

## Using machine learning approach to classify lifting tasks from instrumented insole measurements

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**Introduction:** Low back pain (LPB) and low back injuries (LBI) represent the majority of work-related musculoskeletal disorders (WMSDs). Improper lifting technique, pushing or pulling, have been shown to lead to WMSDs. Back pain can occur as a result of a single high load event or cumulative trauma. Therefore, it is important to monitor both individual high load and cumulative exposures of workers performing lifting tasks. Enhanced "in-the-field, real-time" monitoring and quantification techniques could provide greater insight to improve our understanding of the most influential parameters causing low back pain. The approach of using instrumented insole and machine learning classification algorithms to classify lifting activities and estimate exposure offers a great promise, due to being non-invasive and non-obtrusive to the worker. The simplicity of such sensory system and comfort of the workers are important considerations for successful transfer of this technology into workplaces

**Methods:** We performed experiments simulating lifting tasks commonly observed at workplace as shown. These tasks included lifting and lowering of a box of various mass (5.7 kg and 12.5 kg), lifting heights (ground, knuckle height and shoulder height) and lifting behaviour (overreaching or fast/jerky). The instrumented insoles were inserted in subject's shoes to measure the normal ground reaction forces from each foot ( $fzL$  and  $fzR$ ), total ground reaction force ( $Fz$ ), three-axis accelerations from each insole  $Acc_{ij}$ ,  $i = \{x, y, z\}$ ,  $j = \{L, R\}$ , and centre of pressure (COP) of the individual foot. We computed statistical features (mean, standard deviation, autocorrelation, peak spectral density and power spectral density) for the time series of the signal measurements that were used as input to the machine learning algorithm (k-Nearest Neighbor). We chose an epoch size of 2 sec with 90% overlap.

**Results:** Results show that using only instrumented insoles it is possible to detect the lifting tasks with varying weight and lifting behaviour with the average accuracy of 87%. The classifier has successfully detected and distinguished between lifting events when lifting two different loads in two different postures: lifting 5.7 kg in a stoop posture (80% accuracy), lifting 12.5 kg in a stoop posture (79 % accuracy), lifting 5.7 kg in a squat posture (80% accuracy), and lifting 12.5 kg in a squat posture (90 % accuracy). The hazardous overreaching lifting was detected with 91% accuracy.

**Conclusions:** In this study, we developed an algorithm to detect and classify lifting events based on measurements from the instrumented insoles. The measurement system is non-invasive and enables potential longitudinal monitoring of workers at workplace. The use of instrumented insoles to identify lifting tasks of a worker represent a significant step toward estimating the exposure of a worker. Accurate identification of lifting events including various lifting weight allows identification of some of the most important injury risk parameters, such as lifting load and frequency. In addition, instantaneous detection of proper or hazardous behaviour further enables providing direct feedback to the worker to improve lifting posture and behaviour and therefore reduce the risk of injury. Implementation of our system in real occupational settings will be the aim of our future studies.

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