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Evaluation of ergonomic approach and musculoskeletal disorders in two different organizations in a truck assembly plant

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The aim of this study was to assess the ergonomic physical exposure, organizational and psychosocial factors in a truck assembly plant for two different cycle times (11 min and 8 min). A self-reported questionnaire was applied to evaluate subjective physical exposure, organizational and psychosocial factors by operators in two organization of an assembly process. The initial cycle time was 11 min (system A) and the new was 8 min (system B). The same work and assembly tasks had to be completed in both systems. However, the organization and distribution of the tasks and workstations were reorganized. The results of the questionnaire showed that subjective estimation by the operators regarding ergonomic risk factors was better in the new organization and self-reported WR-MSDs symptoms were fewer. However, exposure to risk factors and WR-MSDs symptoms was not statistically different between two cycle times. The findings provide better understanding of how organizational changes can modify ergonomic exposure in manufacturing assembly industries. Effective interventions are thus not only engineering solutions but also organizational and administrative adaptations.

1. Introduction

Manufacturing success in the competitive industrial world depends on employees' wellness and reducing costs (Falck and Rosenqvist, 2012; Törnström et al., 2008). Although ergonomics is integrated in the production system of many industries to improve human wellbeing and to prevent work related-musculoskeletal disorders (WR-MSDs), these disorders are still the main cause of occupational disease in many countries (Putz-Anderson et al., 1997; Roquelaure et al., 2002a). Claims for WR-MSDs have increased and it is estimated that 40% of occupational costs are related to WR-MSDs (Speklé et al., 2010). Forty-five million employees are affected by WR-MSDs in Europe, and in France 46,537 of all occupational claims in 2012 (86%) were for WR-MSDs (Roquelaure et al., 2002b; Caisse nationale…, 2012). In addition to the effects of WR-MSDs on business performance, they have considerable impact on human quality of life as they are the main causes of discomfort and pain in the workplace. WR-MSDs present serious ergonomic problems, particularly in the automobile industry due to the wide variety of ergonomic high risk tasks including tightening, picking up, lifting, material handling, as well as the characteristics of assembly line work (Wang et al., 2011). Several dimensions of ergonomics such as physical, organizational and psychosocial risk factors may be reasons for disorders among assembly operators. Physical risk factors, including repetition, awkward postures, forceful movements and heavy lifting can increase the risk of WR-MSDs (Fredriksson et al., 2001; Widanarko et al., 2014, 2015). Organizational risk factors such as time constraints, work rate and workload also have a role in the prevalence of WR-MSDs. Furthermore, psychosocial risk factors such as low decision latitude, high psychological demands, and low social support may influence these disorders. Recent studies have shown that these factors may independently increase the risk of musculoskeletal disorders or the interactive effect between them may cause WR-MSDs (Widanarko et al., 2014; Widanarko, 2013). Inman et al. (2003) showed that the odds of WR-MSDs for physical risk factors and time constraints (organizational risk factors) was 2.61, while the independent effects of these risk factors was less than one (Inman et al., 2003). In a study in a large population, Widanarko et al. (2014) showed that physical, organizational and psychosocial risk factors were independently associated with WR-MSDs. Moreover, the combined effects of these risk factors significantly

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increased the risk of WR-MSDs. However, good conditions of organizational and psychosocial factors can reduce the adverse effects of high physical workloads (Widanarko et al., 2014, 2015; Widanarko, 2013).

In order to adjust work situations and reduce WR-MSDs, there are many physically oriented intervention studies in manufacturing assembly industries. However, few studies have investigated organizational changes and their consequence for WR-MSDs. The effects of long and short cycle times were investigated by Johansson et al. in a truck manufacturing company, and musculoskeletal symptoms were similar in both systems. However, fewer physical risk factors were reported for the long cycle time (Johansson et al., 1993). Fredriksson et al. (2001) reported that changing from a line out system with a long cycle time (20 min) to a line system with a short cycle time (90 s) decreased physical risk factors significantly (Fredriksson et al., 2001). However, musculoskeletal symptoms and perceived physical exertion increased. It was concluded that psychosocial factors and poor organization design could increase musculoskeletal disorders although the new organization had improved physical working conditions. A new designed flow-line process increased the prevalence of musculoskeletal symptoms for fish-filleting plant operators. The authors concluded that all dimensions of work characteristics should be taken into account to reduce musculoskeletal symptoms (Ólafsdóttir and Rafnsson, 1998). Some advantages of a long cycle time were reported if physical and psychosocial aspects were considered in the design of the production line. The complex nature of musculoskeletal disorders means there is a need to evaluate the various elements of the ergonomic approach and consider them as a principle for designing new organization (Johansson et al., 1993; Kadefors et al., 1996; Engström et al., 1999).

Reorganization of workstations for the reason of increase of production volumes were undertaken in a truck assembly plant in France. The cycle time was decreased from 11 min to 8 min and over this reorganization ergonomic approach was considered. Furthermore, technical improvements were implemented in the reorganized production line in order to reduce the physical ergonomic workload. The purpose of this study was both to investigate ergonomic approach elements in truck assemblers including physical, organizational and psychosocial factors from operator's viewpoint and to evaluate the likely changes in the ergonomic factors after reorganization in the new cycle time. Our hypothesis was that fewer physical risk factors and musculoskeletal symptoms should occur in the new system because of reorganization of the high workload tasks between different workstation, technical ergonomic changes and reduced working at the hard workstations.

2. Materials & methods

2.1. Workplace description

This study was carried out as a follow up investigation into two production cycle times of a truck assembly plant in France. The cycle time (known as takt time in the factory) is defined as time for performing the assigned tasks in addition to recovery time. The initial cycle time was 11 min (system A) and the second cycle time was 8 min (system B). Eleven workstations (known as work position in the factory) from one sector of the truck production plant were selected for data collection and each workstation included a number of sequential assembly tasks. For production reasons the factory decided to change the cycle time from 11 min to 8 min. The organization of the workstations was therefore changed and some tasks were transferred between workstations and certain new posts were created. Furthermore, extra operators joined a variety of workstations. However, the main tasks of most workstations remained unchanged. In system A, the “Selective Catalyst Reduction (SCR) tank” workstation included unloading and transferring the support by means of a lifting tool. The principle components of the SCR support tank were then assembled in sequence and finally the completed assembly was fed up the line by wagon. The changes regarding system B at this workstation were almost entirely organizational. As the layout and the zone of SCR support assembly was changed, many non-necessary movements which related to picking up components were eliminated. Furthermore, another operator was added to this area to perform the extra tasks so that the tasks at this workstation in the new cycle time were the same as the former system. Completed SCR support tanks were assembled in the truck chassis at another workstation on the line. In system A, this post included tasks such as assembling and tightening the reservoir, and connecting hoses and cables. In the new system connecting two hoses, tightening hose clamps and finishing cable rooting on the top of the SCR tank were performed by another operator. The third workstation in system A was preparation and picking up the air filter, air pipe, heat cover, SCR tank, cab tilt cylinder and straining cylinder. One operator performed these tasks in three cycle times. In system B, this post was broken down into two posts i.e. “picking up the SCR tank and cab tilt cylinder” as well as “preparation and picking up air filter, air pipe, and heat cover”. Furthermore, the straining cylinder task was transferred to another post (assembling air filters in the line) but some extra tasks were added into “picking up the SCR tank and cab tilt cylinder” workstation because of changes in the production. Some modifications were also performed in the layout and organization of this zone.

Preparation and integration of the bumper on the chassis was performed in the zone near the assembly line in system A and it included four workstations in which one operator worked (11 min for each post). The main tasks of these series of workstations were preparation of the washer tank, fog lamp, cab tilt pump, picking up bumper and sun visor, preparation of the bumper, assembly of light box, and bumper assembly on the chassis and tightening. In system B, this workstation was divided into five workstations (8 min for each post). The tasks in this zone were almost the same as the initial system but two tasks including picking up the bumper and sun visor were transferred to other sectors of the factory. The “air filter assembly on the chassis” workstation included assembling the air filter, air pipe, cab tilt cylinder, heat cover and connecting hoses on the chassis in the initial system. In system B, the heat cover assembling task was transferred to the right mudguard workstation and the cylinder straining task was added to this post. Two workstations, i.e. boarding steps and mudguards left and right on the initial system, were distributed to four workstations (i.e. boarding steps left and right and mudguards left and right). Fitting together the air pipe and the inlet pipe task and heat cover assembly task were added to these workstations. Overall in system B, two tasks (picking up the bumper and sun visor) were eliminated (transferred to other parts of the factory) and one task (Fitting together air pipe and inlet pipe) were transferred to this zone. System A comprised eleven workstations and system B fourteen workstations (Table 1).

2.2. Procedures and subjects

The first part of the study for initial cycle time was performed before the summer vacation in July 2013. The new system and organization were then established during the holiday. The second part of study was carried out in March 2014 seven month after changing the cycle time, when the operators had adapted to the new conditions. The operators in the initial and second phase were the same but extra people were employed at the new workstations. System A, therefore, comprised 17 workers and system B included