In-field and in-lab ergonomic assessment of manual materials handling tasks using a passive back exoskeleton

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There is an interest in investigating the effects of physical assistance devices such as exoskeletons in terms of reducing the risk and rate of work-related musculoskeletal disorders. Most previous studies were conducted in laboratory environments since in-field evaluations are often challenging. However, the outcomes of in-lab and in-field evaluations may not always be comparable. Moreover, workers may use some assistive tools to lift or move heavy items while holding a bending posture, leading to different risks of low back pain. Thus, we conducted an experiment to assess the differences between the in-lab and in-field levels of ergonomic risks during the manual materials handling tasks, using two different assistive tools while wearing a passive exoskeleton.

For the purpose of our study, 125-lbs circular disks were lifted using the assistive tools with and without wearing a passive back-support exoskeleton (BackX, SuitX, CA, USA). Each trial took 2 repetitions and 5 seconds standing still at the beginning of each motion. The in-lab data was recorded from 10 able-bodied participants (7 males, 3 females, body mass: 61±8 kg, body height: 171±48 cm, age: 23±1.5 y.o.) and the in-field data were recorded from 10 able-bodied workers (9 males, 1 female, body mass: 75±12 kg, body height: 175±11 cm, age: 36±6 y.o.). We collected data using electromyography (EMG) sensors and inertial measurement units (IMUs) to record muscle activity and body posture, respectively. Furthermore, the ergonomic risk assessment was performed using the rapid entire body assessment (REBA) score. The REBA scores measured using IMU data and the max normalized EMG amplitude for each task were compared between in-field and in-lab experiments. EMG amplitude of each participant was normalized to their previously measured maximum voluntary contraction.

The muscle activity measured from in-field experiments was significantly larger for most muscles and smaller for some other muscles compared to the in-lab data (p < 0.05). Muscle activities while using either tools with exoskeleton were also significantly larger for some muscles and smaller for others when the task is performed in-field compared to in-lab. In addition, the REBA score of in-field workers using both tools while wearing the exoskeleton was significantly larger than the REBA score of the in-lab participants.

The results of this study suggest the need for ergonomic risk assessment and occupational exoskeleton evaluation in real-world environments in addition to lab assessments. The sources of this difference between the in-lab and in-field results could be 1) potential differences between the task implementation in the two environments, 2) the lack of experience of in-lab participants compared to in-field workers and 3) the inconsistency of the male-to-female participants ratios between lab and field experiments.