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USE OF A PASSIVE SHOULDER EXOSKELETON FOR MANUFACTURING - TRANSFER OF LAB FINDINGS TO A REALISTIC WORK SETTING

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1. INTRODUCTION

Among work-related health problems, musculoskeletal disorders have the highest prevalence. In Europe, 49% of the "craft and related trades workers" report musculoskeletal pains in the shoulder, neck or upper limbs [1]. Risk factors for developing musculoskeletal disorders include repetitive work, working in a non-neutral posture, and handling heavy loads [2].

By design, shoulder support exoskeletons can transfer load from the upper arms to the torso and reduce the force the shoulder muscles need to provide to compensate for gravity affecting the human arms, thereby relieving shoulder muscles and joints. Laboratory findings to date suggest exoskeletons reduce user's acute physical stress and strain in the exoskeleton's target area [3].

It is important to assess the efficacy of exoskeleton support in real work situations. In the current study, data was collected in a manufacturing facility during work. We hypothesized that the use of the exoskeleton relieved the shoulder muscles during work above shoulder level.

2. MATERIALS AND METHODS

Twelve male manufacturing technicians volunteered for the experiment. Each participant was instructed how to use the DeltaSuit shoulder support exoskeleton (Auxivo AG, Schwerzenbach, Switzerland) and had the chance to wear the exoskeleton during their normal work tasks prior to the measurements. Work tasks included marking and drilling holes, sandblasting, and applying tape, plaster, and polish. The used tools weighed between 0 - 3 kg.

Figure 1: The DeltaSuit shoulder support exoskeleton.

After the training period, anterior deltoid muscle activity was recorded bilaterally using Trigno surface electromyography sensors (Delsys Ltd, Natick, United States) during work. An IMU on the upper arm was used to distinguish periods of overhead work from periods with arms below shoulder level (Delsys Ltd, Natick, United States).

With each participant, we aimed to collect one hour of data doing the same task with and without the exoskeleton. On one occasion, less than 30 min of data was collected, and during two sessions, the EMG sensors came loose.

The signal was filtered with a 4th-order Butterworth band-pass filter with cut-off frequencies of 10 and 500 Hz. The signal amplitude normalized to maximal voluntary contraction is reported. The exoskeleton and control condition are compared using dependent sample t-tests.

3. RESULTS

The dynamic work tasks involved alternating periods of arms above and below shoulder level, resulting in varying levels of anterior deltoid activation (Fig. 2). Exoskeleton use significantly reduced deltoid amplitude by 34.9% ($p < 0.05$, Fig. 3) in a static position without the weight of a tool. Periods with arms at or above shoulder level during work were selected based on IMU data. The exoskeleton significantly reduced deltoid amplitude in the dominant arm by 18.0% ($p < 0.05$, Fig. 3).

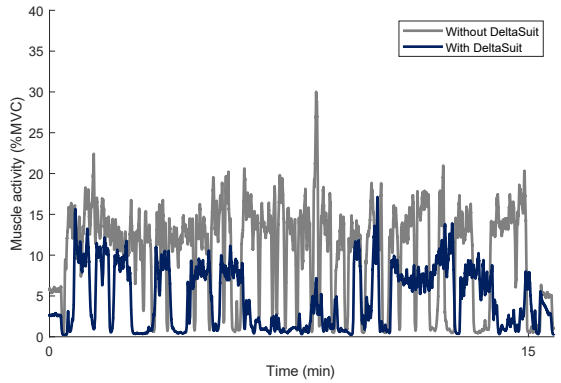

Figure 2: Dominant arm anterior deltoid muscle activity of one participant working with and without exoskeleton.

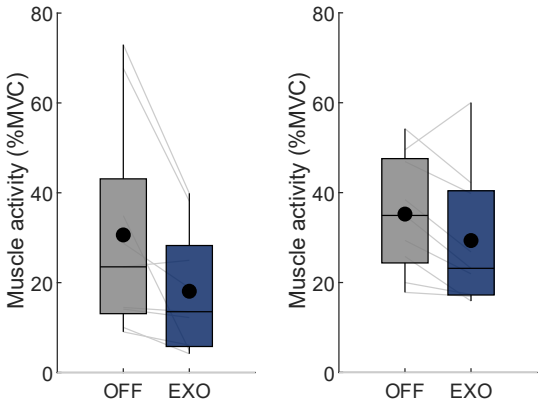

Figure 3: Boxplot of anterior deltoid amplitude while statically holding arms up (left) and during periods of arms over shoulder level within the normal work situation (right)

Participants reported being quite satisfied (4.1 of 5) with the provided level of support.

4. DISCUSSION

This study set out to quantify the support provided by the DeltaSuit shoulder exoskeleton during use in manufacturing by measuring shoulder muscle activity under realistic conditions during a range of manufacturing tasks. The results show that the exoskeleton support results in a relevant reduction in shoulder muscle activity during manufacturing work.

The reductions in muscle activity in the field are slightly lower than our findings under laboratory conditions. We previously reported a 45% reduction when holding arms above shoulder level without the additional weight of a tool and a 32.9% reduction during dynamic power tool handling [4,5].

In the next step, we plan to collect more data under realistic working conditions.

5. CONCLUSION

The Auxivo DeltaSuit supports the shoulder muscles during manufacturing work in a real work setting. In line with the physiological data, the manufacturing technicians reported being quite satisfied with the provided support.

COMPETING INTERESTS

Olivier Lambercy is an academic advisor to Auxivo AG. Annina Brunner, Rachel van Sluijs, and Volker Bartenbach are employed by Auxivo AG.

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