The influence of job rotation on wrist position sense: a preliminary study among assembly workers in a real-life occupational setting

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Abstract

The effectiveness of job rotation in industrial environment is still controversial, namely during tasks with high functional similarity, as assembly tasks. Thus, the aim of this study was to investigate the influence of job rotation on wrist position sense acuity among experienced assembly workers. Eight healthy assembly workers divided in two groups (four assembly workers performed task rotation and four assembly workers performed tasks with no rotation) participated in this field study. Manifestations of muscle fatigue of wrist flexors and extensors muscles were obtained by surface electromyography during a standardized test contraction, while wrist position sense errors were assessed by electrogoniometry. After a workweek, despite not statistically significant, wrist flexors muscles in the no rotation group showed EMG signs of fatigue. The two groups showed a trend to increase position error for flexion after a workweek. Future research should include a higher number of participants and other techniques to evaluate muscle fatigue and their impact on positon sense acuity.

Keywords: job rotation, assembly work, wrist, proprioception

Presentation Preference: Poster

1. INTRODUCTION

Several authors reported that disorders in wrist and hands are associated with repetitive manual work (Hansson et al., 2000; Barr, Barbe, & Clark, 2004). However, work-related musculoskeletal disorders (WMSDs) are a complex condition influenced by other factors such as organizational factors (e.g., design of individual jobs) (Wells, Mathiassen, Medbo, & Winkel, 2007). A recent prospective study focused on finding the risk factors related to work organization for incident carpal tunnel syndrome, revealed that payment on a piecework basis and work pace dependent on automatic rate were associated with this disorder (Petit et al., 2015). Time aspects of work have particularly interest in the current time-intensive production systems with strictly standardized assembly procedures at time-balanced station on the assembly-line. Auto components industry is an important cluster of manufacturing in Portugal, aggregating about 200 companies and creating approximately 41 000 direct jobs (AFIA, 2015). Assembly work is frequently used in the automotive industry (Landau et al., 2008) and are characterized by standardized procedures, cycle times less than 30 s, high repetitiveness of movements and low variability (Kilbom, 1994). The exposure to assembly work for extended periods of time without sufficient recovery may lead to acute physiological responses, such as muscle fatigue. This complex phenomena may affected motor control and introduce proprioceptive deficits. The joint position sense is included in the conscious proprioception and is defined as the ability to accurately reproduce a specific joint angle (Hagert, 2010). In a real-life occupational setting, proprioceptive deficits caused by muscle fatigue may be an important initiating factor associated with the occurrence of WRMSDs (Björklund, Crenshaw, Djupsjöbacka, & Johansson, 2000). Ergonomic interventions such as job rotation may increase physical workload variation and has been proposed to minimize injury risk and fatigue in jobs with repetitive tasks (Wells, McFall, & Dickerson, 2010). However, research studies do not consistently support the effectiveness of job rotation against musculoskeletal disorders, as well, as muscle fatigue (Mathiassen, 2006; Santos et al., 2016). Additionally, there are only few studies that investigated the effect of this administrative intervention in real-life occupational settings. Considering the hypothesis that exposure to repetitive work can induce muscle fatigue, and consequently, introduce proprioceptive deficits, this preliminary study investigated the effect of job rotation on wrist position sense acuity among experienced assembly workers.

2. MATERIALS AND METHOD

2.1. Participants

The present field study was conducted in a company that produces mechanical cables for the automotive industry. Eight female healthy volunteers (age: 28.75±4.40 years; stature: 157.50±5.72 cm; weight: 56.64±7.12 kg; body mass index: 22.78±2.33) with a work experience over 12 months and right-handed participated in this study. To evaluate the influence of job rotation, two groups were selected: group 1 (G1) was constituted by four assembly workers rotating between five workstations at two hour intervals (rotation conditions) and group 2 (G2) that was constituted by four workers that worked always in the same workstation (no rotation conditions).

2.1. Work tasks

Participants worked in assembly lines that included different workstations with standardized tasks. All workers adopted standing postures using the upper limbs to place the materials in the equipment and to press the control buttons.

2.3. Experimental procedure and instrumentation

Data were collected before the beginning of the work week (start) on Monday and after the end of the work week (end) on Friday. No considerable differences in the production volumes were observed. On each occasion the participants began by performing a position sense test of the right wrist. A twin-axis Goniometer 110 (Model Biopac TSD130A) was used to measure wrist angular movement and it was fixed as presented in the Figure 1. In these trials, participants sat upright with their feet on the floor, and their knees at 90º (accuracy: ± 2º measured over a range of ± 90º). Additionally, their shoulders were parallel to the floor and their forearm was flexed (105º) horizontally and supported, with the forearm and wrist in a neutral position. The trials were performed in a seated position with right arm on the chair arm pad, allowing flexion-extension movements about the right wrist joint while keeping the lower arm fixed at 90°of elbow flexion. Participants were blindfolded and, in six trials, moved actively their hand from the reference position (0° of wrist flexion and extension) to the target position (45º of wrist extension and flexion). The magnitude of the position error was evaluate by calculating the absolute error of the joint angle, defined as the absolute difference between the memorized angle and the reproduced angle. Next, the subjects were equipped with recording equipment for electromyography activity (EMG) of flexor carpi radialis muscle (FCR) and extensor carpi radialis muscle (ECR), globally considered wrist flexors and extensors muscles. EMG recordings were performed during maximal voluntary contractions (MVC) and during an isometric test contraction with a duration of 180 s at 15% of the MVC using a hand dynamometer (BIOPAC TSD121C). The disposable Ag-AgCl electrodes were placed according to Mogk & Keir (2003b). In these trials, participants sat upright with their feet on the floor, and their knees at 90º. Additionally, their shoulders were parallel to the floor and their forearm was flexed (105º) horizontally and supported, with the forearm and wrist in a neutral position. EMG-based measures of muscle fatigue were root mean square (RMS) and median frequency (MF). According to several authors fatigue occurs when time domain parameters, such as the mean amplitude and RMS amplitude increase (Larivière, Arsenault, Gravel, Gagnon, & Loisel, 2003), and mean power frequency (MPF)or MF decrease (Balasubramanian, Adalarasu, and Regulapati, 2009). RMS values were normalized to the EMG values measured during the maximal handgrip strength at the start of the week. All data analysis were performed using AcqKnowlegde 4.1 for Mac OS X (BIOPAC Systems Inc., Santa Barbara, CA USA). Statistical analyses were performed in SPSS 22.0 (SPSS Inc., Chicago, IL, USA). Wilcoxon signed rank test and Mann-Whitney U-test were performed to verify if there were any differences between EMG parameters and absolute error in each measured moment and between groups, respectively. Statistical significance was accepted at $p<0.05$.

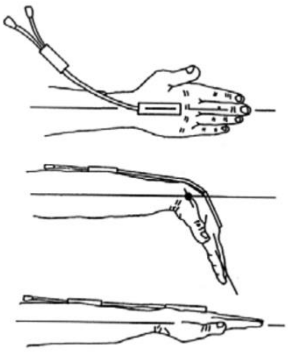

Figure 1 –Wrist: Twin-axis Goniometer 110 mm (Model Biopac TSD130A)

3. RESULTS AND DISCUSSION

The results of EMG of FCR and ECR muscles demonstrated that there is no consistent evidence of EMG manifestations of muscle fatigue over the course of the workweek in the two groups studied. MF values decreased only for FCR muscle in G2, indicating fatigue. However, no significant differences were found between groups ($p>0.05$). For EMG RMS data, significant differences were found between muscles in each moment ($p<0.05$). Some factors may have influenced the changes of EMG parameters of muscles under study, such as change of muscle tissue and alterations in the balance of force between synergistic muscles resulting from learning and coordination (Bennie, Ciriello, Johnson, & Dennerlein, 2002) and crosstalk phenomenon (Hansson et al., 2009).
Absolute error increased after a week in the direction of wrist flexion (see Figure 2). G2 had higher absolute error (6.08±4.26) than G1 (4.61±3.14) and G3 (4.92±2.92) for flexion in the initial measurement. However, G1 showed a greater increase in errors after a workweek (7.19±6.78). On the contrary, the absolute errors for extension have a decrease after a week for all groups. Despite the G2 demonstrated higher error than G1, statistical analysis did not reveal any effects of rotation schemes on the exposure groups. Additionally, absolute errors are independent of the moment of evaluation ($p>0.05$). Small sample size and inter-subject variability may also have influenced the effects of rotation.

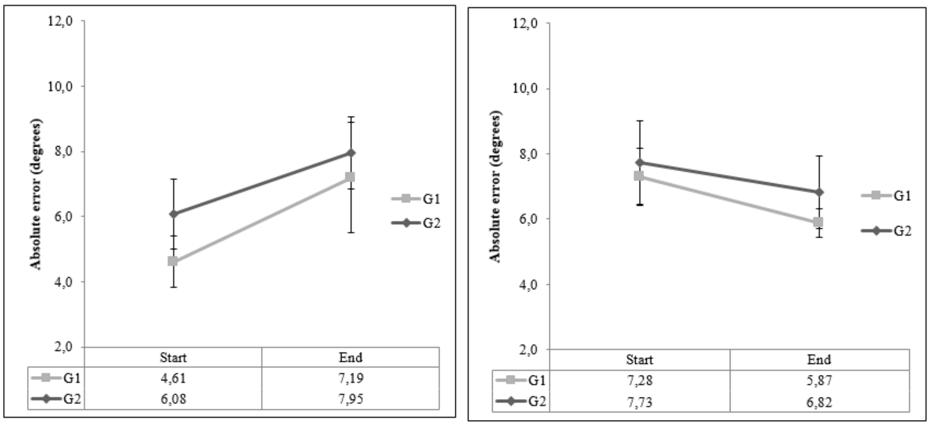

Figure 2 – Absolute errors (degrees) between target and matching positions before work and after a work week for wrist flexion (left) and wrist extension (right) (n=8). Data are expressed as the means ± standard error of the mean.

4. CONCLUSIONS

The results of the present field study suggest that no significant benefits of job rotation were evident in terms of EMG signs of muscle fatigue and wrist position sense. The effectiveness of job rotation during realistic working tasks have some limitations most likely due to the acyclic nature of the performed tasks, to the constraints associated with the production goals, and even to the individual characteristics of the sample. Future work should include a higher number of participants and other fatigue measurement techniques.

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