Occupational Hazards in a Pathological Anatomy Service

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Abstract. Based on an Ergonomic Work Analysis the objectives of this study were to assess and evaluate the working conditions of a Pathological Anatomy Service (PAS) in a Private Portuguese Hospital. Twelve workers participated in the study and six tasks were analyzed and assessed with the RULA method. The main results of this study have highlighted that the work done in this PAS entails risk factors probably responsible for the prevalence of musculoskeletal symptoms and the high levels of eyestrain. According to RULA results, the risk for the development of MSDs is present in almost all tasks suggesting that investigation and adjustments in the work situation are required. Considering the chemical risk assessment, several nonconformities were found in terms of labeling, storage, workplace and worker's training. Globally, the obtained results are in accordance with those reported by other studies.

Keywords: Musculoskeletal Disorders (MSDs) · Ergonomic Work Analysis · Visual fatigue · Pathological Anatomy Service · Rapid Upper Limb Assessment (RULA) · Binocular microscopes · Microtomes · Embedding centers · Digital pathology · Chemical risk

1 Introduction

Work-related musculoskeletal disorders (WRMSD) represent an important cause of occupational disability in developed countries and are responsible for high absenteeism rates. They are among the most costly health problems that society is facing today affecting millions of workers in Europe and cost employers billions of Euros [1, 2].

Musculoskeletal Disorders (MSDs) are injuries and illnesses that affect muscles, nerves, tendons, ligaments, joints, spinal discs, skin, subcutaneous tissues, blood vessels, and bones. Therefore, WRMSD are MSDs to which the work environment and the performance of work contribute significantly, or MSDs that are aggravated or prolonged by work conditions [3].

World Health Organization (WHO) attributes a multifactorial etiology to WRMSD. These disorders seem to be a consequence of the worker exposure to the different

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number of work-related risk factors. “A risk factor is any source/situation with the potential to cause injury or lead to the development of a disease” [4]. WRMSD are associated with a diversity of risk factors such as: a) Physical factors – involving repetitive movements, sustained awkward and uncomfortable postures, static muscular constraints, strained hand and arm movements, the combination of strain and repetitiveness, sudden muscular effort, exposure to vibrations, low temperatures in the work environment, mechanical compression on tissues b) Psychosocial factors known as Work Stress: including long work-shifts, lack of work-pauses, short work cycles, task invariability, short deadlines, work pace, high cognitive demands, lack of autonomy over work, task demands, negative psychosocial situations such as a weak social support from colleagues and management and job uncertainty c) Individual factors: including age, gender, professional activities/skills, sports activities (workers’ fitness), domestic activities, recreational activities, alcohol/tobacco consumption and, previous WRMSD [4, 5].

In a Pathological Anatomy Service (PAS), it is recognized that the main tasks performed expose the pathologists and other technicians to awkward and uncomfortable postures that, in combination with others risk factors, may be responsible for the development of eyestrain and chronic pain syndromes [5–8]. Despite of the recognition of the association of prolonged microscope use with the development of chronic pain syndromes for nearly 3 decades [7], this problems remains present. Some of the tasks’ particularities are known as responsible for WRMSD such as: sustained awkward posture while using binocular microscopes, turning knobs repeatedly while using microscopes, microtomes and embedding centers, etc. [5, 6].

In addition to the risk of WRMSD, the constant handling of chemical substances and their presence in SAP is also a concern. According to Ferro et al. [9], the perception of professionals, who work in pathological anatomy laboratories, regarding the hazardousness of chemical products handled/stored is not high enough to ensure the desirable levels of safety and health at work. The absence and/or devaluation of the implemented protection measures are one of the problems recognized in some studies as being associated with this type of services [10].

An Ergonomic Work Analysis was required to assess and evaluate the working conditions of a PAS in a Private Portuguese Hospital. The mains objectives of this study were:

- to investigate possible relationships between the working conditions and the complaints reported by workers;
- to characterize the most painful tasks/workstations in terms of the associated musculoskeletal disorders (MSD) development risk;
- to characterize the PAS in terms of chemical risk;
- to propose some preventive measures.

2 Materials and Methods

This study was carried out at a pathological anatomy service (PAS), in a Private Portuguese Hospital, from September 2018 to May 2019. Eighty percent out of fifteen workers involved in this service were invited to participate and an informed written consent was previously obtained. The confidentiality of data was always guaranteed.

This study comprised 3 fundamental stages which integrate different kinds of objectives and materials: Global Characterization of the Work Situations; Risk Characterization (MSDs and Chemical risk assessment) and Risk control, following the methodology adopted by Costa et al. [6]. The first stage integrated three objectives: the characterization of both the operators and tasks: the prevalence of complaints (musculoskeletal or visual fatigue) among PAS professionals, based in a self-reported symptoms questionnaire, organized by body regions; the associations between variables (individual/work-related characteristics) and the prevalence of complaints reported and the identification and selection of the most painful task/workstation. The second stage integrated the characterization of the selected task/workstation in terms of the associated MSD development risk. Additionally, the chemical risk assessment of PAS was integrated. The third stage integrated the proposal of several preventive (technical and organizational) measures.

2.1 Data Collections and Procedures

Different methods, tools and equipment were used according to the specificity of each stage of the study. For the first stage, the data were collected through free/systematized observations, conversation with workers and a questionnaire specifically developed for this purpose. The questionnaire intended to identify key parameters for the workers' characterization, evaluate their perception of the real working conditions, identify self-reported musculoskeletal and visual symptoms, as well as to evaluate the workers' risk perception. The questionnaire was based on the adapted version of the Nordic Musculoskeletal Questionnaire (NMQ), proposed by Serranheira et al. [11] and others available in the literature [6, 10], and information provided by the PAS' workers. The questionnaire comprises 42 questions distributed in four sections (A, B, C and D). The main objectives and associated items can be found in Martins et al. [5].

For the second stage video recording allowed to collect images related to work activity. For this purpose, a digital camera of a mobile phone was used. To characterize the associated risk of MSD development, by each task selected, the Rapid Upper Limb Assessment (RULA) was applied following the methodology adopted by Carvalho et al. [6]. A complete description of the RULA method can be found in the article written by McAtamney and Corlett [13]. RULA was applied considering the following criteria: a) tasks selected by workers as more difficult; b) tasks previously related to accidents; c) tasks requiring risky postures and repeatability. At the end the average scores obtained for each analyzed task/subtask were considered. For the Chemical Risk Assessment a checklist was developed (adapted from [14]) and a matrix-based risk assessment method, proposed by Pité-Madeira, was applied [15]. The checklist was organized in four parts: a) Packaging, Labeling and Safety Data Sheets; b) Storage; c) Workplaces and Workstations, and d) Training and Information for Workers. The Pité-

Madeira matrix-based risk assessment method was applied considering that it is easy to apply; makes it simple to classify the risk according to the level of risk found, proposes a clear and objective action plan (action measures) and finally, it was adopted by the Department of Public Health (2010) of the Ministry of Health in Portugal, to assess the chemical risk associated with situations in which risk factors do not have reference values assigned. The risk level (R), in percentage, is obtained by the application of Eq. 1. It should be noted that in the presence of more than one index (Table 1), in the variables under study, the one with the greatest severity should be selected. This means that the application of this method does not only evaluate the risk for the Health of the professionals, but also evaluates the risk in terms of system Safety.

$$R[\%] = \frac{\log P \times \log G}{\log N_P \times \log N_G} \times 99 + 1 \quad (1)$$

where,

P – Probability index = Q x T (1 to 4 levels); Q = Quantitate index of substance used;
T – Task characteristics (see Table 1)
G – Gravity index = F x To (1 to 4 levels); F = Substance' Physical characteristics;
To – Substance' toxicity, based on Safety Data Sheets (SDS) (see Table 1)
N_P – Probability Index Scale*; N_G – Gravity Index Scale*
* the maximum obtained level available considering the scale used by each variable, in this case = 16)

Table 1. Index by variable used in Probability and Gravity. (adapted from [15])

	Probability (P)		Gravity (P)	
Index	Q	T	F	To
1	Solid > 100g Liquid > 1000 ml	Open system with long duration or task made frequently;	Oxidizing Corrosive Explosive Flammable	Acute toxicity
2	Solid: 11- 100g Liquid: 501-1000 ml	Open system with task made in moderate duration;	Very volatile liquid (p.e <50°C) Aerosols Gases	HAZARD Serious health hazard
3	Solid: 1- 10g Liquid: 100-500 ml	Open system with short duration or task made rarely;	Volatile liquid (p.e 50-100°C) Powdery solid Lyophilized solid	ATENTION
4	Solid < 1g Liquid < 100 ml	Closed system	Non-volatile liquid Dense solid	ATENTION

The relationship between Risk Level, Risk Classification and corresponding Action Level is showed in Table 2.

Table 2. Risk Level (R), Risk Classification and respective Action Levels (adapted from [15]).

R [%]	Risk Classification	Action levels
R ≥91	Unacceptable risk	work cannot be started without reducing risk
81 < R ≤90	Significant risk	needs immediate intervention to reduce risk
66 < R ≤80	Moderate risk	corrective and preventive measures must be implement-ed within a specified period to reduce the risk
41 < R ≤65	Acceptable risk	only requires prevention since the risk has been reduced to the ALARP level
0 < R ≤40	Negligible risk	does not require any measure, the risk is controlled

Data processing was performed with the Statistical Package for the Social Sciences (SPSS©) (version 24). Descriptive analyses were made to summarize the socio-demographic data, job characteristics and the prevalence of complains.

The Chi-square test was used to identify possible associations between variables and the prevalence of complaints. The nonparametric Mann Whitney and Kruskal-Wallis tests were used to compare RULA results by shifts (Morning (M)/Afternoon (A)) and by task. In all cases, a significance level of 0.05 was adopted. Whenever the null hypothesis was rejected the Pairwise Comparison Test was used. The Action Level 2 of RULA method, which corresponds to a RULA Grand Score (RGS) equal to 3 or 4, was considered the level above which a high-risk level of MSD development is present.

Twelve (80%) workers (5 Pathologists/6 Technicians/1 Administrative) agreed to participate in the study answering the questionnaire. Six tasks (Inclusion, Macroscopy, Thinning, Microtomy, Microscopy and Digital Pathology) were analyzed and assessed with the RULA method. The first four tasks are accomplished by Technicians and the last two tasks by Pathologists. The Administrative is responsible for all Lab secretarial work. 162 postures distributed by 6 tasks were used to apply RULA. The tasks assessed were performed by one or two out of four workers (#1, #2, #3 and #4) and during one or two shifts (M/A). Five chemical products were selected to integrate in this study: *Formol, PreservCyt, Cytolyt, Ethanol 96%* and *Xylol*.

3 Results and Discussion

The body regions with the highest percentage of complaints were the cervical (83%), the dorsal (75%), and the lumbar (58%) spine, plus the right hand (67%) and the right shoulder (50%) corroborating the results showed in others studies [6, 7, 12, 16, 17]. The repetitiveness of the arms movements; the flexion/rotation of the head and prolonged sitting were the main reasons, related with characteristics of the tasks, pointed out by the workers to present some of these complaints. Eighty three percent of the workers reported visual fatigue; 40% out of these considered that the symptoms had some impact in the perception of information. The Chi-square test revealed that there were no statistically significant associations between the MSD symptoms/Visual Fatigue and the variables (individual/work-related characteristics) ($p > 0.05$). The risk level for the development of MSD, for all the evaluated tasks, is between the Moderate (67.3%) and High (29%) suggesting that adjustments in the work situation are relevant for 97.5% of the observed postures (Risk Level $\geq$ 2) and further investigation is needed. For the tasks Digital Pathology, Microtomy, Microscopy and Inclusion the Biomechanical loading at the "Neck+Trunk+Legs" was the most important for the final results corroborating the results shown by Maulik et al. [16]. Considering the average values of RULA the riskiest tasks were identified: Inclusion (Risk Level = 2.7), Microtomy (Risk Level = 2.4) and Macroscopy (Risk Level = 2.2). Digital Pathology and Microscopy have the same average value (Risk Level = 2). There are statistically significant differences on Score B in the Microscopy task ($p = .038$) and on RGS in the Macroscopy task ($p = .034$) between shifts. The differences found may be due to: specificities of the body pieces being analyzed at the lab or to the operative modes of each technician. Considering the results obtained by task, the Kruskal-Wallis test suggests that there are statistically significant differences among results from all variables assessed ($p < .00$). The Pairwise Comparison Test did not reveal a pattern in difference found on variables Score B, RGS and Risk Level. On the other hand, the differences found for Score A were between the Microscopy and all other tasks, except Digital pathology.

Considering the Risk level obtained by matrix-based risk assessment method the *Formol* presented the highest (R = 82.18) followed by *PreservCyt, Ethanol 96%* and *Xylol* (R = 75.25), and *Cytolyt* (R = 57.43) which means that corrective and preventive measures must be implemented within a specified period to reduce the risk. Considering the chemical risk assessment, several nonconformities were found in terms of:

- Labeling –Safety Data Sheets (SDS) not available;
- Storage - absence of impounding basins, substances storage without ventilation system, dangerous substances are not stored in their own compartment, storage without taking into account incompatibility and reactivities, storage is not done in signposted areas, materials stacked and ordered inappropriately;
- Workplace – without signs for the use of personal protective equipment (PPE's), without fire extinguisher, the PAS has no means of natural air renewal; there is no emergency plan and emergency numbers are not accessible/visible;
- Worker's training – workers not trained to read labels, to work with hazardous substances, nor to evacuate workplaces;

Globally, the obtained results are in accordance with those reported by other studies [9, 10].

4 Solutions Proposed

To reduce the risk of developing MSD and complaints presented by workers some technical and organizational solutions were proposed: a) rearrangement of the Digital Pathology workstation; b) if possible, acquire adjustable microscopes with tilting and telescoping eyepieces, or adapt existing microscopes with longer ocular tubes and platform adapters; c) select adjustable chairs, desks and other equipment and provide footrests to help workers to support lower limbs; d) workers should become aware of their posture and better understand the MSD risk factors; e) whenever possible workers should take pauses or rotate among tasks and learn how to fit the workstation to their needs; f) Promote awareness training for Chemical Risk (hazards, consequences, correct use of appropriate PPE's, storage, interpretation of SDS).

5 Conclusions

This cross-sectional study was conducted in the pathological anatomy service of a Private Portuguese Hospital. The main results of this study have highlighted that the work done in this PAS entails risk factors probably responsible for the prevalence of musculoskeletal symptoms and the high levels of eyestrain such as: high work intensity, awkward postures, turning knobs repeatedly, high cognitive and visual demands.

According to RULA results, the risk for the development of MSDs is present in almost all tasks suggesting that investigation and adjustments in the work situation are required. Considering the chemical risk assessment, several nonconformities were found in terms of labeling, storage, workplace and worker's training. Globally, the obtained results are in accordance with those reported by other studies.

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