Shoulder-assist exoskeleton effects on balance and muscle activity during a block-laying task on a simulated mast climber_Dataset

Introduction

Masonry work, a sub-specialty of the construction industry, consists of brick and block-laying. Masonry workers often perform these tasks daily using an elevated work platform (e.g., mast climbers). Mast climbers are elevating equipment used to replace traditional scaffolds. They have been available in the United States since the 1980s. Mast climbers are capable of handling much greater loads of workers and materials than traditional scaffolding. They also make reaching greater heights much easier, thereby improving efficiency on construction projects. However, working on an unstable work platform at elevation can increase the risks of slips, trips and falls, including falls to a lower level. From 1990 to 2017, there were a total of 35 recorded fatalities associated with the use of mast climbers. Of the 35 fatalities, 13 were masonry workers (OSHA report). Additionally, working on a mast climber can also create awkward working postures due to the confined nature of the workspace. Masonry work can be physically demanding. Concrete block can weigh between 9-27 kg. The rate of overexertion among masonry workers was 33.4 per 10,000 FTEs compared to the average rate of 21.5 per 10,000 FTEs in all industries (BLS data). Shoulder-assist exoskeletons present an attractive possibility to reduce MSD risks in masonry workers if the exoskeletons do not cause adverse effects to the workers' stability and balance.

In this study, we evaluated effects of three models of passive shoulder-assist exoskeletons on balance and shoulder muscle activity during a masonry task on a simulated mast climbing work platform. The balance-related parameters and shoulder muscle activities were compared when using or not using the exoskeletons. We want to evaluate the hypotheses that the exoskeletons (1) reduce shoulder muscle activity and (2) decrease the stability of the workers.

Methods

- **Experiment.** A total of seven male participants were recruited for this study. A customized workstation was built to simulate a typical working setup for masonry workers on an unstable work platform. The subjects were standing on the unstable work platform and asked to lift a cinder block (35 lbs.; 8 X 8 X 16 inches) from the production table and place it on the simulated wall. The production table height was set at the subject's hip height. The simulated wall height was set at two different levels—the subject's elbow height and the shoulder height. The subjects repeated the same tasks twice and at two heights of the simulated wall with four different device conditions—without wearing an exoskeleton (NoExo), and wearing three passive shoulder exoskeletons (Exo1, Exo2 and Exo3) respectively.

- **Balance.** The K-Force plates (KINVENT Biomechanique SAS, Montpellier, France) equipped with electronic force transducers was used to record the subject's ground reaction forces. Three balance-related parameters were calculated using the coordinates of center of pressure (COP) recorded by the force plates: (1) the mean distance (MDIST), (2) the total excursion (EXCUR), and (3) the mean velocity of the movement (VEL).

- **Muscle Activity.** Electromyography (EMG) data were collected from six shoulder and upper arm muscles from each participant's dominant side—upper trapezius (UppTrapezius), anterior deltoid (AntDeltoid), medial deltoid (MedDeltoid), posterior deltoid (PostDeltoid), biceps and triceps. The raw EMG data were filtered by applying a 4th order Butterworth band-pass filter with lower and upper cut-off frequencies of 20 Hz and 450 Hz. The signal was then rectified by taking the absolute value. The rectified EMG signal was then smoothed by the Root Mean Square (RMS) envelope with a 50-millisecond moving window. The peak EMG value across all the dynamic trials was used as a reference EMG value for the EMG normalization. The mean and peak normalized EMG data were calculated for each trial. The data from replicate trials were averaged for the same conditions.

Citations

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