship. Reducing working hours per day or week seems on the surface to decrease productivity. However, this does not necessary reduce productivity. Rather, the reduction of work hours per day or week leads to high efficiency and fewer errors, and eventually increases productivity.

Under multi-tasking or scarce states, concentration on one thing induces tunneling for other things. Cognitive processing ability of not only a concentrated task but also other tasks is degraded. All tasks cannot be appropriately executed due to the limitation of cognitive resources (bandwidth). Therefore, we cannot help making a tradeoff among tasks, and we tend to prioritize things to be done immediately. Therefore, we cannot worry about and plan the future, and we cannot afford to take into account the occurrence of errors or mistakes and worry about the future without discounting. Slack makes it possible to recover readily from an error or mistake, and makes us more creative. Slack does not make scarce states, and makes us afford to concentrate on a task under a moderate feeling of tension, stress, or workload.

Less slack due to scarcity (too low and too high workload) leads to a lack of motivation for making effective use of cognitive resources necessary for effective work or problem solving. The motivation to exerting cognitive efforts and solve a problem is low and the slack to heighten motivation is less when we are faced with scarcity. As the adaptability cannot be increased under low and high workload, the task cannot be processed with flexibility. Therefore, it is impossible to cope with an error caused by less or excessive concentration. It is speculated that slack by means of moderate working hours contributes to increased flexibility and adaptability, and eventually enhances workers' efficiency.

4 Difference of Attitude Toward Long Working Hours Between Japan and US

4.1 How Different Way of Thinking Lead to Different Recognition of Working Hours and Productivity Relation

Comparing training hours in spring training between MLB and NPB, long training duration is apparently dominant in Japan. As mentioned above, the number of pitches for 17–18 years old high school students in US is strictly forbidden to pitch more than 105 over four days. After they pitch more than 80, they cannot pitch in the competition for four days. Contrary to this, Japanese high school baseball pitchers sometimes pitch more than 500 during a week. The tendency of traditionally-accepted long working hours is also reflected in such a tendency in baseball. In other words, it seems that the tendency of long work hours in Japan seems to be traditionally reflected in activities other than those in workplaces. Long working hours seem to be inherited even in longer training hours of NPB players and unrestricted number of pitches of high school baseball pitchers.

In Japan, there are following proverbs related to "Wa" (harmony). These proverbs include: selfless devotion, self-sacrifice for an organization, self-annihilation for the sake of an organization, and cherish the harmony among the people. While Japanese NPB players never attend childbirth of their wives during the year's baseball season, NPB players from US never fail to prioritize childbirth of their wives and return back to their home country and be absent from the game for a while. It is said that Japanese players are unable to witness to their parents' death if they are during the year's baseball season. They are encouraged to prioritize their job (play baseball in the game). Such a way of thinking is never applicable to NPB players from US or other countries. Such characteristics of Japanese players reflect Japanese culture to think and view not the trees but the forests.

There is also a famous word "joint responsibility" in Japanese high school baseball. If some players of high school baseball team commit anti-social acts (for example, caught and admonished by a police), the baseball team must be collectively responsible for the undesirable act taken by a few members of the team. Consequently, the team is forbidden to match other teams and to participate in a variety of competitions for a predetermined period. In US, only players who committed anti-social acts are forbidden to participate in the competition. This vividly represents the cultural difference between Japan and US.

The difference above leads to different way of thinking about working hours and productivity and different recognition of the importance of reducing working hours for increasing productivity between US and Japan.

4.2 How Recognition of Scarcity and Slack Relation Affects Attitude Toward Long Working Hours

The strategy of long work hours is frequently widespread so that the delay of schedule is recovered or the achievements are enhanced and the achievement goals are satisfied. On the basis of the discussion in Sect. 4.1, this study definitely demonstrates that investing more time by increasing the number of workers or forcing workers to concentrate on a long-hour work does not increase efficiency and concentration on each work. Rather, shorter work hour works for increasing cognitive processing competence and efficiency and accuracy of job or work.

The scarcity and slack relation is applicable even to the issue of reducing work hours per day or week. Even if work hours increase, the scared state cannot be compensated for. To address this issue and reach a solution to scarcity in workplaces, we should attempt to increase slack of each worker without increasing work hour per day or week with the purpose of enhancing creativity necessary for problem solving in workplaces.

5 Discussion

It seems that the difference of way of thinking or viewing things between US and Japan apparently affect training hours or the strategy of restriction of pitches in baseball societies, the work hours per day or week, and the tolerance to the reduction of work hours. The way of viewing things that emphasized not the forests but the trees and the simplicity readily leads to the recognition of the importance of slack and enhancing slack with moderate work hours that does not impair creativity of workers and maintain the workload at a moderate level. Japanese management should be more actively recognize the importance of workers' performance enhancement by a full understanding of scarcity and slack relation. The increase of work hours to compensate for the scarcity in a variety of workplaces such as the necessity to meat a imminent deadline never works, and we should recognize the importance of increasing slack to resolve a variety of scarcity issues in workplaces with more creativity (slack).

As have already mentioned, harmony-based way of thinking (see not the trees (individuals) but the forests (organization)) peculiar to Japanese is represented by self-annihilation for an organization, cherish harmony among the people, selfless devotion, self-sacrifice for an organization.

These properties might make Japanese tend to think that longer work hours lead to resolve the issue of scarcity (low efficiency). Moreover, Japanese will not pay attention to slack-scarcity relation and will not manage processing competence of each worker to increase the efficiency of workplace or organization as a whole.

6 Conclusions

From (i) the perspective of cross-cultural difference of way of thinking or viewing things between US and Japan and (ii) scarcity and slack relationship, the difference of attitudes toward long working hours between US and Japan was discussed. The cross-cultural difference (whether "Wa"-based culture is dominant or not) between US and Japan affected the recognition that the reduction of work hours leads to the enhanced efficiency.

It is speculated that US people tend to be more acceptable to the effectiveness of reduction of work hours on the basis of the accurate understanding of scarcity-slack relation. These results indicate that the reduction of work hours must be practiced taking into account cross-cultural differences, that is, how things are interpreted and viewed (which is emphasized, the forests (organization) or the trees (individuals)).

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A Mixed Methods Case Study: Japanese Sojourners' Intercultural Awareness

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Abstract. Ministry of Education in Japan is promoting Japanese students to develop English communication competence and intercultural communication competence. One way that they do this is by encouraging students to study abroad. English communication skills have been reported to improve during study abroad, as short as even one-month study abroad. However, intercultural communication competence is under researched, and intercultural competence has not been reported to develop during short-term study abroad, nor medium-term study abroad. In addition, there has not been any report of clear relationship between English proficiency and intercultural communication competence. This study focuses on investigating the cases of Japanese students studying abroad for one month in Canada. The purpose of this study is to describe cultural learning. The participants of this study are 29 students. Two research questions were generated: Q1) What cultural awareness took place during study abroad? Q2) Did sojourners' cultural awareness differ depending on the proficiency levels? This case study is a mixed methods case study, in which cases for qualitative analysis are identified by the quantitative study, which was previously reported.

Keywords: Study abroad · Intercultural communication · Case study · Qualitative analysis · Mixed methods study

1 Introduction

1.1 Short-Term Study Abroad and Intercultural Awareness

The present study defines short-term Study Abroad (SA) as four-week-long SA programs. However, in general, short-term SA can mean a semester or less time abroad. Short-term SA programs can attract sojourners who cannot afford the time and money to be away for long, and also those who want to participate in multiple SA programs [1].

Intercultural awareness refers to "how people become aware of other ways of thinking, living or behaving and how they perceive their experiences with others" (p.285) [2]. Intercultural awareness is referred to as a "prerequisite" for Intercultural Communication Competence [2]. One of the shortcomings of short-term SA is the limitation in intercultural development as the amount of processing time for intercultural experience is short so that sojourners do not reflect on what they have seen or

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experienced [3]. For short-term SA pro-grams, intercultural learning has to be deliberate with course assignments or debriefing exercises. Research studies show the need for facilitation to enhance development of intercultural skills and awareness at pre-departure for any SA program length [4, 5].

2 Methods

2.1 Research Purpose and Research Questions

The purposes of the present study are to document intercultural awareness of sojourners who did not have any pre-departure support for developing intercultural skills and awareness, and to explore the differences in their intercultural awareness depending on the proficiency levels. For these purposes, the present study employs a mixed methods case study approach. In case studies "researchers develop in-depth analysis of the case, often a programme, event, activity, process or, one or more individuals. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (p. 14) [6]. A mixed methods case study is "a type of mixed methods study in which the quantitative and qualitative data collection, results, and integration are used to provide in-depth evidence for a case(s) or develop cases for comparative analysis" (p. 116) [7]. The research project follows a sequential explanatory design of mixed methods [7], which starts with a quantitative "first phase", followed by a qualitative "second phase". The quantitative "first phase" was reported by Tajima [8]. Tajima reported on improvement in English proficiency and affective factors, such as Willingness to Communicate, Motivation, and Language Anxiety after short-term SA. The present study is a qualitative "second phase", in which qualitative findings are reported on the same participants. Further, the present study will report on four multiple cases identified by the quantitative "first phase" (Fig. 1).

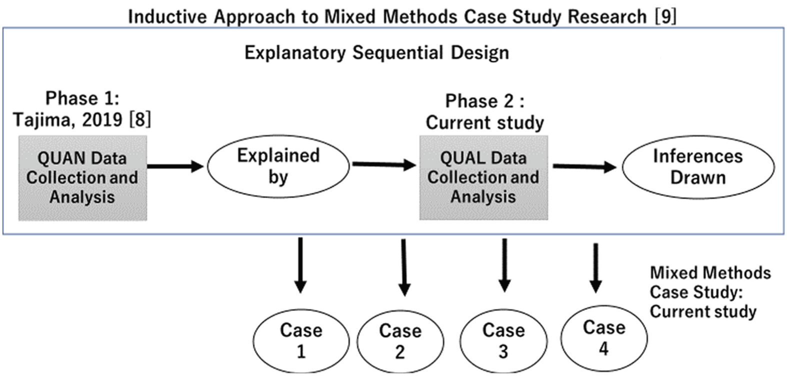

Fig. 1. Diagram of procedure for the research project. Indication of the current study within the research project.

Two research questions were generated: Q1) What cultural awareness took place during study abroad? Q2) Did sojourners' cultural awareness differ depending on the proficiency levels?

2.2 Sojourners' Time Abroad

Sojourners for this study were 29 Japanese female students from two universities in Tokyo, Japan. Sojourners participated in two different SA programs in Canada. The two SA programs were situated in the Province of British Columbia and in the Province of Alberta. For program details in terms of English instruction, homestay, and extracurricular activities, as well as linguistic proficiency gain measured by CASEC [11], and affective factor outcomes of the sojourners, see Tajima [8].

2.3 Qualitative Data

The qualitative data consist of pre-departure and post-return individual interviews, and while-abroad focus group interviews. All participants were given semi-structured interviews for 15 to 30 min each at pre-departure and at post-return, and multiple focus group interviews were conducted while-abroad. All interview sessions were conducted using learners' native language, which is Japanese, then the interview data were submitted to NVivo qualitative data analysis software [10]. The results were translated into English for dissemination by the researcher (Tables 1 and 2).

Table 1. Pre-departure (about two weeks prior to departure) data

Semi-structured interview question samples about intercultural communication
What are the images of your host country?
Do you know anything about your host country's culture?
How would you cope with cultural differences in communication?
Do you think you will experience homesickness or culture shock and why?

Table 2. Post-return (one week to four weeks after returning) data

Semi-structured interview question samples about intercultural communication
How did you cope with cultural differences in communication?
Did you experience homesickness or culture shock and why?
How did you cope with cultural issues at your homestay?

3 Results

3.1 Word Frequency Counts

All 29 students' interview responses from pre-departure and at post-return were submitted to NVivo for frequency counts. The differences in the number of utterances in Tables 3 and 4 indicate that sojourners were more expressive after they came back

Table 3. Pre-departure frequency counts results (more than 30 counts) (N = 29)

Positive	Frequency	Neutral	Frequency	Negative	Frequency
Up	59	Canada	158	Homesick	37
Improve	52	Communication	77	Shock	34
Try hard	40	Japanese people	52		
Come true	37	Homestay	51		
Can do it	34	Host family	50		
		Speaking	41		
		First time	36		
		Listening	34		
		Program	32		
		Culture	31		

Table 4. Post-return frequency counts with minimum length of 3 words (more than 30 counts) (N = 29)

Positive	Frequency	Neutral	Frequency	Negative	Frequency
Understand	102	Canada	112	Shock	37
Up	63	Homestay	98	Homesickness	36
Fun	48	Communication	78		
Change	44	Image	53		
Got used to	34	Eat	53		
Start talking	34	Properly	45		
Improve	32	Japanese people	44		
		Host family	40		
		Listening	39		
		Culture	35		
		Others	35		
		Everyone	31		

from SA in general. This is not surprising as sojourners had experiences to talk about after SA. In addition, Tables 3 and 4 indicate that sojourners were using more positive words after SA. For instance, "understand", "up" and "fun" were the top three positive words that sojourners used in post-return interviews, suggesting that sojourners had positive experiences during SA in general.

3.2 Cases of Sojourners

The following section describes case study. Sojourners were divided into 4 groups (cases) as shown in Table 5 depending on the English proficiency test results. The detailed quantitative analysis and the results are reported by previously mentioned study by Tajima [8].

Table 5. Cases based on the English proficiency results at post-return (N = 29)

4 English proficiency cases	English proficiency score bands	N
Case 1 (Advanced)	1200 and higher	7
Case 2 (High-intermediate)	1100 and higher	11
Case 3 (Intermediate)	1000 and higher	5
Case 4 (Low-intermediate)	999 and below	6

3.3 Tendencies of Cases

Research question two was to explore whether sojourners' intercultural awareness differ depending on the proficiency levels. All interview responses were bounded into four cases as shown in Table 5. This section illustrates typical responses of each case.

3.3.1 Case 1: Intercultural Awareness of Advanced Proficiency Sojourners

Limited Understanding and Awareness of Host Country and Its Culture Before SA: Semi-structured interview responses at pre-departure of 7 sojourners from Case 1 (Advanced) revealed their very limited knowledge and images about the host country and its people. Most of them had short utterances when asked about the host country's culture. Common responses were very brief, and included simple selection of vocabulary such as, "more friendly", "cheerful", "use more gestures", and "direct in their speaking".

No Greater Improvement in Their Cultural Awareness of Host Culture After SA: Sojourners continued to express and describe host culture and the people in a limited way, such as "very kind". However, some sojourners were able to elaborate and explain with real experiences.

3.3.2 Case 2: Intercultural Awareness of High-Intermediate Proficiency Sojourners

Limited Understanding of Host Country and Cultural Awareness Before SA: Pre-departure responses of 11 sojourners in total from Case 2 indicate that the understanding varies, but mostly limited. Some sojourners talked about the images from the media. For instance, sojourner 3 responded as follows. "I don't even know which westerner from which country, but on TV, I saw them being really nice to foreign visitors. They are nice to anyone, not depending on age or anything." (pre-departure interview response, Sojourner 3)

No Greater Improvement on the Understanding of Host Culture After SA: Most of sojourners were not able to express anything more than nice and kind about the people in the host culture. This is a typical response by sojourner 4. "I didn't have any negative images of Canadians before going there. My impression is that there were very kind people there." (Post-return interview response, Sojourner 4)

3.3.3 Case 3: Intercultural Awareness of Intermediate Proficiency Sojourners

Limited knowledge of Host Country and Cultural Awareness before SA: Similar to Case 1 and Case 2, Case 3 sojourners gave short utterances. For example, Sojourner 20 gave this response: “I haven’t researched about Canadians so I do not know anything about them.” (Pre-departure interview response, Sojourner 20)

Limited Improvement of Cultural Awareness, but Sojourners were able to Elaborate their Impressions with Examples: Here is an example based on real experience from Sojourner 13: “Foreigners are not indecisive so we need to decide yes or no. So if I cannot make up my mind and say “hmm…”, then I think I might get scolded, so I tried to reply quickly. If I am indecisive, I might make them annoyed.” (Post-return interview response, Sojourner 13)

3.3.4 Case 4: Intercultural Awareness of Low-Intermediate Proficiency Sojourners

Limited Understanding, but Some with Previous Cultural Exposures Before SA: Semi-structured interview response at pre-departure of 6 sojourners mostly had stereotypical images about the host culture. They used words such as “very calm”, “cheerful”, and “nice”. Some had previous exposure to Canadians who were willing to express more. For instance, Sojourner 16 talked about her Junior high school teacher from Canada as follows. “Their social distancing is smaller, so, distance between bodies are closer. Also, the conversation is frank. Even when conversing with people for the first time, the conversation is frank.” (pre-departure interview response, Sojourner 16)

Miscommunication Triggered Cultural Understanding: Having some difficulties and miscommunication at homestay due to low English proficiency triggered some awareness of cultural differences. For example, Learner 7 described understanding the different communication styles, though it was supported by the researcher who was consulted by the sojourner.

> “I still think that Canadians are calm (as I imagined before coming). But, when I had a little problem at my homestay, and consulted you (researcher), you told me that I must tell the family (what I want), because people don’t understand if you don’t say, so, I realized. I also stopped smiling too much if I don’t mean it. In the end, I tried to say what I wanted or thought about.” (post-return interview response, Sojourner 7)

4 Conclusion

This study reports findings from the qualitative phase of a mixed methods case study. First, it was found that sojourners had positive short-term study abroad experience, in general, and were more expressive when they came back This was seen by pre-departure and post-return semi-structured interview responses. Post-return interview responses tended to be longer with more positive words. Second, sojourners' intercultural awareness did not differ depending on the proficiency levels. Rather, the amount of intercultural awareness depended more on previous exposure to non-Japanese and culture. This was seen by drawing on typical semi-structured interview responses in each case.

As previously noted in the Introduction section, the time to process intercultural experience is short, so intercultural awareness needs to be facilitated and deliberate. The current study confirms this and concludes that short-term SA experience is not enough to make sojourners become culturally sensitive, whether the learners are high English proficiency sojourners or low English proficiency sojourners. The implication is to suggest the need for facilitation at pre-departure to raise intercultural awareness while abroad.

Acknowledgments. This study is a part of a bigger research project, which compares and contrasts the short-term SA programs in both traditional SA destination and non-English speaking SA context, and the research project is funded by the Ministry of Education, Culture, Sports, Science and Technology Japan, Grants-in-Aid for Scientific Research, Research (C), Grant number: 16K02984.

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Effects of Spectral Distribution in Light Sources and Physical Properties of Discrimination Samples on Discrimination of Depth

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Abstract. It has been reported that visibility has been reduced as a result of changes in light sources used for inspecting and repairing railway stock from incandescent lamps to LED lights. Notably, workers in their 50s have reported that objects look flat under LED lights. This study examined the effects of the wavelength and illumination levels of lighting on fine depth discrimination ability. The results indicated that appropriate illumination levels and the wavelength of light that result in high visibility might not be different depending on the age.

Keywords: Visual inspection · Working environment · Safety · Handy-light · Age · LED lights · Illuminance · Color temperature · Depth discrimination ability

1 Introduction

Inspection and repair of railway stock are conducted daily in railway yards to ensure the safety and the comfort of railways. Japan is a country with a rapidly aging population, and as a result, many people are reemployed after 60 years of age, which is the average retirement age. Therefore, developing working environments in which people can work safely and comfortably until 65 years of age is a priority in Japan.

Many types of visual inspections are conducted for detecting minute abnormalities for repairing railway stock. Even today, these inspections are conducted by the naked eye. Specific parts of vehicles such as the underbody of railway carriages and the inside of equipment boxes are dark. Lighting such as handy-lights is used to inspect these places. Recently, the lighting used in workplaces has changed from incandescent lamps to LED lights, which have dramatically changed the working environment. As a result, some workers in their 50s have reported reduced visibility because objects look flat under LED lights. Most visual inspections require excellent depth discrimination to

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judge defects, such as loose screws and dented equipment. Therefore, maintaining the safety and the quality of railway stock requires identifying the lighting conditions of handy-lights that can maintain the visual discrimination ability of railway workers regardless of their age.

It has been reported that the relative lamination sensitivity to short-wavelengths of light declines because of the yellowing of the crystalline lens with aging [1, 2]. It has also been reported that color perception shifts in the direction of yellow on chromaticity coordinates because of the yellowing of the crystalline lens [3]. Moreover, there is a report that the tolerable borderline luminance of glare discomfort declines with aging or by the increase in the correlated color temperature [4].

Binocular parallax and shadows cast by local lighting are considered to be fine depth clues. The contrast ratio between the irradiated area and the shaded area is an essential factor in shadow perception. It has been reported that contrast sensitivity declines with aging, especially in high spatial frequency bands [5]. Therefore, it might be possible that people tend to miss fine abnormalities because of aging.

In this study, we examined changes in lighting conditions caused by the introduction of LED lighting, especially the characteristics of lighting using white LED as the light source, and the effects of changes in visual functions with aging on the fine depth discrimination ability of inspection workers. Furthermore, a safe lighting environment, regardless of age, was examined.

2 Method

2.1 Participants

Participants in their 20s–30s (n = 13) and in their 50s–60s (n = 14) without a history of eye diseases such as cataract or glaucoma, and with normal or corrected vision over 1.0 (N = 27), took part in the study. All the participants were men because there are very few women inspecting trains and conducting repairs.

2.2 Materials

Two types of metal plates with two grooves with a diameter of 0.1° that were cut using end milling were prepared. The depth of the two grooves of each plate was identical, 1 mm (Plate 1), whereas the depth of the two grooves of the other plate was different, such that the left grove was 1 mm and the right grove was 0.6 mm (Plate 2). The surfaces of the metal plates were matte anodized to reduce reflected light.

2.3 Lighting Condition

The experiment was conducted in a dark room. The local lighting was set between the participant and the target. Spectra Tune Lab (produced by LED Motive) was used as the lighting source. Spectra Tune Lab is a wavelength-tunable light source on which 10 types of LED with different wavelengths that can be individually adjusted. Four types of lights that simulated an incandescent light bulb, fluorescent light, white LED, and sunlight, having three levels of illuminance (50, 1000, and 5000Lx) were prepared such that there was a total of 12 (4 $\times$ 3) conditions. The irradiation angle was set at 10°, and the irradiation distance was set at 25 cm.

2.4 Task

Participants were requested to judge any differences in the depth of the right and the left grooves when observing the metal plate placed 1 m away from the participant to estimate the fine depth discrimination ability. One set of tasks consisted of 50 trials. The two plates were presented randomly; Plate 1 was presented 10 times, and Plate 2 was presented 40 times.

2.5 Design and Procedure

The experiment was conducted from September 13 to October 25 of 2019, for 25 days in the laboratory of JR West Safety Research Institute. The content and purpose of the experiment were explained to the participants in advance. Moreover, their written informed consent for participation was obtained. Furthermore, we assessed differences between right and left eyesight, the presence of astigmatism, and the degree of presbyopia in the participants. After taking these measurements, the laboratory was darkened, and participants were made to wait for dark adaptation before practicing the task. After mastering the task, the participants conducted a one-set task under 12 conditions. To prevent any order effect; the 12 conditions were randomized for each participant. The visual angle was fixed using the chin rest so that the head position would not change based on the condition. Participants' responses were classified as follows; those responding "there is a difference" for Plate 1 were classified as "false alarm," those responding "there is no difference" for Plate 1 were classified as "correct rejection," those responding "there is a difference" for Plate 2 were classified as "hit," those responding "there is no difference" for Plate 2 were classified as "miss." Moreover, participants were required to evaluate subjective visibility in each task set using a five-point scale ranging from 1 (Not at all visible) to 5(Highly visible).

3 Results

Figures 1, 2, 3 and 4 shows changes in miss rates and the evaluation scores for subjective visibility when the illumination levels and light wavelengths were changed. Regarding Figs. 1 and 3, the bars for 50Lx, 1000Lx, and 5000Lx indicate the mean values of the miss rate and the subjective evaluation scores under the 50Lx, 1000Lx, and 5000Lx conditions in four wavelength conditions. Regarding Figs. 2 and 4, the bars of the incandescent light bulb indicate the mean values of the miss rate and the subjective evaluation scores under the 50Lx, 1000Lx, and 5000Lx conditions using the incandescent light bulb. The other three bars also show the mean values of the miss rate and the subjective evaluation scores under the 50Lx, 1000Lx, and 5000Lx conditions using fluorescent light, white LED, and natural light. The error bars show the standard deviations. A two-way mixed analysis of variance (ANOVA) was conducted using one between-subjects factor (two age levels) and two within-subject factors (three illumination levels and four wavelength levels). The results indicated that the main effect of light wavelength was significant for the miss rate ($F(3,75) = 3.384$, $p = .031$). Multiple comparisons conducted using the Holm method indicated a significant difference between the incandescent light bulb and fluorescent light, as well as between the incandescent light bulb and natural light for all the participants. Moreover, a significant difference was shown in the miss rate between the incandescent light bulb and fluorescent light for participants in their 50s or 60s. The Friedman test for differences in subjective visibility scores indicated no significant differences.

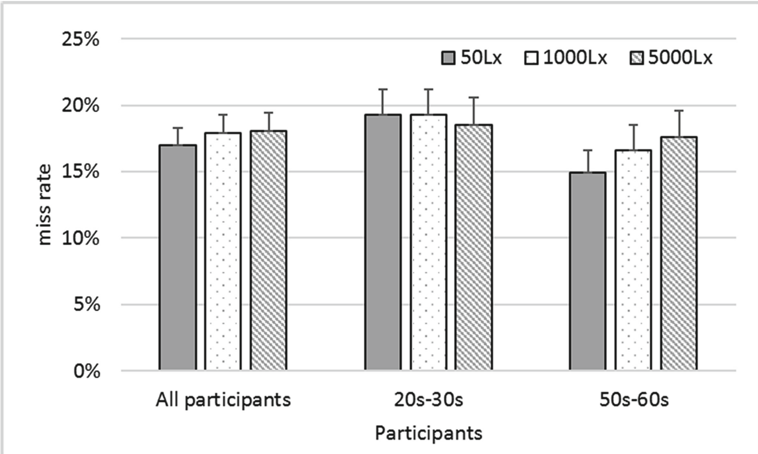

Fig. 1. Illumination levels and miss rates

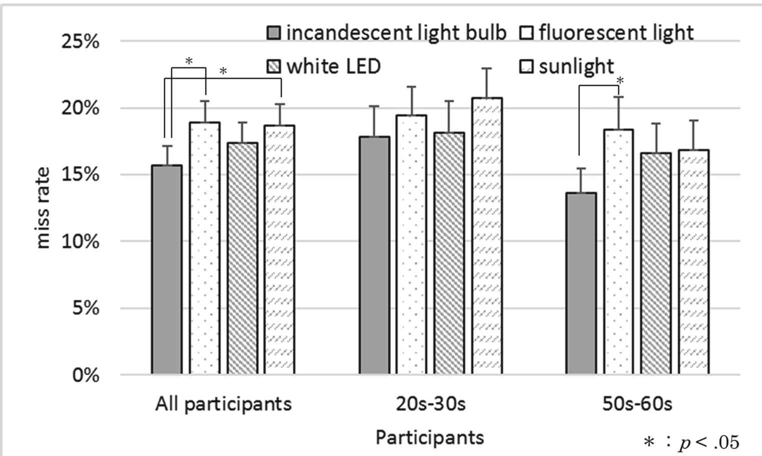

Fig. 2. Light wavelengths and miss rates

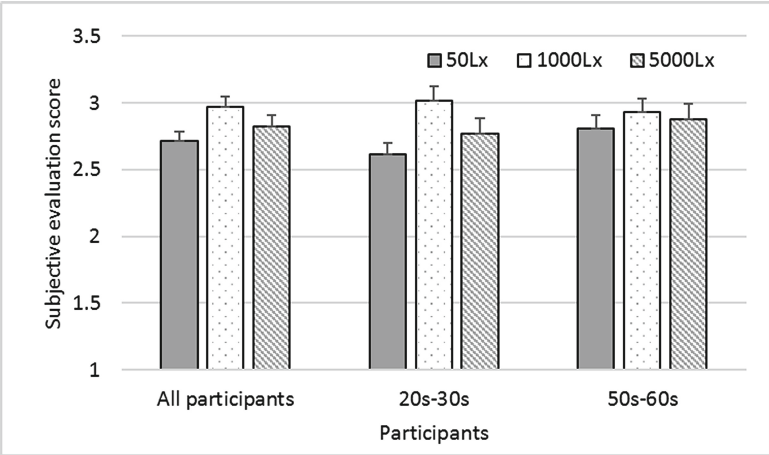

Fig. 3. Illumination levels and subjective evaluation scores

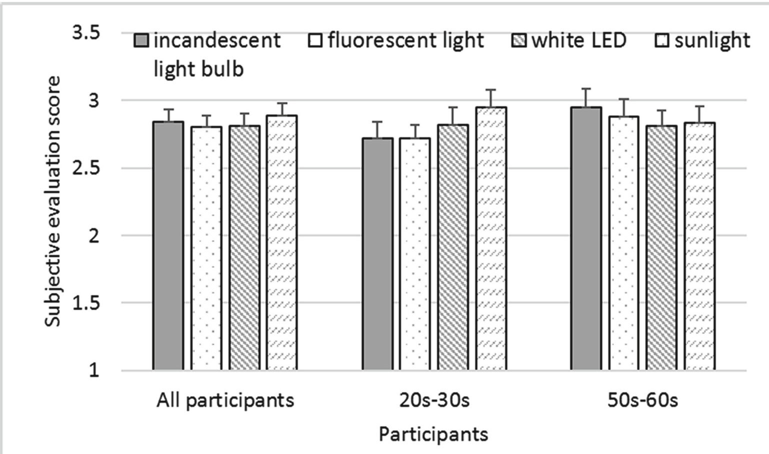

Fig. 4. Light wavelengths and subjective evaluation scores

4 Discussion

No differences were shown in the fine depth discrimination ability between participants in their 20s or 30s and those in their 50s or 60s. Moreover, there were no significant between right and left eyes, the presence or absence of astigmatism, or the degree of presbyopia on task achievement. However, there was a decline in the miss rate when the wavelength of the light was similar to an incandescent light bulb, although this effect was rather small. The effects of lighting conditions and changes in visual functions with aging on the fine depth discrimination ability were rather small, and the possibility that characteristics of LED lighting might affect fine depth discrimination ability was not demonstrated in this study.

It is possible that the ANOVA did not demonstrate significant differences between lighting conditions and age groups because of large individual differences regardless of age. Another reason for the lack of significant differences in the ANOVA might be the constant contrast, which is a major depth clue between lighted and shaded areas. Measuring the contrast between lighted and shaded areas using a luminance meter indicated a high, nearly constant contrast of approximately 0.99, when the target was irradiated by local lighting in the darkroom, regardless of the illumination levels or the wavelength of the light. Although this experiment was conducted in a darkroom, the actual inspection of railway stock is conducted using handy lights under dim lighting conditions. The contrast between the irradiated area and the shaded area using local lighting under dim lighting conditions change considerably depending on the illumination level. Therefore, it is necessary to conduct an experiment under conditions that are similar to the actual working environment of railway stock inspectors. Nevertheless, the reasons for large individual differences in task performance regardless of age cannot be explained by this experiment.

5 Conclusions

Changes in the fine depth discrimination ability based on lighting conditions and the effects of changes in visual functions with age were examined because it had been reported that visibility of workers especially in their 50s is reduced when the lighting source that is used for the inspection and repair railway stock was changed from incandescent bulbs to LED lights. Nevertheless, the results of an ANOVA did not show a significant effect of illumination or age differences on depth discrimination ability, although there was a large individual difference. It is suggested that future experiments should be conducted under conditions that are closer to the actual environment of inspection. Moreover, visual functions should be investigated in detail to develop a safer working environment.

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Investigating the Differences in Privacy News Based on Grounded Theory

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Abstract. The current study explores how privacy is covered in the news in two different cultural contexts, by summarizing both an issue framework and a subject diagram utilizing privacy dialogues in the news coverages. Data was collected through Google and Baidu, most commonly used engines in the US and China through 2016 to 2019. Adopting a qualitative method based on the Grounded Theory, 400 news samples were coded following theoretical sampling procedure and reached a theoretical saturation. Our analyses yielded three main topics namely technology, data collection and use, and privacy law making and eight subtopics in the US and China that were framed differently in distrust aspect, and significantly different in reporting perspectives. We also found that subjects covered in privacy news were mainly related to legal topics. And a common ground was identified in the data protecting aspect for both users and data collectors.

Keywords: Privacy · News · Cultural differences · Topic framing · Qualitative method

1 Introduction

The whole world is engaged in an ongoing dialogue around privacy. In recent years, the intensive use of technology in various aspects of human social activities as well as the easy accessibility to data collection and user information have both heighten people's awareness and concern for privacy issues [1]. The emergence of smart devices mostly depends on people to provide their personal data. Studies showed that people are concerned more about their privacy and are aware of their associated risks with data collection [2].

Since the application of the new European General Data Protection Regulation (GDPR) in May 2018, the debate about online privacy has increased. Although many countries around the world have a common understanding on protecting personal privacy, the interpretation and legal applicability of privacy vary. Some countries have chosen to make privacy a fundamental right, while others have chosen to incorporate it into other constitutional doctrines. There are still some countries that have yet to adopt any privacy protections. Those differences' implications for organizations, individuals and international business are enormous, and these differences significantly add complexity to privacy protection. Under such a context, questions arise as what could be perceived as privacy when privacy is perceived differently across countries [3, 4].

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An established way to assess the above-mentioned dialogue around privacy issues as well as the proposed different context of understanding privacy is by analyzing the media coverage. The coverage of media content could be seemed as both “reflecting” and “shaping” the public discourse [5, 6]. News reporting could influence the public understanding and attitude in mainly two aspects. On one hand, by reporting on specific topics, it shapes the audiences what issues should be viewed as important and relevant to them, which is Agenda Setting. On the other hand, by highlighting certain aspects of a topic, the media could reflect the understanding or value behind the discussed social problem, which is Issue Framing. The outlet of media could represent the general public by integrating voices and standpoints of people from all trades: policy makers, citizens, the majority and the minority, groups and organizations, key opinion leaders and whoever that are engaged in a specific topic or issue.

Previous studies on privacy issues between cultures largely emphasized on perceptions and behaviors [7, 8] and scholars discussed privacy conflicts caused under different cultural contexts mostly at individual level. Some scholars studied privacy between different cultural contexts in a higher governmental level. For example, among them are Binbin Chen [9] and Taewoo Nam [10] who examined the relationships between surveillance acceptability and various factors. Some researchers looked deeper into the law and regulation domain, to see whether people’s understanding is in accordance with what are being recorded in law and regulation and thus further enhance the law, regulation and policy making [11, 12]. A few of the researchers looked into the fundamental aspect of differences of privacy understandings caused by cultural values [13], but few of them reads into empirical cases in evaluating the understand and values.

To explore understandings on privacy in different cultural contexts, by adopting a qualitative method, the current study analyzes the issue framing outline between two different countries: The U.S and China, by studying the media coverage during the time period of the year 2016 to the year 2019. The dominant research question guiding the current study is as followed:

RQ: Does different cultural contexts, such as the U.S. and China, influence what people read about privacy issues through their respective popular media coverage?

2 Background

Grounded Theory (GT) originated in sociology studies and is now being adopted as a common alternative method to qualitative method to study social topics. It is a systematic methodology in the social sciences involving the construction of theories through methodical gathering and analysis of data [16]. The use of grounded theory offers an enriching way to think about a proposed social context, e.g., it was used to discover the meaning of spirituality in cancer patient to show how their beliefs influence their attitude towards cancer treatments. Such qualitative analysis presented by the grounded theory is known by looking at the phenomena following the procedures of “codification process” and “theoretical sampling”, and it is deemed to be examine method to think about the “social realities” [17]. The research guiding by GT often presents some well-built categories to form a theoretical structure that could explain some relevant phenomena. Thus, GT categorization method provides more than descriptive research because it involves the extraction of concepts, the building of categories, the extraction of dimensions and properties as well as their inter-relationships.

The media coverage of any topic can both “reflecting” and “shaping” the public discourse [5, 6]. News content is an important asset to understand what stories are happening and what topics the public is looking at. In recent years, privacy news was reported with stories in many scenarios. For instances, big data makes people aware of privacy, Chinese enterprises overseas businesses failed because of privacy, current law and regulation system could not provide sufficient support for privacy protections in China. Analysis of news data could help to understand what privacy news were reported and what topics of privacy news tend to capture people’s attention.

Though privacy has been proposed as one of the most fundamental human right worldwide, the development of privacy protection in China is at least 10 years behind that of the western countries such as the U.S [14]. In western society, the academic discussed about the right of privacy since Warren and Brandeis identifies privacy as “right to be left alone” in 1890 and the definitions about privacy have been interpreted in different perspectives [15]. The western dialogue of privacy has significantly affected the discourse of privacy related topics in China. From 1990s, a few scholars in China in began such discussion of that in western country 100 years ago, and those Chinese scholars developed some definitions of privacy based on the discussions outside of China [14]. To look back into the history of privacy, it is not difficult to foresee some challenges brought along with the localization of both privacy and privacy laws for China. Previous Chinese scholar pointed out that differences between China and the West in privacy lies in (a) legal aspect, that China recognize privacy as a right related to civil code instead of constitutional right; and (b) Chinese concepts of privacy are articulated on the purpose of “promoting social harmony” which is significantly from the western system that is based on “human rights and freedoms” [12]. As noted by previous researcher, “there are ways of protecting personal data that might not be fully applicable in China and we have new cases, new scenarios but we don’t have all the answers yet” [14].

3 Method

The current study adopted random sampling method. Data of privacy news pieces were collected from google.com (for the U.S. news) and baidu.com (for the Chinese news). Keywords “privacy” and “yinsi” were used. Date period were set from 1st Jan 2016–31th Nov 2019. The selection was based on the “relevance” result from the search engine. For each search results, sort by relevance and select the top 10 pieces of news in the front page. If there by any chance have repeated news, delete them and keep one piece of news with same content only.

In total, 469 samples were collected from Google for the U.S news pieces and 470 were collected from Baidu for the Chinese new from 2016–2019. Traditional U.S media includes such as Financial Times, Forbes, Chicago tribune, The Wall Street Journal, The Washington Post, The New York Times; while the online media covers sources of ABC News, CNN, CBS, USA Today, NPR, NBC News, Business Insider and so on. For Traditional Chinese news media, sources cover Renmin Daily, Beijing

Daily, Jurisprudence Daily, The Procuratorate Daily, China Education Newspaper and such; while the online sources contain Caijing.com, 21CN tech, IT168.com, global daily, cctv.com and such.

Based on the grounded theory theoretical sampling procedures, the authors started conceptualization and extracted key concepts from the news and summarize each piece of news into a short sentence or phrase. According to "theoretical saturation appearance" and the evidences building framework, the samples will become more and more selective along with the coding process [16]. Theoretical integration was conducted by categorizing concepts into sub-topics through further coding and topics through theoretical sampling, see Table 1. During the final validation processes, the authors conducted validation analysis to see whether there remains conflicting points, unnecessary categories or instauration. The theoretical sampling stops when it reaches to saturation, which means no more new concepts appeared in this process.

Table 1. Samples of coding results from the U.S news.

Representative sentences from news	Concepts	Semi-topics	Topics
"Have sadly fallen behind the **law**s of many other countries" in the face of rapid technological advancements	Privacy anxiety on technological advancements	Expectation of privacy laws	Privacy laws
Privacy **legislation** has hit some speed bumps **…**and whether **individuals** should be allowed to sue **companies** for alleged violations	Hard to make consensus on legislation	Establishing privacy laws	
…. proposed **legislation** he said would bring meaningful punishments for companies that violate **people's** data privacy, including larger fines and potential jail time for CEOs	New bill with meaningful punishment		
People can't trust **companies**—whether it's a private or public company or **a government**	Distrust of companies	Distrust of data collectors	Data collection and use
This also means keeping only the data that your **organization** needs and deleting the rest	Collecting only the data needed	Proper data collection	
Canadians have growing concerns about the use and exploitation of their personal information by both **government** and **private businesses**	Distrust on corps and govs data use	Distrust on data collectors	
Amazon is cracking down on third-party apps that accessed **customer** information and are in violation of its policies	Third-party apps data misuse	Data misuse	
Google has released a compilation of in-depth research on vulnerabilities in **Apple**'s iPhone operating system	Operating system flaw	Privacy risks of technology	Technology

4 Results

Our results show that there are three main topics that were being covered by news media as shown in Fig. 1 - the triangle diagram of privacy involving subjects: (1) legislators protect the privacy of users by restricting data collectors (including companies, third-parties, and government and etc.) through legal processes, this overall shows the relationship between lawmaker and user and data collectors; (2) data collectors provide users with technical services while collecting users' data, showing the relationship between data collectors and users. Based on this, this article constructs a structure diagram of subjects and relationships through privacy news.

Figure 2 illustrates the framework for privacy news topics in two countries. Technology, Privacy Laws and Data Collection and Use are the three common topics in both the two countries. In sub-topics, while Chinese coverage reveals distrust for companies, the U.S dialogue involves distrust both for companies and the government, it could be an evidence of the America's "libertarian press traditions" contrasting to China's "paternalistic approach" [11]. In general, the overall coverage is not significantly different, but many differences can still be found in the concept forming process. Whether it is future technology development, economic globalization, or better communication between countries, understanding of the three privacy-related subjects (user, lawmakers, data collectors) in different regions can play an important role.

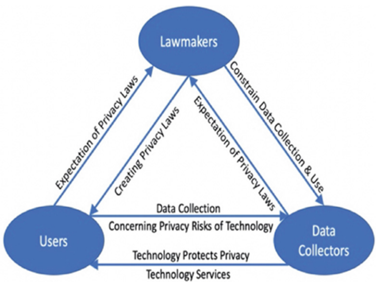

Fig. 1. Interconnections between subjects in news coverages

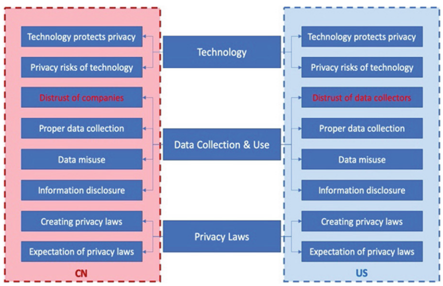

Fig. 2. Framework for Privacy Topics and Sub-topics in the U.S and China

5 Discussion

Data Protection Awareness and Public Trust. The perspectives chosen in the news converging vary: *(1)* The U.S news reports pays more attention to corporates' misuse of information, information leakage, and unnecessary information acquisition and storage. Meanwhile Chinese reports reflect the weaker awareness of privacy protection among the public, and when it comes to law making, most articles reposting from overseas media. *(2)* In a physical domain, Chinese media pay heavy attention to both the invasion of privacy about data and about individuals' personal lives; while the majority of U.S reports emphasizing on the online privacy data protection. For online data protection, US users seem to be using Encryption software, Anonymizers, System Cleaners and such system as an opt-out to help them avoid online privacy violations. Since China does not have an organization to conduct privacy education, most people do not know how to protect their online privacy [11]. *(3)* When it comes to legislation level, the U.S media's report on regulations is triple than that of the Chinese media and seeing from the media content, the legislation process being discussed show relatively weak completeness in China to that of the U.S. However, the speed of legislation is relatively faster and more direct in China, contrasting to the U.S which needs to balance the interests of all parties and is difficult to reach an agreement. A key difference is that in the U.S, the judiciary is an independent entity, while in China, the courts are subsidiary bodies of the ruling government [11]. *(4)* The tendency of showing distrust to data collectors is more significant in the U.S than that of China, which also shows that people pay more attention to privacy protection.

Common Ground for Data Legislation and Regulations. (1) *Users call for data protection.* Semi-topics in Fig. 2 further shows the relationship between privacy topics. Users use data collector's technology but at the same time they are worried about the privacy risks caused by the technology. Especially in US news reports, many users have revealed *distrust feelings* for data collectors, sometimes the destruct feeling comes from the government, and the US users look forward to enhancing Law and regulation to protect privacy. In China, the privacy law is relatively inadequate, contents show privacy-related policies and regulations are being gradually introduced, while US privacy laws are relatively more developed, but the interests of multiple parties need to be balanced in the process of law formulation, so it often appears circumstances in which opinions are not unified and laws cannot be passed. (2) *Data collectors call for clear data policy.* Data collectors are also advocating for the enhancements of privacy laws. They are both subject being restricted by regulations meanwhile beneficiaries from policies and regulations. With clear legal regulations, they could avoid high fines caused by violations and could also clarify the future business direction of development. Data collectors in the U.S also seem to have a certain influence in the process of law making and strive to campaign for policy trends that are beneficial to their own interests.

Cultural Shocks in Different Privacy Spheres. The public interpretation of the concept of privacy is different in the two countries, relating to different cultural contexts. The specific requirements of privacy laws and policies in different countries are different; data collectors have different implementation of privacy protections and related regulations. (1) *Culture-Shock in Physical Sphere.* The need for privacy is different from one culture to another and some culture need more or different kinds of privacy than the other [18]. For example, when Chinese tourists were taking pictures in Australia, and enjoying the scenery abroad while taking pictures of foreign kids in a beach, the local people got annoyed because they consider it as a privacy invasion to their children. *(2) Culture-Shock in Digital Sphere.* Another example of this phoneme is the case of Tick Tik which is a very popular app in China. When the company was expanding its overseas business landscapes, it failed dramatically, it was sued for privacy infringement in overseas markets and got banned in Australia, EU. In such a case, the privacy concerns played a crucial role.

6 Conclusion

This study is a cornerstone in providing an in-depth analysis to the privacy values due to cultural differences by creating both an issue framework and a subject diagram in the news coverages from two different countries. It would help people in the legislative sectors, business, researcher and individual to form a basic logic flow in seeking information for privacy through the news media content. For example, what kinds of perspectives people could have under different cultural contexts? When legislative department are making future policies learning from a different culture, they could refer to the perspectives that need to scrutinize; industry businessman could equip with basic knowledge even from online outline to avoid making further mistakes and expanding overseas business in a way fitting the cultural contexts. Researchers could refer to this ground-based study to further amplified the result while individuals could seek changes based on the proposed topic framework. It is suggested for future researchers to look at the topics being proposed with the progress with the legislation process, to consider the influence of media dialogue on the policy making process and evaluate the in influence of agenda setting in such cross-cultural context—for example, are there any unnecessary or misleading policy making emphasis that is being caused by the media coverage which might have cost time and energy but have little influence?

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Creating a Design-Led Guideline on Cultural Heritage for a New Concept of Korean Tea House in Overseas Market

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Abstract. Unlike the strong global café culture, the tea industry still suffers from an ageing user base and has failed to engage younger consumers due to a lack of experience and differentiation of tea products or services. However, considering the current trend of 'health and wellness', tea could have a good market opportunity to overcome its lack of strong penetration, by promoting its health benefits. Korean tea and its associated culture can in particular provide both physical and mental health benefits. Therefore, it is necessary to consider how tea houses can create the right strategies to satisfy customers. This research paper identifies the value of 'experience' design and cultural heritage as well as customers' demands regarding the experience of a tea house.

Keywords: Experience design · Cultural heritage · Korean tea house · Healthy lifestyle trends · Food service category · Branding

1 Introduction

Coffee shops are bringing almost all generations, including younger consumers, into the coffee category, and inducing them to choose quality coffee rather than instant. Sitting down in a coffee shop, trendily decorated and surrounded by other brand-conscious people, is not just about the coffee, it is an experience. On the other hand, despite the health benefits, tea in particular suffers from an ageing user base and failed to engage consumers, especially younger consumers due to lack of experience, differentiation and clear concept of tea products or services. Although British afternoon tea has gained popularity, the average users are business people, wealthy people or tourists, as popular afternoon teas are normally served in expensive hotels. This trend shows that today's consumers are increasingly willing to pay more for new, interesting, quality beverages and desserts for a pleasurable experience. And a good experience, something that is memorable, meaningful or pleasurable, can increase the value of a company in people's minds and enable the customer to personally appreciate their relationship with a company, even beyond their expectations [1].

In addition to the general health benefits of tea, Korean teas have been used largely for medicinal purposes before they have gained popularity as a daily beverage. There are four types of traditional teas in Korea: green tea, medicinal herb tea, fruit-based tea, and grain-based tea. Each type of tea has its own characteristics, including a different

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taste and differing health benefits. The warmth and pleasant aromas of traditional Korean tea is more than just a beverage to Koreans and it give people feelings of contentment and happiness, in part by clearing the mind. This explains why Korean tea history is uniquely based on profound philosophy [2]. Stewart-Allen asserted that when a company's brand is infused with heritage, it can provide leverage for that brand, especially in the global market [3]. Therefore, branding and design will be very important, as they can transform problems into opportunities and translate routines and procedures into value-adding creative processes [4]. To improve the current situation with a new strategy efficiently, I believe that there is potential to take better advantage of the niche of Korean tea and culture in a way that can provide both physical and mental health benefits, considering the consumer needs. Therefore, the idea of Korean tea houses will be analysed and compared with other tea houses that have strong brand identity in order to create a healthier lifestyle as well as to improve awareness of the health benefits of tea and Korean culture.

2 Literature Review

2.1 Experiential Design, Cultural Heritage and Branding

Great experiences are the result of deep thought and deliberation, not just an accident. Customer experience is influenced by all of the touchpoints within a company; most touchpoints are designed for products, environments, communications and services. Physical objects are considered the most tangible outcomes of design, but their primary function is to engage people in an experience [2]. In this sense, aesthetic is very important as it provides an emotional experience based on form, style or sculptural content: these characteristics have led designers to design products that are more appropriate to the experiences demanded of consumers [5].

The word "cultural heritage" can be defined as the entire corpus of material signs - either artistic or symbolic - handed on by the past to each culture and, therefore, to the whole of humankind. As a constituent part of the affirmation and enrichment of cultural identities, and as a legacy belonging to all humankind, cultural heritage gives each particular culture its recognizable features and is the storehouse of human experience. [6]. From a strategic point of view relating to branding, Stewart-Allen observed that when a company's brand is infused with heritage, it can provide leverage for that brand, especially in the global market. Brand heritage is one of major elements that can help clarify, enrich, and differentiate an identity [7].

2.2 Han Style (Korean Style) and Design-Led Branding Model

The Han style refers to the source of Korean culture representing and symbolizing Korea, encompassing the branding of Korean traditional cultures which can be commercialised, globalised, and used in everyday life [8]. By nurturing Korean products and providing a deeper understanding of Korean language, lifestyle and traditional culture, the Korean government also expects Han style to add value and enhance the national image.

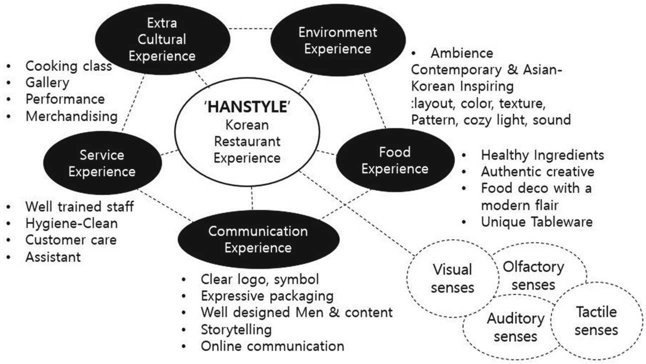

Fig. 1. Han style: design-led branding model from design research 2

In order to create a design-led branding model based on Korean heritage for strengthening brand identity of Korean restaurants in overseas market, the 'Hanstyle' design-led branding model (Fig. 1) was developed by Yujin Joung (2011) during Design Research Project 2 in London. The model combines the development of the Korean restaurant brand strategy and touchpoints based on the 'Han style' concept. The new Korean restaurant experience is divided into five categories and each closely connected to the others. This model has demonstrated that Korean restaurants in overseas market could build a strong brand identity and image through better experience design and Korean heritage. By designing each experience area, Korean restaurants in overseas market can differentiate themselves from others and build strong identity by providing higher emotional satisfaction to customers.

3 Research Methods and Analysis of Findings

3.1 Observation

Observation was conducted as a direct way to explore the best Korean tea houses in South Korea, and to investigate a potential strategy regarding Korean food/beverage and Han style. As a structure observation, the 2019 Korean food/beverage & tourism expo and the three tea houses were observed with design measurement criteria. The three tea houses: Osulloc, Tea Therapy and The Lounge, were selected because they have a great reputation amongst Koreans and foreign visitors for their tea and dessert, service, communication and environment, which are some of the most important factors in tea house business success (Table 1).

Table 1. Details of observation.

The famous Korean tea houses in Korea	Segment	Location	Design audit
2019 Korean food/beverage & Tourism Expo Visited on 9th May 2019	Korean food, beverage Korean tea/tableware Korean style packaging	AT Centre, Seoul, South Korea	'Design Audit' (wheeler 2006)
Osulloc Visited on 14th June & 25st June 2019	Korean tea house Korean tea shop Korean tea museum	Seoul & Jeju island, South Korea	
Tea Therapy Visited on 24th June 2019	Korean tea house Oriental medical clinic	Seoul, South Korea	
The Lounge Visited on 2nd July 2019	Hotel lounge/bar which serves stylish Korean dessert and tea	Park Hyatt Seoul, South Korea	

Key Points from Observations of the Three Korean Tea Houses

1. Creative menus and healthy ingredients: the menus and menu items of the three Korean tea places reflect the current trends to gain the competitive edge in the tea house industry. They highlight the quality and healthy aspects of Korean tea and dessert and provide a certain type of specialised Korean tea and dessert with a creative modern flair, rather than just traditional teas.
2. Design and Korean heritage: the tea houses provide a fashionable tea drinking experience based on Korean heritage. All three tea places focused on creating unique environments and experiences with memorable and unique colour, texture, scale, light, sound, smell, and comfort, as these elements manage consumers' perception and inspire them to come back again.
3. Consistent communication: since the target group of the three Korean tea places is both Koreans and foreigners, they put great attention in delivering consistent and clear communication of their brand message through menu design and content, logos, pamphlets, packaging and narratives on the website.

3.2 Case Studies

Five case studies were used. Three case studies: Jugetsudo, The Tao of Tea and Café Mo, were chosen based on the results of the literature review, in order to investigate good practices in tea house branding. The other two case studies, Chuan Spa and Chaum, were conducted to investigate good use of therapy treatments in modern society. Detailed information was gathered from published electronic data, newspapers, websites and magazines (Table 2).

Table 2. Details of case studies.

Successful tea house	Segment	Location	Analysis
Jegetsudo	Japanese tea house, Tea shop	Paris, France	Brand description and Design strategy by applying Han style design-branding model (Yujin 2011)
The Tao of Tea	Chinese tea house, Tea shop	Portland, USA	
Café Mo	Moroccan tea house	London, UK	
Therapy places	Segment	Location	
Chuan Spa	Chinese spa & medicine treatments	London, UK	
Chaum	Stem cell therapy, Spa, Food & Tea therapy and fitness	Seoul, Korea	

Key Points from Three Case Studies - Tea Houses

1. From the development stage, these three tea houses have worked closely with design professionals and aimed for design, quality and atmosphere for long-term success. Their efforts in design proved that design with an edge provides more PR value than advertisements can buy.
2. Each tea house used its own cultural heritage when designing brand identity and creating touchpoints in order to provide unique experiences.
3. Each tea house provides various authentic menu options for targeting a local audience. Teas/desserts are served with a modern and traditional flair and have maintained authentic taste.
4. The tea houses have built an emotional connection with customers by providing an impressive and authentic experience through consistent and clear communication and the multi-sensory aspects of each tea house's environment.

Key Points from Two Case Studies - Therapy Centres

1. From the first development stage, design professionals have been involved closely to build a strong brand identity and to engage all five senses of the customers. Both places have created aesthetically pleasing spaces that foster relaxation through design elements in order to provide a unique experience to customers and make emotional connections with them.
2. By providing various and customised therapy programs, both therapy places help today's hectic and time-pressured customers to sooth their minds, restore vitality and adopt healthier lifestyles.
3. The facilities offered include personalised consultation and customised treatments by qualified experts such as medical professionals, spa specialists and nutritionists.
4. With the purpose of boosting the immune system, both places provide tea therapy programmes designed by experts.

4 Discussion

From the case studies and observations, it has been seen that those tea houses and therapy places gained the popularity by designing overall experiences based on the effective use of visual and verbal expression as well as sensory appeals. Today's consumers take functional features, benefits, and product quality as a given. They want products, communications and campaigns that fascinate their senses, touch their hearts and stimulate their minds [9]. Therefore, to truly influence consumers' purchase-decision making, emotion needs to be situated at the heart of the strategy by appealing to consumers' five senses. Since eating and drinking is a sensual experience and is imbued with special meanings in many cultures [10]. Korean tea houses should go beyond basic functionality and provide higher level of emotional consumer satisfaction. With regard to this aspect, design can be the basis for energising consumers' hearts, minds, and souls [11]. Therefore, every customer contact needs to be designed from the customer's perspective in order to give customers a sense of discovery, a memorable experience and a clearly defined brand story [12]. During the research, it has been discovered that the stages of the relationship and buying interaction between a customer and a tea house brand can be divided into three: pre-experience, experience and post-experience. The matching or even exceeding of customers' expectations along their customer journey is significant in how that customer satisfaction and needs are met needs to be constantly designed and measured. While keeping in touch with the increasing demands of customers, and harmonising the spirit of the brand, brand details need to be designed with differentiation and individuality [5]. Therefore, the experience at a Korean tea house should be designed by harmonising all the elements of brand identity throughout all experiences in order to resonate with customers, differentiate itself from competitors and provide memorable experiences. In addition, it is identified that the successful tea houses from the case studies and observations leveraged the culture, history and identity of their homelands to create distinctive brand experiences that are contemporary as well as uniquely inspired by their own culture [13]. Therefore, using cultural heritage can play a crucial role for Korean tea houses in creating a unique and specific identity of a brand and making a memorable experience.

5 Conclusion and Recommendation

The findings have demonstrated that Korean tea houses in overseas market could achieve a high level of consumer awareness and perception through better experience design and a strong brand identity based on Korean heritage. The research has shown that experience design needs to be used more actively in each experience category: product, environment, communication, and service in order to create a better tea house experience. While closely connecting the core four categories of experience as shown on the Fig. 2, it is crucial to understand customers first, as experiences should be designed based on their lifestyles and demands. Allen & Simmons emphasised that any company, product or service will make little progress if it cannot show what it is about and how it is different [14]. The use of cultural heritage can help the brand to differentiate itself from others, with its own unique brand story based on Korean culture, history and identity. In this regard, the Korean tea house brand strategy model was created as a ‘total chain of experience’ – by developing a visual and verbal identity with coherency and consistency in order to add distinctive value at every stage of the experience, and by leveraging the five senses across every possible touchpoint from the pre-tea experience to the post-tea experience, in order to provide higher emotional satisfaction for customers.

By integrating all the findings, the Korean tea therapy house design-led branding model was created based on the brand strategy model, in order to establish a new vision of a Korean tea house for the twenty-first century and to provide a new guideline for a new concept of Korean tea houses in overseas market. The tea house is reinvented from the typical tea house to a multi-purpose place where people want to visit as part of their healthier lives. The new tea house would adopt a tea therapeutic area and offer various quality options from the tea room and store, tea ceremony and meditation, tea classes and exhibitions, tea clinic and tea spa. All these five spaces provide customer-centric services by qualified professionals and deliver a desirable customer experience in an emotionally profound way with rich sensory pleasure through experience design and ‘Han style’ (Fig. 2).

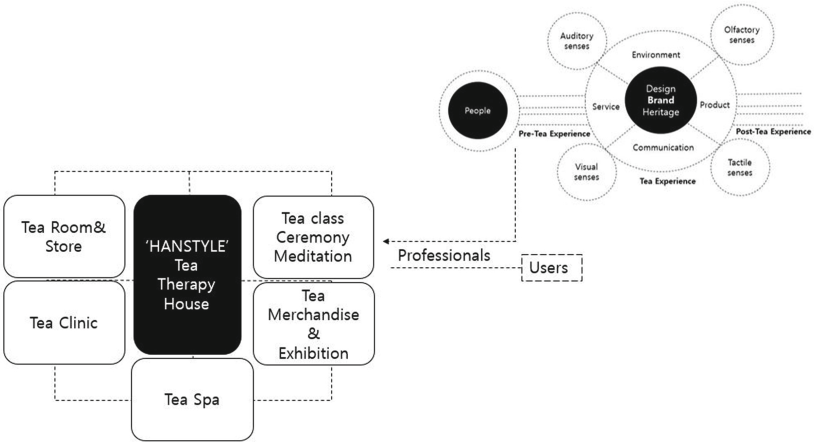

Fig. 2. The korean tea therapy house design-led branding model (left) based on the korean tea house brand strategy model (right)

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Positive Emotions of Human Service Employees

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Abstract. While the role of customer service employees is important as they can add value to the products and services in an organization, information technology (IT), artificial intelligence (AI), and automated machines may be more productive than employees. Thus, employees may perceive role conflict. According to previous studies, the perception of role conflict by employees reduces trust in organizations and task performance. This study shows that positive emotion, such as the affective delivery of customer service employees, serves a buffering function and provides a useful antidote in the workplace. Conversely, negative emotion, such as emotional exhaustion due to role conflict, devastates the intrinsic motivation of employees.

Keywords: Positive emotion · Airline · Human service employees · Trust role conflict

1 Introduction

The service sector accounted for over 70% of total employment and value added in OECD economies (OECD, 2005). In the United States, 108.5 million people (71% of all nonfarm payroll employees) worked in the private service-providing industries as of December 2019, according to the U.S. Bureau of Labor Statistics. Among the major service-industry sectors, the largest number of people were employed in trade, transportation, and utilities (27.9 million workers), followed by education and health service (24.5 million), professional and business service (21.6 million), and leisure and hospitality (16.9 million).

In recent years, there has been a tendency for information technology (IT), artificial intelligence (AI), and automated machines to substitute jobs previously performed by human service employees in airlines. While the role of customer service employees is very important as they can add value to the products and services of airlines, IT, AI, and automated machines may be perceived to outperform and be more productive than human service employees. Therefore, employees might perceive role conflict in the workplace.

In this article, the author explores how positive emotion and negative emotion of customer service employees play the role of mediator or moderator, and, whether mediate or moderate the decreasing propensity of trust due to role conflict in the workplace.

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2 Literature Review and Hypotheses Construction

2.1 Role Theory

Role theory indicates that when expected employee behaviors are inconsistent, the employee will experience stress, dissatisfaction, and perform less effectively than if employee expectations did not conflict [1]. For example, when an organization changes its employment policy, reduces social welfare, or increases working hours, the employees perceive a role conflict. The employees may also lose trust in the organization. Ross [2] argues that the combination of corporate-driven globalization, deregulation, subcontracting, and outsourcing leads to an increase in the number of hours worked and flexible work hours, and a decline in job security and worker autonomy in a broad range of occupations and professions. Therefore, the author proposes the following hypothesis:

Hypothesis 1: Role conflict is negatively associated with organizational trust.

2.2 Positive Emotion and Negative Emotion

The role of emotion in the workplace, often an implicit theme in an organization, has been a constant research objective. The interactive effects of the work context and employees' emotional state were frequently discussed as job satisfaction, intrinsic motivation, stress, and mood. Hochschild [3] argued that common expectations exist concerning the appropriate emotional reactions of individuals involved in service interactions.

"Affective delivery" is an aspect of emotional labor that is particularly required for human service employees. Service-industry professionals are required to express positive emotions, for example, a friendly attitude and a warm reception. Empirical evidence has indicated that employees' practice of affective delivery can be beneficial to an organization. These benefits include a higher level of customer satisfaction [4], better service quality evaluation [5], and improvement in customer willingness to return and recommend [6]. In this study, the affective delivery practice of human service employees was used as a positive emotional variable.

Hypothesis 2: The role conflict perceived by human service employees has a negative relationship with affective delivery.

2.3 Trust in Organizations

While trust has been widely hailed for its central role in establishing and maintaining close, cooperative, and productive relationships, damage to trust through defection and betrayal can have a devastating consequence on relationships [7].

In today's fast-paced global business environment, the effect of building trust in organizations may be easily forgotten. Conversely, trust in organizations should be fundamental in uncertain and complex environment. As reorganization and downsizing increases, employees are more likely to perceive a violation of psychological contracts. Thus, employees may have a distrust of the organization [8].

In the service organization, the affective delivery practice of human service employees provides better service to customers [9]; thus, customers are more likely to become loyal customers. The practice of affective delivery might not only improve customer buying behavior but also increase employees' confidence in the organization. Thus, the author proposes the following hypothesis:

Hypothesis 3: Affective delivery practiced by service employees has a positive relationship with trust in the service organization.

2.4 Emotional Exhaustion

Emotional exhaustion refers to chronic mental and physical exhaustion due to excessive work and stress. Emotional exhaustion describes feelings of being emotionally overextended and exhausted by one's work [9]. Thus, emotional exhaustion is the affective state of the individual and the result of continuous circumstances of mental and physical effort that can occur among individuals who do "people-work" or human service employees. Human service employees who perceive role conflicts may also experience emotional exhaustion. In this study, emotional exhaustion was used as a negative emotional variable. The author proposes the following hypothesis:

Hypothesis 4: Role conflict perceived by service employees has a positive relationship with emotional exhaustion.

2.5 Distrust in Organization

According to previous research focusing on personality, distrust is caused by psychological confusion [7]. For service employees who perceive emotional exhaustion at work due to excessive stress and unreasonable physical effort, the experience of emotional exhaustion might lead to a decrease in trust towards the organization. Thus, the author proposes the following hypothesis:

Hypothesis 5: Emotional exhaustion perceived by service employees has a negative relationship with trust.

2.6 Moderating Effect of Affective Delivery

According to the behavioral decision theory that examines trust and distrust from the viewpoint of rational choice, in a game situation where various motivations are mixed, "trust" is a cooperative act, and "have distrust" is an uncoordinated act [7].

Furthermore, affective delivery is an employee's behavior that expresses positive emotions by facial expressions and attitudes when dealing with customers and is therefore considered to be cooperative behavior with the company. Therefore, affective delivery might moderate the tendency of role conflicts to reduce trust in an organization (Fig. 1).

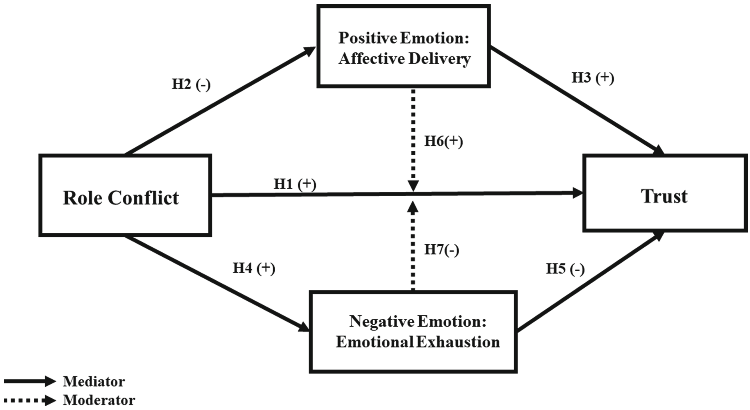


Fig. 1. Hypothesis construction of multi mediation model

Hypothesis 6: Affective delivery moderates or mediates the negative relationship between role conflict and trust.

2.7 Moderating Effect of Emotional Exhaustion

The importance of trust in an organization is that shareholders in companies can effectively work together to achieve their goals [7]. On the other hand, employees experiencing emotional exhaustion from excessive mental and physical stress at work may have reduced trust in the company. Therefore, emotional exhaustion experienced by the employees might not moderate.

Hypothesis 7: Emotional exhaustion does not moderate or mediate the negative relationship between role conflict and trust.

3 Method

Participants. The final sample consisted of 414 flight attendants (78% female and 22% male) working for a European airline. Participants ranged in age from less than 20 years to more than 60 years, with an average of 39.9 years. Participants also ranged in tenure from less than 1 year to more than 30 years, with an average of 16.6 years.

Measures. A 5-point Likert-type questionnaire was used to test the hypotheses. The questionnaire was distributed to 500 flight attendants working for a European airline and valid responses were received from 414 (82.8%) respondents. Table 1 shows the descriptive statistics of the variables used in this study, the correlation analysis, and the reliability results by Cronbach's alpha coefficient. Then, the direct and mediating effects between variables were verified by path analysis using covariance structure analysis (SEM). In addition, the multiple hierarchical regression analysis (Table 2) shows an interaction effect between role conflict and affective delivery (positive emotions) and other interaction effects between role conflict and emotional exhaustion (negative emotions).

4 Result

4.1 Multiple Mediation Model

As a result of correlation analysis, a negative correlation ($r = -.19$, $p < .001$) was observed between role conflict and trust. In the results of covariance structure analysis (SEM), a negative path coefficient ($r = -.12$, $p < .001$) was also observed between role conflict and trust, and hypothesis 1 that predicted the negative relation between role conflict and trust in the organization was supported. The goodness-of-fit summary of the SEM model shows CMIN/DF = 1.935, CFI = .953, GFI = .930, TLI = .945, RMSEA = .048.

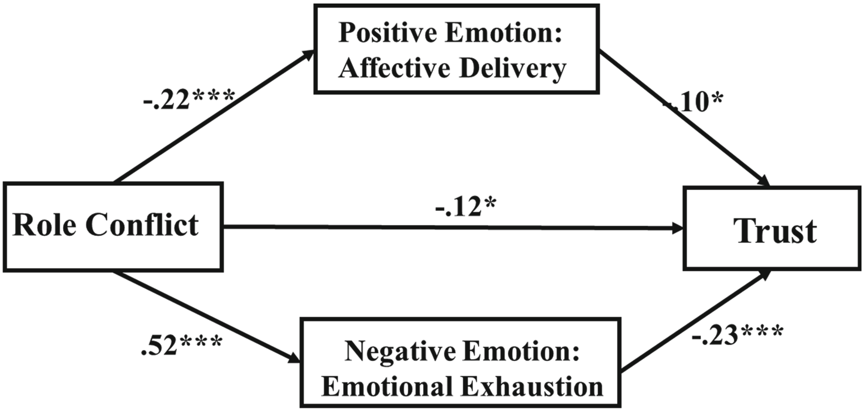
Table 1. Descriptive statistics and correlations

	Variable	Mean	S. D.	α^d	1	2	3	4	5	6	7
1	Gender[a]	.74	.44								
2	Tenure[b]	4.11	1.51		.12**						
3	Age[c]	3.98	.79		.02	.76***					
4	Trust	3.13	.74	.94	.21***	.21***	.12**				
5	Role Conflict	3.40	.74	.93	−.14***	−.05	−.02	−.19***			
6	Emotional Exhaustion	3.43	.87	.93	−.16***	−.03	.01	−.26***	.48***	.25***	
7	Affective Delivery	4.50	.53	.82	−.10**	.14***	.22***	−.04	−.20***	−.2.0***	−.06

Note: *** $p < .01$, **$p < .05$, *$p < .10$. N = 414.
[a]Gender: coded as Male = 0, Female = 1.
[b]Tenure: coded as = 0–5 years, 2 = 6–10 year, 3 = 11–15 years, 4 = 16–20 years, 5 = 21–25 years, 6 = 26–30 years, 7 = more than 30 years.
[c]Age; coded as 1 = less than 20, 2 = 21–30, 3 = 31–40, 4 = 41–50, 5 = 51–60, 6 = more than 60
[d]Reliability represents Cronbach Alpha coefficients.

Regarding hypothesis 2, the correlation analysis showed a negative correlation ($r = -.20$, $p < .01$) between role conflict and affective delivery. The results of path analysis also showed a negative path coefficient ($r = -.22$, $p < .01$), which supports the prediction of Hypothesis 2 that there is a negative relationship between role conflict and affective delivery.

For hypothesis 3, contrary to the predicted hypothesis, the correlation analysis revealed no significant correlation between affective delivery and trust. The result of the path analysis also showed no positive coefficient between affective delivery and trust ($r = -.10$, $p < .01$). Therefore, the positive direct effect between affective delivery and trust of hypothesis 3 was rejected. On the other hand, affective delivery was found to have a mediating effect between role conflict and trust.



CMIN/DF=1.935, CFI=.966, GFI=.914, TLI=.960, RMSEA=.058
Pass coefficients are described as standardized coefficients

Fig. 2. Result of the multi mediation model

Table 2. Multiple hierarchical regression analysis for testing the effects on trust

Variables	*B*	*B*	*B*
1. Gender	.13**	.11**	.14**
2. Tenure	.20**	.18**	.10**
3. Akc	−.02	−.02	−.01
4. Role eunfliet	−.08	−.04	−.22
5. Emotional Exhaustion	−.20***	−.17***	.15
6. Affective Delivery	−.08*	.15	−.09
7. Interaction (I) : Role Conflict * Affective Delivery		−.55***	
8. Interaetion (2) : Rule Cunflict *x* Emotion Exhaustion			−.56*
F	10.90***	36.59***	9.91***
Adjusted R^2	.126	.376	.131
ΔR^2		.250	.005

Note: n = 414. Standardized regression coefficients are reported. ***$p < .01$, **$p < .05$, *$p < .10$.

As for hypothesis 4, the correlation analysis showed a significant positive correlation ($r = .48$, $p < .01$) between role conflict and emotional exhaustion. Path analysis also showed a significant positive relation ($r = .52$, $p < .01$) between role conflicts and emotional exhaustion. Therefore, hypothesis 4 was supported (Fig. 2).

As for hypothesis 5, the correlation analysis showed a significant negative correlation ($r = -.26$, $p < .01$) is observed between emotional exhaustion and trust. Path analysis also showed a significant negative relation ($r = .23$, $p < .01$) between emotional exhaustion and trust. Therefore, hypothesis 5 was supported.

4.2 Multiple Hierarchical Regression Analysis

Table 2 shows the results of the multiple hierarchical multiple regression analysis. The results indicate, when the interaction between role conflict and affective delivery was included in the multiple regression equation, an interaction was significantly observed ($B = -.55$, $p < .01$) [F (7, 406) = 36.592, $p < .01$, $\Delta R^2 = .250$].

Thus, regarding hypothesis 6, the interaction between affective delivery and role conflict is considered moderating the decreasing tendency of trust to a certain extent, when the perception of role conflict is low. On the other hand, if the role conflict perceived by the employees is high, the group of employees who normally use affective delivery might not be able to moderate the decreasing trend of trust. Therefore, hypothesis 6 was partially supported. Figure 3 shows two plot graphs. One shows the interaction between role conflict and affective delivery (left) and the other shows the interaction between role conflict and emotional exhaustion (right). As a result of multiple hierarchical regression analysis, when the interaction between role conflict and emotional exhaustion was included in the multiple regression equation, a significant interaction was observed ($B = -.56$, $p < .01$) [F (1, 406) = 9.913, $p < .01$, $\Delta R^2 = .005$].

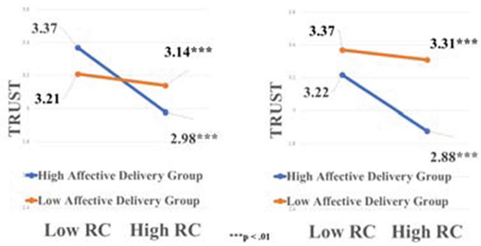


Fig. 3. Interaction of role conflict and affective delivery (left) and Interaction of role conflict and emotional exhaustion (right)

Regarding hypothesis 7, it is considered that an employee group with low emotional exhaustion will moderate the decreasing tendency of trust to some extent. On the other hand, the employee groups with high emotional exhaustion tended to have lower levels of trust in the organization than those with lower emotional exhaustion. If role conflict is high, it may be very difficult to repair a damaged trust in the organization. Therefore, hypothesis 7 that predicted emotional exhaustion cannot repair the decreasing trend of trust due to role conflicts was supported.

5 Discussion and Implication

IT, AI, and automated machines have been substituting jobs previously performed by employees. Employees might ask what the role of human service employees is in the organization. In this study, the author used affective delivery as a positive emotion and emotional exhaustion as a negative emotion of employees. The author examined the mechanisms by which these emotional variables mediate or moderate the decreasing trend of trust due to role conflicts in the organization.

The results of this study suggest that the human service employees' practice of affective delivery or showing positive emotion in interactions with customers can repair the decreasing trend of trust when the level of role conflicts is low. Thus, the positive emotion of employees serves a buffering function and provides a useful antidote in the organization. Conversely, it is difficult for the employees who perceived emotional exhaustion to repair the decreasing trend of trust in organizations when the level of role conflicts is high.

Those results imply that negative emotion due to role conflict devastates the intrinsic motivation of employees. Though the advances of technology can make aspects of human life more efficient, it also creates a contradictory situation of employment.

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Analysis of the Dissemination of Chinese New Village Culture Based on "Operation Hammer" – Taking Siburan Village as an Example

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Abstract. Most of the research objects are based on the new village in the West Malaysia peninsula. In order to understand the new village of East Malaysia, this article takes the village of East Malaysia as an example. It analyzes the dissemination of the village in Siburan in the background of the "Operation Hammer". This paper examines the problems that exist in the development of new villages in Sarawak, puts forward the countermeasures to solve the problem, and has a robust research significance media form facing challenges in the future development road. It is necessary to reflect and innovate this development constantly.

Keywords: Chinese new village · Operation Hammer · Siburan · The aspect of communication

1 Introduction

This study, from the perspective of local facts, analyzes how the Chinese new village in Sarawak was born under the background of "operation hammer" to understand its history and culture, and analyzes Malaysians' cognition of the new village culture and its communication status. The Chinese new village is a place where the Chinese in Malaysia live together and has a unique meaning. These special settlements are not built by the residents themselves, but the products of special culture generated by historical events. As a new generation of Chinese Americans, they should have some understanding of the history of the new village and know how the ancestors experienced this evolution, so as to carry forward the new village culture.

1.1 New Village

"New village", as the name implies, is "new village". The new village was formed in the 1950s and is now 70 years old. It was founded in the period before Malaysia became independent. After the Malaysian communist party started its armed struggle, the British colonial government of Malaya issued a "state of emergency", restricting the contact between the Chinese in the suburbs and the Malayan communist guerrillas in the forest, bringing together the Chinese who had been scattered in the suburbs, and

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restricting their freedom. They had to work from 7 morning to 6 evening and return as soon as the time came. These concentrated sites later became the new Chinese village, which is now the new Chinese village. According to statistics, there are now 450 new villages in Malaysia, covering all corners, with a population of more than 1.2 million, or 20% of the total Chinese population, while Malaysians and Indians live in kampong.

1.2 Operation Hammer

Operation hammer took place in 1965 after an attack on a police station 18 miles down jing-lian road in Kuching. Hakkas living between 17 and 22 miles along Kuching jin lian road in sarawak have been affected. To deal with the communists, the government resorted to a strategy of enforced isolation – the famous "operation hammer" in Sarawak history – similar to the cage policy used in the German colonies. The villagers were herded into three new villages, initially under 48 h of martial law, then extended to 10 days, and finally permanent new villages. The villagers were confined to a restricted area surrounded by two layers of barbed wire and had to pass through a gate while being examined and questioned. Every household in the village has a household registration and is subject to population checks at anytime.

After more than ten years of control life, with the late opening of the new village control area, its economic status gradually improved and the new village began to develop. However, most of the researches on new villages in the past were focused on the historical studies during the period of new village control, and most of the research objects were also new villages in the west ma peninsula. Sarawak new village took place in the historical background of "operation hammer", gathering a large number of Chinese called Chinese new village, has its unique historical significance. It is helpful in understand the degree of Malaysians to the new village culture and the problems and solutions in the inheritance of the unique historical culture

2 Literature Review

Studies related to the new village of Sarawak are currently being carried out by Vernon l. Porritt and Yong Kee Howe. Each of them made a detailed arrangement and exploration of the "hammer action" which broke out in Sarawak in 1965 under the context of the cold war, and both of them placed the research subject in the historical context of the period before and after the control of the new village. Porritt studies to the Hammer action: 1965 sand pull the colonial force "(Operation Hammer: Enforced Resettlement in Sarawak in 1965) to discuss. The book from the second world war communism to Malaysia for the influence of the content of the core, and as the sand was founded in 1963, the federation of Malaysia, the more local the historical trace of the federation of Malaysia and Indonesia was close connection between left Sukarno regime, and then extended to the "iron hammer" ultimately in the sand, the more reasons, and later in new countryside scheme of control under local conditions [1]. Yong's research involves three new villages, focusing on the historical memory of the events in 1965 and the subsequent period of new villages' control. In Yong's article, he mentioned the process of his interview in new village. He found that people in new village did not like to mention the memories under the different and official discussions with him, and even felt that it was sad and sad to mention that period of the past, so that the period of the past that should be hard to remember and familiar was like "silence" in new village [2]. Yong believes that the people of new village are reluctant to talk much. In addition to the improvement of the situation of new village, they choose to face the new life instead of confining themselves to the shadow of the past, but they are also limited by the fact that the people of new village still haven't come out of that period of history, but they are forced to temporarily forget it in the historical memory [3].

In recent years, Taiwanese researchers from Malaysia also selected two new villages in the Malay peninsula as case studies, and completed studies on the changes of cultural landscape in new villages [4] and social changes in new villages [5]. In GuYanqiu study, although she mentioned the new countryside in the past because of martial law relationship to form a space field monitoring and isolation, but later along with the time, when the change of social gradually moving towards industrialization, commercialization, commercial or industrial zone of the new countryside nearby, also gradually changed, and this kind of change not only exists in the new village side landscape changes, also includes population after into the impact new village. Although both of them leave behind all previous seemingly or historical studies and focus on individual new villages through in-depth interviews, they still focus on the social changes of individual new villages in their public domain.

Cai jingfen, a local researcher in Sarawak, took Dafu village, one of the three new villages in Sarawak, as a field case. Her study is also the first case study on the Chinese new village in Sarawak. In her research, she skipped the previous studies on new villages in Sarawak and considered them in the context of the left-wing movement. Instead, she began to focus on the inheritance and ritual of women's marriage in the contemporary society of Dafu village, a hakka village [6].

3 Dissemination of Chinese New Village

In previous studies, the research on Chinese new villages has mainly focused on historical reviews and economics of new villages, emphasizing how new villages are established and developed. However, the awareness and dissemination of the new village culture has rarely been mentioned and paid much attention. For the Malaysia people's cultural awareness and specific communication, I used a questionnaire survey to analyze and study. At the same time, the author uses professional data analysis software SPSS as auxiliary software to ensure the authenticity and relevance of the data obtained by the author.

This study was distributed to Malaysian Malaysians in various regions of Malaysia by filling out a questionnaire online and conducted a sample survey. A total of 438 questionnaires were received for this questionnaire, and 438 valid questionnaires.

Table 1. Demographic profile of study participants.

Statistical analysis	Kind	Percentage
Sex	Female	44.29%
	Male	55.71%
Age	Under 18	8.45%
	19−28	49.54%
	29−38	10.96%
	39−48	11.64%
	49−58	12.56%
	Above 59	6.85%
Ethnic group	Chinese	97.95%
	Bidayu person	1.14%
	Iban person	0.23%
	Another	0.68%
Hometown	Mingnan	13.01%
	Chaozhou	6.39%
	Hakka	31.05%
	Guangdong	8.68%
	Others (e.g. Fuzhou, Hainan)	40.87%

3.1 Transmission

In order to understand the communication effect of Malaysia new village culture, the first step is to investigate the knowledge of interviewees about the new village culture and its history. The survey found that the high proportion of 84.02% indicated that Malaysians generally had no understanding of the new village culture, while the low proportion of other options indicated that their cognition and understanding of the new village culture were not comprehensive enough, and there was a bias. In addition, the survey results show that except for the elderly, a large proportion of respondents do not know about new village. Visible, Malaysia still did not pay attention to the new village, the degree of knowledge is very low. Among the 15.98% of the respondents, most of them learned about the history of "operation hammer" from the Internet and their elders or parents. From this, we can see that the oral transmission of the history from generation to generation through the elders and the Internet can be better passed on, so that the residents of the new village can have a better understanding of the history and meaning of their place of residence.

3.2 Correlation Analysis

In order to explore the relevance of the questionnaire and make the survey data more targeted, the following assumptions are made, and the results are explored through cross-analysis of independent variable dependent variables and correlation analysis of SPSS.

H1: Age is related to whether you have heard of Operation Hammer

H2: Ethnic groups are related to the degree of understanding of the origin of the new village culture

H1: Compare age to whether you've heard of operation hammer

As can be seen from Table 1, the proportion of Malaysians over 59 years old who have heard of "operation hammer" is much higher than that of other age groups, while there is still a difference between ages in other options. For example, Malaysians aged 19–28 have not heard of "operation hammer". But in order to prove the correlation between the two factors, SPSS was used. It can be seen from the table that the corresponding correlation coefficient is −0.361 and the p value is 0.00, which is less than 0.05, indicating that the data contains statistical significance and indicates that there is a negative correlation.

H2: Compare the understanding of ethnic groups and the origin of new village culture.

From Table 1, we can see that compared with other ethnic groups, Chinese got a larger proportion, which is also the only ethnic group that has a very good understanding of the new village culture. Therefore, it can be seen from the table that the corresponding correlation coefficient is 0.091 and the p value is 0.058, which is almost equal to 0.05. Therefore, it has statistical significance. That means there's a little of a positive correlation.

As the product of national history, the status and existence value of new village are unquestionable. It is very necessary to make new positioning and planning for it so that it can keep up with the pace of the times. In addition, the author believes that new village culture as a unique Chinese culture should not be forgotten by the Chinese. The new village is a product of history, so its cultural value is obvious. The establishment of the new village enriched the Chinese culture of Malaysia while promoting the spirit of unity and self-improvement. These spirits have become the cultural identity of the new village. Although the ancestors of the residents of new village also came from different places, the disasters and bad luck they experienced together prompted them to trust each other and help each other in the same boat. Therefore, the new village is a cultural symbol for the Malaysian Chinese and deserves their continued support. In today's rapidly developing society, if we want to spread the spirit of the new village culture, appropriate use of multimedia equipment, combined with the older generation to tell the history, there will be a certain effect.

4 Conclusion

This study is based on the historical background of the new village, and mainly discusses the cultural development and communication status of the new Chinese village in Malaysia through this event and region. From this study, we found that the Malaysian Chinese did not have the concept or understanding regarding the new village, let alone the culture of the new village. The author believes that the new village is the historical product of Malaysian Chinese, which needs more attention and to develop its culture.

By the time flies, the significant changes have taken place in the new village, which is not the old one. The reason for its initial establishment is gradually forgotten by the contemporary Malaysian Chinese, and the suffering of the former new village life is gradually not understood by the contemporary Malaysian Chinese. Even the residents living in the new village do not understand the cultural history of the new village, let alone the Malaysian Chinese living in the urban area. For many reasons, the new generation of Malaysian Chinese can only get historical information about the new village through history textbooks and literature books.

In Sarawak's new village, there are differences in their native places and customs, but they do not have a generation gap in language. Instead, they have cultural integration. From the initial difficulties to the present, the new village has become a unique historical product of Malaysia. Its existence is of particular significance. Its emergence is conducive to the unity of Chinese identity in Malaysia and strengthens their cohesion. With the coming of the 21st century, Malaysia is also moving towards the goal of advanced countries in 2020. Therefore, how to make good use of the existing assets of the new village is very important.

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The Reality of the Globalizing World and Shaping the Professional Identity of an Individual in the World of "Boundaryless" Careers

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Abstract. Global transformations of the contemporary world, to which almost all aspects of social existence are subject, seem to be inevitable and their complexity difficult to grasp. On a micro and macro scale, new opportunities and prospects emerge, but also fears and anxieties, which are the contours of the society of the future. The qualitative specificity of new transformations in the relationship between the global and the local, society and the individual, and the links between them, is not without significance for the multi-contextual changes in the world of work, which place new demands upon employees. This vision implies definitely new ways of interpreting the world and the quality of judgments on the condition of contemporary man - including man as a "manager" of his own career. In a knowledge-based economy, which in turn makes the orientation of modern society towards knowledge a reality, the key element is the development of the careers of its members and investing in a career "portfolio". Commitment to career development is characterized by the development of personal career goals, attachment to, identification with and involvement in these goals. Changes in the world of "borderless" careers update the problem of proactive behavior of individuals pursuing their careers. The distinguishing feature of proactive career planning, management and management is the awareness of being a subject who performs actions in the desired direction and influences the surrounding reality by initiating changes. Involvement in an internally defined career may be an important source of the crystallization of the (professional) identity of a subject, which seems necessary for the development of his or her career in the world of "borderless" careers in the reality of the globalizing world. Identity is formed in the context of social and cultural influences undergoing a permanent change in reality. Identity styles determined by social-cognitive processes refer to individual preferences in the processing of information about the subjective self, in decision making, in the choice of strategy for constructing or avoiding crystallization of one's identity and the quality of career decisions in the world of "borderless careers". In a situation where no a priori career scenario guarantees success, an investment in a career identified as "owned" by an entity becomes a necessity and forces its proactive planning and management.

Keywords: Globalization · Career · Professional identity · Boundaryless career

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1 Introduction

Multi-contextual social transformations, expressed in the permanent creation of contemporary society, contribute to the difficulty of grasping and unambiguously defining the factors determining it. Responsible discourse requires that attention be paid to the temporal and spatial dimension. Typically, "global" theoretical consideration refers to the complexity, heterogeneity, progressive interdependence of the world's societies and the awareness of its holistic nature. The complexity and temporal multidimensionality of the contemporary globalizing society (its ambiguity, ambivalence, transience, diversity) and the transformation of the socio-cultural reality subjected to constant fluctuations make it difficult to describe and standardize the heterogeneity of the society objectifying itself in its actions. Consequently, the nature of global connections and interdependencies contributes to the integration and disintegration of the world economy at the same time, which is not without significance for the formation of a new configuration of global politics and market structures. Contemporary processes of globalization of the world economy, its reorganization and restructuring, make us reflect on the specificity and dominance of global economic transformation. Undoubtedly, a fundamental element of the phenomenon of economic globalization, and in particular of the development of a free market economy, are changes in the work environment, work structure, perception of work, as well as in the sphere of characteristics, meanings and values attributed to work. It is hard to overestimate the significance of these changes for the quality of career formation, development and modification of its individualized paths. The multifaceted and multilevel structure of social reality, understood by K. Dąbrowski as "the entirety of phenomena that take place in the external and internal environment of man and are perceived captured and experienced by him/her through the senses and mental, emotional, imaginative and intuitive activities, which are mutually connected" [1], points to the particular topicality of the questions about the meaning and scope of the concept of "identity" and, in this context, raises the need to seek answers about the possibilities and abilities of an individual to plan and form a career path and shape his/her (career) identity. This theme becomes particularly crucial in the context of young people pursuing their career.

2 Formation of (Professional) Identity as Reflective Activity

The problem of identity crystallizes the problem of the individual trajectories in the career and construction of the professional identity of an individual. In this sense, like "any other formalized narrative, it is something that has to be worked out and that naturally requires a creative contribution" [2] and reflective approach to one's own biography. Identity is a "reflective loop in which one returns to oneself when one departs from oneself" [3]. In the context of the transformation of the modern world, it seems particularly important to seek and specify the answer to the question: "Who am I in this rapidly changing world?" (a dynamic question). An individual, in response to the complex question of a dynamic nature, in his or her view of the world and planning of career prospects, perceiving the pace and intensity of changes, tries to determine to what extent he or she is an active subject of prospective changes taking place in cultural and social contexts [4].

In a situation when social life is perceived to be organized around a multitude and variety of alternatives (a feeling that is not only observed but also experienced), the individual is faced with the task of determining his or her relationship with this world, which is not without significance for the quality of career planning and management and the modification of his or her individualized paths. It is a kind of internal exploration and an element of searching for an answer to a complex and recurring question: Am I a subject of prospective changes and if yes, to what extent? The significance and dynamics of changes implies changes in the identity aspects of social life in which a person seeks and defines him/herself. In particular, for young people participating in the fluctuating reality, who are in the period of double transit: from youth to adulthood and education at the academic level to the labor market, finding an answer to the question: "Who am I becoming?" becomes particularly important, but also turns out to be more and more difficult to specify in the "multitude of worlds".

The formation of identity is a reflective activity. As J. Rainwater puts it, "we are not what we are, but what we will make of ourselves" [5]. Identity decisions made by young people at the threshold of adulthood determine their further development, namely the development of their potential. Awareness, feeling and adjudication of an individual about "who am I?", "who am I becoming?" enables them to formulate a vision of the desired state. In the sense we are considering, crystallization of one's own identity determines the direction of development of a career perspective and bestows a meaning on it. Unprecedented diversity of individualized lifestyles, understood as a "culturally conditioned way of pursuing needs, habits and norms" [6], causes that one can and should experience a change through which everyone "must become a model for the epoch which we are trying to introduce" [7]. In this sense, the loss and permanent change of individual points of reference updates the problem of identity styles and the issue of "how identity is formed and changed" [8] depending on the social context and quality of young people's involvement in the exploration process. Recognizing and understanding oneself helps to develop a sense of agency and to take responsibility for causality - to make a commitment. Undoubtedly, these processes are important when planning one's own career path.

The modern type of career in the days of "careers without borders" has its consequences for the psychosocial and behavioral attitudes of individuals "whose life goal is professional activity (the basic indicator of mental health) rather than professional inactivity (the basic indicator of social exclusion)" [9]. A common thought, as Amundsen puts it, is that "people make sense of the world of work by subjectively interpreting their own career experience" [10]. In the situation where no career scenario adopted *a priori* brings any guarantee of success, investing in a career identified as "owned" by an individual ("in their own cause") becomes a necessity. The dynamics of contemporary careers called "careers without borders" (*boundaryless careers*), enforces, as A. Bańka emphasizes, proactive planning, steering and managing careers not only among young people or people in early adulthood (i.e. "newcomers" in the period of transition from the education market to the labor market), but also among people from other age groups [11]. This is what the inseparability of career and life is all about, as Wolfe and Kolb pointed out. Although this view was expressed in the 1980s, there are no grounds, given the dynamics and pace of change, for not considering the definition of career development presented by the authors to be out of line with the times when "a career makes a career" (Z. Bauman). They concluded that "career development is connected with life, not only with work. In this way, it refers to the whole life of an individual (…) in constantly changing contexts (…) of life. The pressures of the environment and the constraints, the obligations that attach him/her to other important people, the responsibility towards children and aging parents, the overall structure (…) of the circumstances – these are all factors that must be understood and reckoned with. In this respect, career development, professional identity formation and personal development are combined. Self and circumstances – evolving, changing, revealing themselves in mutual interaction – create the concentration and drama of career development" [12]. The distinguished definition of a dynamic nature (individual vs. environment, continuity and change) sheds additional light on the problem in question. It allows for the recognition that the construction of a career is focused on the lifelong development of an individual, it is a process of crystallizing the identity of an individual in relation not only to the world of work, but to "the world in man and man in the world" (I. Wojnar).

Exploration is one of the basic dimensions in the process of crystallization of identity, which is emphasized on the basis of psychology by J. Marcia, Erikson, A. Brzezińska, among others. The essence is "looking back at oneself, contemplating oneself, trying to understand who one has been, who one is and who one might be in the future, (…) which enables realization of who one is and one's relationship with the external world and with the surrounding environment" [13]. Young people entering adulthood face the necessity of permanent self-determination (in a situation of dominant change and ambivalence) and individualization (forced by the lost "connection" with the community) of their own biography. In the course of one's own life a special place is reserved for the course of an individual career, which is made meaningful by an individual, and this happens, as E. Gurba puts it: "by taking personal initiative in developing professional activity and social relations in managing one's own education and professional career and in planning the future" [14]. We find the development of this idea in the concept of M. Berzonsky's identity styles. It can be considered to be an important addition to the theory of identity statuses of J. Marcia, who refers to the structure of identity as a stable disposition of an individual, an identity conceived as a state (and not a process), resulting from its development [15–17]. And yet, identity is formed in the context of social and cultural influences undergoing a permanent change of reality. M. Berzonsky's model provides an opportunity to dynamically capture the way identity crystallizes.

3 Cognitive Orientations Involved in the Process of Crystallizing (Professional) Identity

Identity styles determined by social and cognitive processes refer to individual preferences in processing information about the subjective self, making decisions, choosing strategies for constructing or avoiding crystallization of one's identity. Identity style is understood by the author as "a way for an individual to deal with solving problems of identity nature" [18]. The model of identity style, proposed by M. Berzonsky, refers to differences in the individual processing of information relevant to identity and differences in the content of the self-concept of the subject. For example, an individual can focus on acquiring information, deliberately process it and evaluate it before he or she decides to commit and define himself or herself, or he or she can automatically adapt and internalize the normative recommendations of significant individuals or groups and communities to which he or she belongs [19]. M. Berzonsky argued that values influence how individuals engage in the process of shaping their identity and dealing with identity conflicts. Values motivate the individual and give direction to his or her life. The conscious, rational, typically information style approach to identity is combined with values that indicate independence and autonomy of an individual while at the same time being able to go beyond personal pleasure and self-indulgence. The normative approach to the aspect of identity is associated with the values of conformity, institutional commitment and responsibility. The diffuse/avoidant approach "full of procrastination and avoidance" is combined with an attitude of personal pleasure and avoidance [20].

Cognitive orientations involved in the process of crystallization of identity may indicate, as M. Berzonsky puts it, different styles of identity, namely: *the information style*, *the normative style*, *the diffuse/avoidant* style, and the *commitment*, also known as an identity engagement factor or engagement force. In the direct effects model, the effects of processing the identity style and the commitment contribute directly and independently to the diversity of research results. An alternative, indicated by the author, is to classify the effect of identity style participation by the level of engagement [21]. However, as the author of the identity style model emphasizes, "identity formation is a long, dynamic process in which the setting of commitments can provide new information and reactions, which may result in a change of priorities" [22]. The concept of identity style refers to beliefs, attitudes, ways of dealing with different situations and making important life and identity decisions. Differences in identity styles are the result of different preferences in choosing social-cognitive strategies to engage (or not engage) in tasks of constructing, maintaining and/or reconstructing a sense of identity [23]. The scale of engagement reflects the strength of motivation, readiness, stability in the realization of the internalized value system, in making decisions related to identity and pursuing the chosen goals. Identity engagement gives the subject a sense of meaning and goal-orientation. Externalized standards and criteria serve as a point of reference when evaluating feedback from problem solving. Commitment can be cognitive, information-based and reflecting the extent to which views and beliefs have been developed and justified by an individual within a framework of rational ideas and evidence, or emotional, reflecting unreasonable but persistent feelings of subjective certainty [24].

Identity engagement is a carrier of a sense of purpose and direction for an individual and provides a "framework" of reference for a value system that serves to monitor, evaluate, regulate behavior and interpret feedback. The power of commitment is positively correlated with careful decision making and problem-solving skills and inversely correlated with the tendency to delay or panic when making decisions [25]. The strength of commitment is positively correlated with careful decision-making and problem-solving skills and inversely correlated with the tendency to delay or panic when making decisions. In Mr. Brickman's approach, commitment "stabilizes the behavior of an individual, which under the given conditions would be exposed to a change" [26]. In this context, it is worth referring to K. Lee's reflection on the need to take into account the emotional aspect of decision making in research on individual's causality in the career, as well as the cognitive aspect. According to K. Lee's research, even those students who can be said to be determined to develop their career path report difficulties in making decisions. They wonder whether the chosen career path will satisfy them and meet their needs and expectations. In order to determine the status of career decision, to anticipate the effectiveness of dealing with career construction, it is important to identify the emotional states of individual subjects. Such an analysis can be used, among other things, to better understand the experience of career indecision [27].

The information style is characteristic for individuals who seek information in the process of identity formation, or more precisely, before making any binding identity decisions. The ways of exploration in the process of crystallization of identity are based on autonomous and active search and reworking of a multitude of different informational data. The essence is to refer to the elements of Self such as: personal standards, goals or value system [28]. Individuals with the information identity style act in a thoughtful way, intentionally seek, evaluate and refer to information that is useful to them. The information style is typical for individuals who reflect on their own views and evaluate them multiple times, especially in contradictory feedback situations. The information identity style is positively correlated with the need for cognition, with cognitive complexity, self-reflection, with rational thought in dealing with problems, with careful decision making, openness to new experiences and conscientiousness. The information style of identity is combined with the subject's activity and causative competence E. L. Deci and R. M. Ryan distinguished integration among regulatory processes. Activities requiring awareness of objectives, values and standards are the result of integrated self-regulation and subject's choices from the options, which by the act of choice determine the subject to the perpetration resulting from their own preferences [29]. Internal exploration is carried out by means of information search, looking into oneself, taking personal values and internalized standards as a reference point. Active exploration of alternatives, information search and flexibility in making commitments [30] belong to the assets of the style represented by this group of young people. The information style is linked to "self-insight, open-mindedness, problem-solving strategies, careful decision making, cognitive complexity, emotional autonomy, empathy, adaptive self-regulation, high levels of commitment and achieved identity status" [31]. The research by D. Czyżowska, E. Gurba and A. Białek shows that there is a connection between the information style of identity and orientation towards collectivism. It is also typical that people who can be attributed equality based collectivism do not easily to submit to authorities [32].

The normative style refers to the way in which an individual can deal with decisions that are important for the Self by accepting and internalizing the expectations of those who are important for the individual or the applicable social norms. Settlement of identity conflicts takes place by referring to such components of Self, as: family, nation, religion [33]. "Normatively oriented individuals show little readiness for internal exploration, have a clear direction of action, have limited tolerance to informational contradictions, and display closure to information that may threaten their personal beliefs and value system. The normative process that, in the view of E. L. Deci and R. M. Ryan (1991), is associated with the internalization of standards, goals and values of significant individuals, makes the commitment not perceived by the entity as fully their own. His or her actions are accompanied by anxiety caused by a sense of possible guilt, approval or duty [34]. According to M. Berzonsky's, the normative style is characterized by a small exploration of alternatives, servitude, a tendency to respect power, attachment to norms and dogmas, conformism towards social and family expectations and rigidity of attitudes when making commitments [35]. Normative commitment is more rooted in emotions than information. Furthermore, normative orientation can reinforce what Langer (1989) calls "immature cognitive commitment". Emotion-based commitment ("cognitively immature") occurs without critical reflection and evaluation of information. However, emotion-based commitment with little evidence that can be confirmed or justified (in contexts where problems, requirements and standards are rather stable), the power of engagement itself promotes the effective functioning of an individual, regardless of the degree of rationality in attitudes. Thus, commitment supported by emotions can materialize the commitment, which is an exemplification of the subject's activity and his/her causative competence [36].

The scale of the diffuse/avoidant style reflects the attitude of procrastination and postponement of the solutions important for the formation of identity, the resolution of identity conflicts. Individuals with the diffuse/avoidant style avoid confrontation with personal problems as long as possible and postpone making important decisions, and their behavior is determined mainly by situational factors. Important, central components of the Self structure are popularity, impressions and reputation [37]. In individuals classified as representing the diffuse/avoidant style, the requirements associated with and determined by the situational context usually dictate or limit their behavioral responses. The diffuse/avoidant style of identity is positively correlated with emotional coping strategies, with situational variability, with neuroticism and depressive reactions, and with meticulousness and cognitive inquisitiveness [38]. In M. Berzonsky's model of identity styles, the diffuse/avoidant one is something more than a dispersed, "lost" Self. This style "involves strategic attempts to bypass or hide potentially negative, relevant feedback (…) with little commitment, with the external location of control and impulsiveness". The results of D. Czyżowska, E. Gurba and A. Białek describe the problem of the diffuse/avoidant style. In studies on young adults gender differences reveal that it is men who are the group with the dominant diffuse/avoidant style of identity, and women are more likely to resolve identity conflicts in a manner characteristic of the normative identity style. Moreover, what is cognitively interesting, there is a link between the diffuse/avoidant style of identity and an orientation towards hierarchical collectivism. Thus, one may risk a claim that the group of women examined will also be characterized by an emphasis on intra-group integrity, a tendency to submit to the will of authorities and an inclination to inter-group competition [39]. It is characteristic of this style to delay facing conflicts and identity problems for as long as possible, and their actions, decisions and choices will be accompanied by behavior that reflects above all a response to the external context and a consideration of consequences. However, the moment of compliance (behavior-context) is a short-term rather than a long-term modification that may affect self-identification [40].

4 Summary

To sum up, it should be emphasized after E. C. Hughes, that "moving perspective" in a career means developing one's own career through personal involvement of an individual. The subjective outlook on a career highlights personal experiences in a career (in the development and planning of its perspective) and takes into account the subjective meanings given to a career. The meanings given to a career are valuable primarily subjectively and not necessarily objectively. "Subjective careers", as Stebbins points out, reflect the individual's own sense of his or her own career and the perception of how it goes [41]. The career domain is dynamic. The needs, objectives, orientations, possibilities and strategies of the subject change, as an individual's life evolves in response to changing personal and social contexts. As M. Piorunek puts it, "educational and professional orientations oscillate between subjective and social contexts of human functioning, being additionally conditioned by the course of an individual's life, and in turn conditioning this course of biography" [42]. Professional orientation, as emphasized by the author, is usually the final sequence of school orientation. Career planning, which in the most general sense is regarded as an initiative taken by an individual, requires, among other things, making an informed choice about the profession. The styles of identity and their relation to ideas regarding the career domain are an interesting construct.

Recognizing the need for a multidirectional approach to career issues and recognizing the quality of ideas and views on the career, the reference to its identity styles sheds a new light on the peculiarities of the subject's approach to the career domain. Reflecting on identity styles when referring to the factor of identity commitment, reveals the differences in processing information, negotiating identity issues and making personal decisions [43], which makes them, from a cognitive point of view, analytically important, because they also serve to clarify the relationships that can be grasped between identity processing styles and opinions, views or perceptions of the career.

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Fashion Design Based on Cross-Cultural Communication

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Abstract. The purpose of this research is to explore the cross-cultural communication perspective with fashion design as the method and China and Thailand as real examples. The design objects are: take Chinese LONG (Dragon in Chinese) and Thai NAGA as cases to study how fashions, as a medium for spreading culture, are able to do crosscultural communication. This study will adopt qualitative research methods which are specifically: (1) Collect the tangible and intangible values of Long and Naga; (2) Design a workshop combining research methodology: focus group and in-depth interview. (3) Apply qualitative analysis to analyze the results; (4) Incorporate the conclusions into the concept of fashion design. The completed tasks include: (1) Research objective cognition of stakeholders in referent cultural backgrounds; (2) Extraction of design concepts on Long and Naga based on stakeholders' cognition; (3) A demonstration of the new methodology which can be used for fashion designers to effectively extract code in the background of cross-cultural communication. The conclusions can be used to explain: how to extract the design concepts of fashions in the background of crosscultural communication; and how fashions can help reduce misunderstandings in cross-cultural communication. The research can be established as a model for other related disciplines and fields.

Keywords: Cross-cultural communication · Fashion design · China Long (Dragon) · Thailand Naga

1 Significance of the Problem

Cross-cultural communication has become a very common phenomenon in the life of contemporary people and society. It involves not only the life level of the "individual" in the world, but also the widely level of the country, such as national relationship and globalization. Cross-cultural communication or intercultural emphasizes the "cross" and "leapfrogging" between different cultures.

Cross-cultural Communication Discipline refers to the activities of communication between individuals, groups or organizations of different cultural backgrounds [1]. Many scholars have pointed out that research on intercultural communication disciplines is still being established and formed. In recent years, some cross studies on

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cross-cultural communication and other disciplines, such as international relations, linguistics, sociology, culture, anthropology, literature, etc. However, there is very little cross-disciplinary research on fashion design and cross-cultural communication. Announce the research question being addressed in research paper, which is use fashion design to do cross-cultural communication, promote mutual understanding and harmony between different cultures, and carry out cultural communication and effective transmission of code.

In order to prove the research question, two symbols are selected in this research, which are very similar in appearance, one is Long, which represents Chinese culture. And the other is Naga, which represents one of Thai cultures, as the design objectives. Figure 1 is showing picture of Long and Naga.

Fig. 1. Picture of Long and Naga (Picture from: http://www.cxtuku.com/pic_844127.html https://www.shutterstock.com/zh/search/Naga+snake)

2 Analysis of the Current Research and Development

The existing researches on cross-cultural communication is the peripheral researches which introduce disciplines relating to cross-cultural communication, including three aspects:

Gudykunst, W. B. [2] interpreted the significance and importance of and the problems in cross-cultural communication disciplines, and pointed out in his research that both verbal communication and nonverbal communication are the two ways of communication. Stuart Hall proposed the theory of encoding and decoding in cultural communication [3], which became one of the important theories supporting cross-cultural communication disciplines, and has been applying even nowadays.

The contents of this paragraph are actually the background knowledge accumulation on researchers on cross-cultural researches. No detailed stipulation is to be made herein because the contents are not closely correlated with this research subject.

After did the literature review, so the research contents in this research are:

1. Carry out on-site investigation by using combined qualitative and quantitative research approaches, based on which, two cultural elements of Long (“Dragon” in Chinese) and Naga are figured out as research objects, to study their cultural

significance and connotation in existing works of art, and integrate them into the fashion design.
2. Apply fashion design methodology that are commonly used in cross-cultural communication study in fashion design.

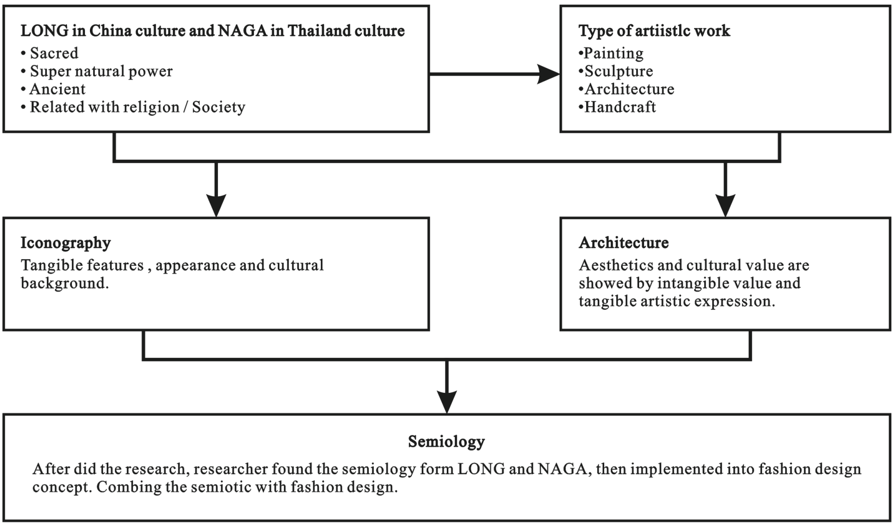
3 Methodology

The study of fashion design methods based on cross-cultural communication can be regarded as a process of "encoding and decoding". First, the designer has to decode the "cultural code". The decoding is divided into two aspects. One is "decode" from the existing literature and artistic works. The research methods used are: literature review, field trip and observation. Another step of "decode" is a survey of audience awareness. In this research, fashion design is to serve cross-cultural communication. In order to understand the stakeholders' awareness, researcher need to conduct surveys with stakeholders before do design. The method used is: workshop (combination interview and focus group).

3.1 Site Visiting and Observation

Researcher has learned a lot of literature review before did site visiting research. A large amount of data has been known from text or historical descriptions. The analysis of Long and Naga artworks is based on the following aspects: the creative approach, the depiction of Long and Naga features, related stories, and interviews with relevant artists and historians. This study will analyze and interpret the data through content analysis. The results of the study will be presented by descriptive text. The research framework is showing in Table 1.

Table 1. Research framework



3.2 Workshop

Data collecting based on analyses the information which get from audiences. The survey of audience perception is divided into the following aspects:

(1) Knowledge about design, including: Symbol information, semantic information;
(2) Explicit knowledge: Pictures, Appearance, Color and so on;
(3) Implicit knowledge: Judgment, Intuition, Experiences, Visual effect, Cognition and so on;
(4) Experiment ways;
(5) Users' Knowledge: Users description about the design objectives;
(6) Cognitive match.

4 Results Analysis Design Thinking

Due to the contents here is limited, the research didn't show the process details, the research process will not be presented here, the following is an analysis of the results.

Finding 1: The answers that participants use for describe Naga, which is "Similar with Long". It means actually Long and Naga are pretty similar.
Finding 2: The words that participants to describe Long and Naga are "adjective", it can find that the audiences lose the cognition about Long and Naga, just know the little information about traditional culture.
Finding 3: What knowledge that audiences want to acquire from fashion design—more cultural contents and philosophical spirit about Long and Naga.

4.1 Design Concepts

The design concept of first set is "S curve line". The worship of Long and Naga originated in the worship of snakes, because ancient humans had awe of nature. Moreover, human fantasy about nature is based on human cognition of themselves, which is why the body of Long and Naga are snake, is from "naked local people" as well.

The design concept of second set is "water": The common point of the Myth about Long and Naga: they have the ability to control water and rainfall. Besides, Naga is the symbol of Mekong River. And Long is the symbol if the sea. Snake born the human and tribes. In philosophy, it is even think that snake is the "tree of life'', mean snake is the water to breed life. The deeper culture is that people began to think about the relationship between life and nature, so ancient humans linked animal worship to imaging about life and gave Long and Naga supernatural abilities.

The 3rd set, the concept design is "Harmonious between human and nature": Both of Long and Naga have ability of control water and fire, and they are a symbol of good agriculture harvest. Beyond that, they are the medium which human can communicate with heaven. Water, fire, air, earth (planting) are shown on the Long and Naga. In philosophy, these four elements make up the world. The ancients gave the Long and Naga more myths. The original fantasy of nature gradually evolved into thinking about the relationship between human, nature, life, and the universe. Human beings hope to live in harmony with nature. Opposition is balance, contradiction is harmonious.

Some design sketches based on the design concept are showing Fig. 2.

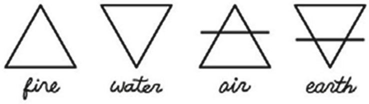


Fig. 2. The symbol of 4 elements, picture from https://tattify.com/product/alchemy/)

5 Conclusion

The outcome of this research will be presented in the form of clothing, extraction of research example using in costume design to do further cultural integration. And will hold a fashion show to show the story about Long and Naga, and will do the further research about audiences' ideas through by fashion show. This research will the subjects to be more fashionable and then combine with modern technology in order to spread-out the ideal to wider range of people. Use different costume design techniques to show the design under cross-cultural background. Such as, Application of fabric reflects Naga and Long's physical characteristics. New image and cultural context of Thai Naga and Chinese Long will be a good example about combine cross-cultural communication with modern fashion design. A mature fashion design research methodology can help fashion designers use clothing to deliver hidden culture and meet the aesthetic needs of the audience. This research is a new paradigm that combines theory, practice and methodology exploration. It not only proposes new models, but also reflects them in the research process. This research wills filly the gap of interdisciplinary learning between the cross-cultural communication and fashion design.

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