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Ergonomics interventions to reduce musculoskeletal risk factors in a truck manufacturing plant

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ABSTRACT

Ergonomic interventions may potentially reduce MSDs, but the context of industries (barriers, ever-changing situations, dialogue processes) might play a significant role in the success of interventions. This study evaluates the effectiveness of ergonomic interventions including engineering/technical and organizational interventions, and the involvement of the stakeholders in reducing musculoskeletal risk factors/symptoms. A pre-post-test experimental study in non-randomized groups was performed over three years in a sector of a truck assembly plant. The mean age of the operators in the sector for the initial and second assessment time was 42.0 (±7.6) years and 39.0 (±8.7), respectively. The mean length of work experience in the current job was 15.2 (±7.2) years and 13.9 (±7.3) for the initial and second assessment times, respectively. Five engineering ergonomic solutions and organizational interventions were implemented after a comprehensive ergonomic analysis. The organizational interventions consisted mostly of transferring and redistributing the tasks, i.e., ergonomically balancing and redesigning of the workstations. Before performing the interventions, the findings of the ergonomic study were presented at several meetings to encourage the involvement of the stakeholders (including managers, engineers, and operators) in the interventions. This study showed that a combination of ergonomic measures—engineering and organizational interventions—could reduce physical workloads. Musculoskeletal symptoms decreased after interventions although the difference was not significant.

1. Introduction

Work-related musculoskeletal disorders (MSDs) are a significant challenge for the automotive manufacturing industry. MSDs represent a high percentage of all diagnosed work-related diseases across occupations and worker groups, particularly in high-risk tasks (Oranye and Bennett, 2018). The costs of MSDs are substantial and include direct costs such as compensation, administrative and medical costs, and indirect costs such as absenteeism, and losses related to product quality and productivity (Landstad et al., 2002; Genaidy et al., 2009; Sultan--Taïeb et al., 2017). Adverse job characteristics such as physical, organizational and psychosocial risk factors have a relationship with the prevalence of MSDs in many occupations, particularly those in truck assembly plants (Driessen et al., 2010; Daniels et al., 2017; Widanarko et al., 2014). Operators in the truck assembly line are exposed to various physical risk factors such as repetition, forceful exertion, awkward postures, manual materials handling, and vibration (Zare et al., 2016; Falck et al., 2014). Furthermore, organizational factors such as un-balanced workstations and insufficient recovery time exist in the truck assembly line workstations (Kazmierczak et al., 2005; Otto and Scholl, 2011).

The literature shows that proactive ergonomics and remedial actions are standard approaches to prevent MSDs and increase productivity/quality in the automotive industry (Driessen et al., 2010; Neumann et al., 2010). However, specific factors such as contextual factors, mal-adapted intervention strategies, ineffective contributions of stakeholders, and poor ergonomic analysis can lead to the unsuccessful intervention practices (Stock et al., 2018; Neumann et al., 2010; Driessen et al., 2011; Burgess-Limerick, 2018; Winkel et al., 2017; Dasgupta et al., 2017). The automotive industries have not usually published their

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intervention strategies, and few kinds of literature have described the intervention processes, their success, and particularly the overall impact on MSDs (Driessen et al., 2010; Westgaard and Winkel, 1997). Gupta et al. and Driessen et al. showed that the participatory ergonomics interventions were ineffective in reducing physical and psychosocial risk factors (Gupta et al., 2018; Driessen et al., 2011). Westgaard and Winkel showed that intervention programs focusing on identifying and solving specific problems are more successful than generic interventions aimed at reducing exposure to a particular level (Westgaard and Winkel, 1997). Previous studies have suggested that a combination of policies including information, education, both compulsory and voluntary strategies would reduce physical workloads and MSDs risk factors (Burgess-Limerick, 2018; Neumann et al., 2010). Van der Molen et al. recommended that ergonomic engineering controls such as lifting tools, combined with a participatory approach and involvement of stakeholders, would efficiently reduce physical work demands and MSDs in the long term (Van der Molen et al., 2005).

The effectiveness of ergonomic strategies in real settings such as truck industry is a matter of debate in the previous literature. This study aimed to evaluate the effectiveness of ergonomic interventions to reduce physical risk factors and musculoskeletal symptoms in the truck assembly line.

2. Materials and methods

2.1. Subjects and context of study

A pre-post-test experimental study in non-randomized groups was performed over three years in one sector of a truck assembly plant. Fig. 1 shows the conceptual framework applied in this study. This framework is similar to the research framework proposed by Van der Beek et al. (2017).

The factory divided the sector under study into smaller groups of workstations to enhance continuous improvement (Liljedahl and Muftic, 2012). Three Improvement Groups (IGs) were therefore studied, and each group included various workstations, a team leader, and the operators (Table 1). The typical tasks of this sector were the assembly of truck parts, wiring, hose connection, picking up objects from a pallet, lifting and carrying parts (manually or with devices), tightening with screwdrivers, and pushing/pulling wagons. Table 1 describes the main tasks of each workstation, and the main risk factors were initially identified.

The cycle time for each workstation in the first part of the study (before intervention) was 11 min. Seventeen operators worked in the sector during the initial assessment time. We included all the operators in the study, but two operators were excluded due to having musculoskeletal symptoms. Finally, 15 operators participated in the study before the intervention. All the operators were men, and the mean age was 42.0 (±7.6). The mean length of work experience in the current job was 15.2 (±7.2) years.

The cycle time decreased to 8 min in the second part of the study (after intervention). Twenty-four operators worked in the sector in the new assessment time, but three operators were excluded from the study because of musculoskeletal pain. The sample of 21 participants included after the intervention. The mean age and length of experience for the participants were 39.0 (±8.7) and 13.9 (±7.3) years, respectively, in the second assessment time.

Another sector of the factory was selected as the control group. The operators of this sector mainly carried out similar tasks as the sector under investigation: picking up parts, material handling, lifting, carrying, assembling, pushing/pulling, and tightening. Furthermore, both sectors were similar regarding work conditions, organization, management, and psychosocial factors. All the parameters, such as the worker demographics (ages, gender, and years of experience), environmental conditions, and social conditions, were equivalent between the control and intervention groups in both assessment times.

All the subjects consented to participate in this investigation and gave the written informed consent before including in the study.

2.2. Data collection

Before intervention, eleven workstations of the selected sector were analyzed by an in-house ergonomic observational method (Zare et al., 2016) and the NIOSH lifting equation (Waters et al., 1993). Twenty-eight scenarios were assessed (including the most common type of trucks and other variant truck models). The workstations assessed by viewing work in person and on video. The majority of tasks at each workstation were observed several times, either in person or on video for several operators included in the study.

The in-house ergonomic standard method used to analyze the workstations consists of 20 factors classified into four categories, including repetition, work posture, force, and energy consumption (Table 2). The methods prioritized the assessment into three levels. The green level shows the minimal risk of musculoskeletal disorders and is acceptable. Yellow denotes moderate risk of musculoskeletal disorders; tasks and workstations assigned yellow might need some improvement in the future. Red is an action level with considerable risks of musculoskeletal disorders, and changes are required as soon as possible. The number of yellows and reds determines the color of workstations classified in one of three categories, i.e., green, yellow, and red.

The NIOSH lifting equation method considered seven factors (load (LC), Horizontal location of the object relative to the body (HM), Vertical location of the object relative to the floor (VM), Distance the object is moved vertically (DM), Asymmetry angle or twisting requirement (AM), Frequency and duration of lifting activity (FM), and Coupling (CM) or quality of the workers grip on the object) to calculate the recommended weight limit (RWL) for a lifting task. The ratio of weight lifted to the RWL yield lifting index (LI). In this study, the task was considered as green when LI value was less than one, yellow when LI was between 1 and 1.6, and red when LI was more than 1.6.

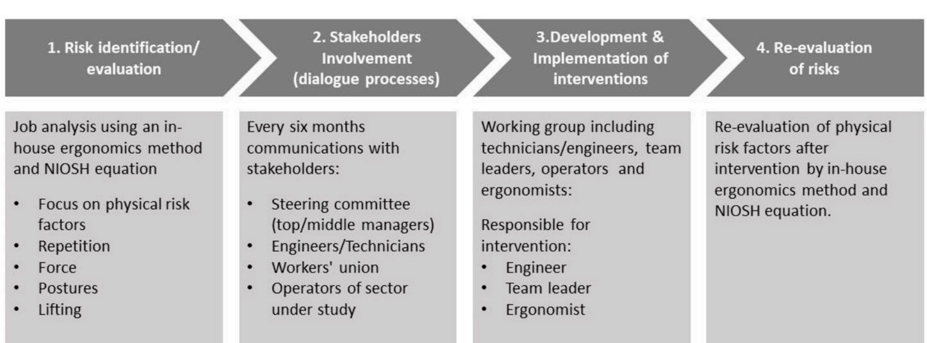

Fig. 1. Conceptual framework used in this intervention research.