Participatory Ergonomics Intervention for Exploring Risk Factors Lead to Work-Related Musculoskeletal Disorders Among Automotive Production Workers

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Abstract. Risk factors related to work activity and ergonomics can make it more challenging to maintain this balance and raise the probability that some individuals may develop musculoskeletal disorders (MSD). This study was designed to identify the ergonomics risk factors that increase work-related musculoskeletal disorders (WMSD) among automotive production workers. The participatory ergonomics (PE) was employed to assess the risk factors related to WMSD by involving production workers and management team. The study was initiated by reviewing previously established studies regarding critical body region pains risk factors. Expert interviews were then conducted to share knowledge from senior management staff members to identify the potential risk factors. The predicted risks factors were assessed with a mixed group of senior workers from three automotive manufacturers through a survey questionnaire. In all, twenty-six dominant risk factors related to WMSD, specifically in the context of automotive production plant operations were found, and these factors can be considered as points for targeting ergonomics intervention efforts.

Keywords: Ergonomics risk factors · Work-related musculoskeletal disorders · Participatory ergonomics · Production workers · Automotive

1 Introduction

The automotive industry is one of the catalyst of the country's development through a high rate of work [1]. In line with this, automotive workers are assets to the nation as they play an important role in ensuring a sustainable growth and market expansion for the industry. However, automotive workers are often exposed to various ergonomics risks due to the nature of their working environment where they are required to deal with machines as well as heavy tools and materials. Moreover, automotive workers are more likely to be involved in repetitive work tasks. Argubi-Wollesen et al. [2] reported that 10% of working processes in the automotive sector involve pushing and pulling

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with more than 40% of them require the manipulation of heavy objects. Thus, the occurrence of work-related musculoskeletal disorders (WMSD) is high in the automotive industry.

There is a consensus among scholars on the multifactorial nature of WMSDs [3]. The WMSD development is influenced by physical demands of certain tasks, work organizational hazards and psychosocial contexts [4, 5]. Besides, personal factors, such as individual perceptions and other related characteristics are equally important in dealing with risk management [6]. The proactive ergonomics should focus on the counteractive action to overcome WMSDs through early detection and reducing risk factors at work, and identifying relevant risk factors in the future [7].

Therefore, this study aims to identify the dominance of risk factors related to WMSD among production workers using PE approach in an automotive component manufacturer. The findings will contribute to a body of knowledge needed to assist the occupational safety and health (OSH) managers by producing effective WMSD prevention strategies in the workplace for the worker's well-being, productivity, and organizational sustainability.

2 Materials and Method

2.1 Investigate the Related WMSD Risk Factor

Literature analysis was used to recognize the risk factors associated with MSD. To identify the relevant literature, established studies related to back, neck, shoulder and arm pain risk factors were identified. The risk factors identified from the literature analysis were reviewed based on the tacit knowledge provided by the industry experts. Senior management team members were selected for interview analysis based on their expertise, experience, and convenience.

The group of subject matter experts consists of a manager and above level, including general manager and managing director. Managers were from the production, engineering, and safety health and environment departments. The interview analysis comprised a question and answer session, verbal problem solving, and observation analysis associated with workplace ergonomics risks factors. Then, the potential risk factors were grouped according to the ergonomics domains, namely individual, organizational, physical and psychosocial domains.

2.2 Survey WMSD Risk Factor Analysis

The questionnaire survey was distributed to a mixed group of production workers working in three automotive manufacturers. A total of 110 automotive production workers were approached based on their expertise, experience, and accessibility as respondents. Male contributed 99% of respondents and more than 40% age between 31 and 35 years. Majority of respondents (29%) had been working for more than 15 years.

The concluded list of risk factors from tacit knowledge analysis was presented to the respondents in the form of questionnaires. The respondents were required to respond on whether or not the factors are critical consideration in evaluating risk factors related to WMSD in the automotive production plant using a 5-point Likert scale. The concluded list of risk factors from tacit knowledge analysis was presented to the respondents in the form of questionnaires. The respondents were required to respond on whether or not the factors are critical consideration in evaluating risk factors related to WMSD in the automotive production plant using a 5-point Likert scale.

The mean value of each factor was determined by multiplying the percentage of respondents with the values of 1, 2, 3, 4 and 5. These values represent the level of agreement: "strongly disagree", "disagree", "not sure", "agree" and "strongly agree", respectively, adding to the resulting factors. The cut-off value (refer Eq. 1) was used and these factors were identified based on the relevant criteria, for which the mean values are greater than or equal to cut-off value.

$$\text{Cut-off value} = \frac{\sum mean\ value}{number\ of\ factor} \tag{1}$$

The selected value appeared to be the natural cut-off point as it was found to be the average mean rating value for all factors included in the survey instrument.

3 Results

The results of the literature analysis were reviewed based on the potential risk factors for body pain identified to be the upper back, lower back, shoulders, neck, and arms. The group of SME experts has identified the potential risk factors related to WMSD (see Tables 1, 2, and 3). Each of the risk factors is placed in the appropriate ergonomics domain, including individual, organizational, physical-job task, physical-workplace and equipment, and psychosocial ergonomics.

Table 1. Dominant individual ergonomics-related risk factors

No.	Sub-risk factors	Cronbach's alpha, α	Mean	Cut off value
IF1	Negligence of workers	0.873	***4.03***	3.61
IF2	Improper use of PPE		***3.92***	
IF3	Level of education		***3.90***	
IF4	Working experience		***3.68***	
IF5	Age		***3.64***	
IF6	Body size		3.59	
IF7	Body weight		3.45	
IF8	Sedentary lifestyle of worker		3.39	
IF9	Employment duration		2.88	

Table 2. Dominant organizational and physical-job task ergonomics-related risk factors

No.	Sub-risk factors	Cronbach's alpha, α	Mean	Cut off value
	Organizational related risk factors	0.822		3.75
OF1	High work load		***3.94***	
OF2	Frequent workdays		***3.85***	
OF3	Exposure to physical demands		***3.80***	
OF4	Worker lack of rest		***3.76***	
OF5	Tight production schedule		***3.75***	
OF6	Long working hour		3.74	
OF7	Irregular working schedule		3.61	
OF8	Shift work		3.56	
	Physical-job task related risk factors	0.890		3.99
PhyJF1	Frequent work lifting		***4.21***	
PhyJF2	Carrying and lifting heavy loads		***4.19***	
PhyJF3	Poor working practice		***4.10***	
PhyJF4	Heavy physical work		***4.08***	
PhyJF5	Forced exertion in job task		***4.05***	
PhyJF6	Poor working posture		***4.03***	
PhyJF7	Static loading of the spine		3.98	
PhyJF8	Prolong static posture		3.96	
PhyJF9	Prolong standing posture		3.88	
PhyJF10	Overexertion		3.72	
PhyJF11	Repetitive of tasks		3.70	

The reliability analysis of 45 risk factors related to WMSD is shown in Tables 1, 2, and 3. The Cronbach's α for the five factors are above 0.7 with the ranged between 0.821 and 0.890. Thus, all studied risk factors are deemed reliable [8]. The survey results for risk factor related to WMSD in each ergonomic domain also presented in Tables 1, 2 and 3. The value of 3.61 appeared as the natural cut-off point as it was found to be the average of mean rating values of all the individual ergonomics-related risk factors. Thus, the five most critical risk factors have presented in Table 1.

Similarly, the respondents rated the factors considered in organizational ergonomics-related risk factors affecting WMSD, and the cut-off value is 3.75 for mean ratings. Hence, the five most important risk factors have shown in Table 2.

The physical ergonomics risk factors were divided into job tasks, and workplace and equipment. The results for job task related risk factors established, and the cut-off value is 3.99 for mean ratings. Consequently, the six most serious risk factors have exposed in Table 3. The results for workplace and equipment related risk factors are summarized and the cut-off value is 3.96 for mean ratings. So, the five most important risk factors have shown in Table 2.

Table 3 displays the dominant psychosocial ergonomics-related risk factors affect WMSD. The value of 3.61 appeared to be the natural cut-off point. Therefore, the five most critical risk factors for psychosocial ergonomics have shown in Table 3. Based on

Table 3. Dominant Physical-workplace and equipment and psychosocial ergonomics related risk factors

No.	Sub-risk factors	Cronbach's alpha, α	Mean	Cut off value
	Physical-workplace and equipment related risk factors	0.821		3.96
PhyWF1	Poor ventilation in working environment		***4.08***	
PhyWF2	Poor workspace		***4.01***	
PhyWF3	Poor temperature in working environment		***3.99***	
PhyWF4	Hand tools and vibration		***3.98***	
PhyWF5	Noise in working environment		***3.96***	
PhyWF6	Poor workstation		3.95	
PhyWF7	Poor work surface height		3.93	
PhyWF8	Heavyweight equipment or tools		3.77	
	Psychosocial related risk factors	0.863		3.61
PsyF1	Fatigue		***4.03***	
PsyF2	Work stress		***3.92***	
PsyF3	Emotional stress		***3.90***	
PsyF4	Frustration with work and not work-related		***3.68***	
PsyF5	Low job support		***3.64***	
PsyF6	Work fast		3.59	
PsyF7	Job task rotation		3.45	
PsyF8	Long working time (overtime)		3.40	
PsyF9	Work intensely		2.89	

the reliability and descriptive analysis, 26 sub-factors that act as the key to assess the risk factors related to WMSD specifically in the context of the automotive production assembly plant were identified.

4 Discussions and Conclusions

The most critical individual ergonomics-related risk factor is the negligence of workers. Negligence is one of the main causes of body pain, accident, and deadly injuries among industry workers [9]. The results of the study reveal that the high workload, is perceived as the most critical organizational ergonomics-related risk factors affecting WMSD. These findings supported the verdict of Weale et al., [10] workers have a high workload experienced MSD pain in a variety of body regions. Furthermore, frequent work lifting, perceived as the most critical physical-job task related to risk factors. The result of this study supports the finding of others, which found the increments of low back pain intensity are more common among workers performing frequent work lifting and lifting heavy loads [11].

The most severe physical-workplace and equipment related risk factors is poor ventilation in working environments. This finding supports the latest studies which

addressed the quality of the environment of a workplace like temperature, ventilation, and noise have influenced the productivity and efficiency of the workers [12]. The finding of the study shows that the most serious psychosocial risk factors is fatigue. Fatigue could lead to work-related disorders and declining in productivity and efficiency [13].

In conclusion, the dominance of risk factors related to WMSD has discovered. Hence, OSH practitioners and engineers can cooperate to minimize or eliminate that risk factors while ergonomics workplace design stage. Finally, WMSD risk can be avoided because of the safe, healthy, and well-being culture created in the organization.

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