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A FIELD EVALUATION OF A PASSIVE UPPER-EXTREMITY EXOSKELETON FOR MANUAL MATERIAL HANDLING IN BLADE MANUFACTURING

Bo E. Seiferheld[1,2*], Jeppe Frost[2], Mathias Krog[2], Afshin Samani[2]

[1]Department of Materials and Production, & [2]Department of Health Science and Technology, Aalborg University, Denmark

*Ph.D. student. bes@mp.aau.dk

INTRODUCTION

Recently, manufacturing firms with labour-intensive tasks started to focus on the technological evolution of collaborative equipment, such as passive upper-extremity exoskeletons (PUEXO) in their potential to reduce work-related musculoskeletal disorders (WMSDs) [1]. Therefore, the purpose of this study, which took place in the blade manufacturing facilities at Siemens Gamesa Renewable Energy (SGRE), was to evaluate acute effects of wearing a specific type of PUEXO (i.e. ShoulderX) on muscle activity, movement kinematics during the task execution as well as subjective evaluations.

METHODS

Seven healthy workers (3 men, 4 women) at SGRE participated in a 3-week long testing period. Participants manipulated fiberglass rugs for blade manufacturing, at baseline, at T1 (3-4 days after baseline), and at T2 (2 weeks after T1). The task consisted of lifting the fiberglass rug and carrying it towards a molding pit and subsequently placing it with manual adjustments to ensure an accurate placement.

While participants performed the task, with (and without) ShoulderX, (95th percentile) and median muscle activity was measured bilaterally with surface electromyography (sEMG) for shoulder and lower back muscles (Noraxon telemyo 2400 G2) at a sampling rate of 3000 Hz. Simultaneously, and synchronized with an inertial measurement unit (IMU) motion capture system, Xsens Awinda (Xsens Technologies BV) sampling at 60 Hz, used to capture task kinematics.

Fig 1. Experimental setup with sEMG and IMU sensors.

RESULTS AND DISCUSSION

Performing the task with the exoskeleton was associated with a reduced shoulder flexor muscle activity by up to 53.5% and was not associated with increased activity in the lower back. A rather large variability in muscle activity was present (cf. Figure 2), indicating that the relative workload was highly dependent on subjective factors such as work technique. Consequently, exoskeletal work was concomitant with altered kinematic pattern of task execution as ~10.3° additional shoulder abduction was observed. Thus, more muscle contribution to maintain equilibrium is required this, however, is if the support from the exoskeleton arms is disregarded. Therefore, abduction might not impose greater risks of WMSD due to the observed decrease in muscle activation which suggests overall shoulder joint alleviation.

The participants a SGRE adapted well to the usage of the exoskeleton and generally reported less discomfort and exertion when the task was performed with the exoskeleton. Additionally, all participants reported that they would recommend the exoskeleton to a colleague and were motivated to further use it during daily work.

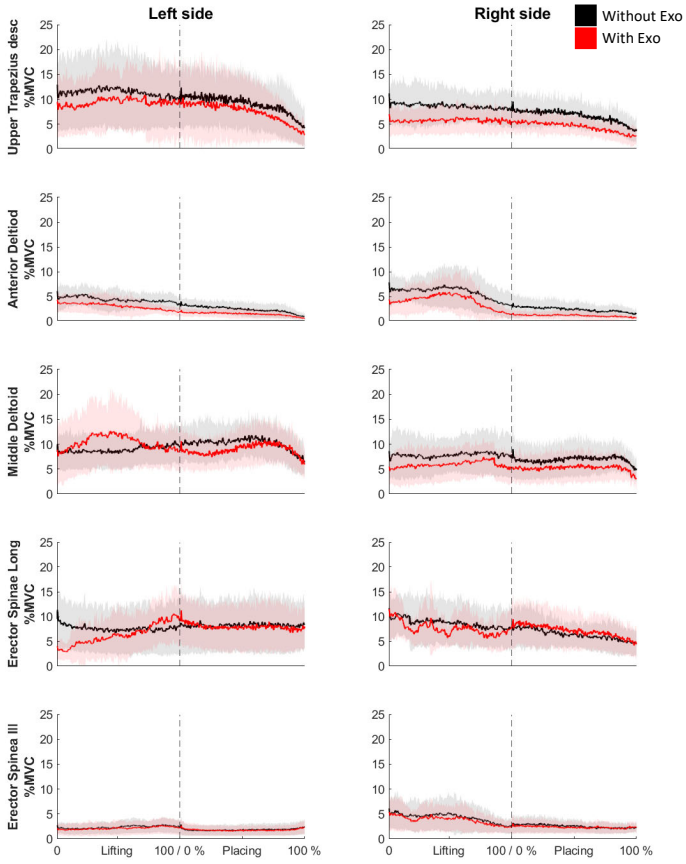

Fig. 2. Median normalized RMS values and corresponding standard deviation of working without (black) and with the exoskeleton (red) for included muscles measured bilaterally.

CONCLUSIONS

ShoulderX had a beneficial effect on muscle workload without applying additional strain to the lower back showing its potential to reduce WMSDs. Additionally, participants reported a high level of satisfaction and motivation towards the use of exoskeletons at their daily work.

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