EFFECTS OF TRAINING AND FAMILIARIZATION ON OCCUPATIONAL EXOSKELETON PERFORMANCE

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Introduction

Passive occupational back-support exoskeletons, such as the LiftSuit, can reduce strain on the back muscles during physically demanding tasks [1, 2]. Biomechanics studies with occupational exoskeletons have primarily assessed the immediate effects of support in novice users. However, adapting to new assistive devices, such as exoskeletons, requires time and it is hypothesized that, after a familiarization phase, users may behave differently when wearing the device. There is limited knowledge regarding the importance, duration, and type of training needed [3], with only one study to date investigating the impact of familiarization on back-exoskeleton efficacy [4]. Therefore, this work aims to understand the effects of exoskeleton familiarization on energy expenditure, muscle activity and subjective perception of the users of back-support exoskeletons.

Methods

In this study 21 participants (13 female) of working age (18 to 65 years) and novel to exoskeletons, were introduced to the LiftSuit (Auxivo, Switzerland) passive back-support exoskeleton. The study consisted of four sessions, containing a total of 1000 supported squat lifts, designed to familiarize the participants with the use of the exoskeleton through training. The sessions were divided into a pre-familiarization, two trainings, and a final post-familiarization session. In the pre- and post-familiarization sessions, muscle activity was measured using surface electromyography (EMG) for four relevant muscles (m. Longissimus (thoracis and lumbar level), m. Iliocostalis lumborum, m. Rectus abdominis, m. Rectus femoris), heart rate was recorded to evaluate energy expenditure, and subjective perception of exertion, discomfort and usability was evaluated. The first and last sessions consisted of two tasks, isometric positions and squat lifts. The isometric positions included a 30° and 60° forward-leaning posture, as well as a squat-stand position. These were held for 10 seconds and were done once without the exoskeleton (OFF) and with the exoskeleton (EXO). The squat lifting included one OFF block of 100 squat lifts and three EXO blocks of 100 squat lifts. Data processing and statistical analysis was performed using Matlab R2022b (MathWorks, United States). Visual inspection was used to detect and remove data with artefacts. To examine the significance between the conditions and the sessions, Wilcoxon signed rank tests were used.

Results

In this preliminary analysis, we report EMG data from the 60° forward-leaning posture. The pre-familiarization session showed a statistical trend with a 20.2%MVC reduction between the OFF and EXO conditions (Fig. 2). In contrast, the post-familiarization session demonstrated a highly significant reduction of 39.9%MVC from OFF to EXO ($p < 0.01$). Additionally, the reductions observed between the two sessions were significantly different ($p < 0.05$).

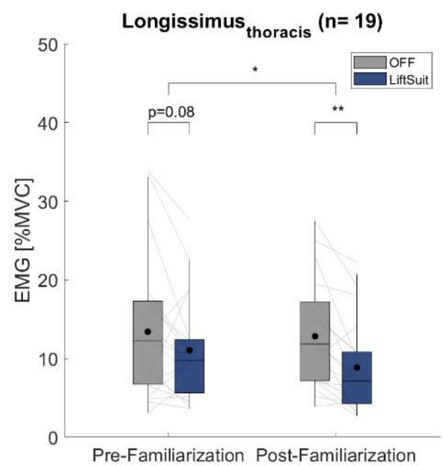

*Figure 2: Change in m. Longissimus thoracis muscle activity as percent of maximal voluntary contraction (%MVC). The data are displayed as box plots, with a dot representing the mean. *: p<0.05, **: p<0.01.*

Discussion

In the isometric 60° forward leaning position familiarization significantly increased the muscle activity reductions from pre- to post-familiarization. As reported by Favennec et al. [4], familiarization with the use of a soft back-exoskeleton did not affect Longissimus activity after a total of 180 squat lifts. Further analysis of dynamic muscle activity data in the squat lift and the energy expenditure is ongoing. Our data suggests that after performing 1000 repetitive lifts, a level of familiarization is reached, that allowed LiftSuit users to double their median support benefit.

References

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