

Ergonomics– rok 2016, ročník 59

Číslo 10



Ying Gao, Neil J. Cronin, Arto J. Pesola & Taija Finni. *Muscle activity patterns and spinal shrinkage in office workers using a sit-stand workstation versus a sit workstation.* Pages 1267-1274.

Reducing sitting time by means of sit-stand workstations is an emerging trend, but further evidence is needed regarding their health benefits. This cross-sectional study compared work time muscle activity patterns and spinal shrinkage between office workers (aged 24–62, 58.3% female) who used either a sit-stand workstation (Sit-Stand group, $n = 10$) or a traditional sit workstation (Sit group, $n = 14$) for at least the past three months. During one typical workday, muscle inactivity and activity from quadriceps and hamstrings were monitored using electromyography shorts, and spinal shrinkage was measured using stadiometry before and after the workday. Compared with the Sit group, the Sit-Stand group had less muscle inactivity time ($66.2 \pm 17.1\%$ vs. $80.9 \pm 6.4\%$, $p = 0.014$) and more light muscle activity time ($26.1 \pm 12.3\%$ vs. $14.9 \pm 6.3\%$, $p = 0.019$) with no significant difference in spinal shrinkage (5.62 ± 2.75 mm vs. 6.11 ± 2.44 mm). This study provides evidence that working with sit-stand workstations can promote more light muscle activity time and less inactivity without negative effects on spinal shrinkage. **Practitioner Summary:** This cross-sectional study compared the effects of using a sit-stand workstation to a sit workstation on muscle activity patterns and spinal shrinkage in office workers. It provides evidence that working with a sit-stand workstation can promote more light muscle activity time and less inactivity without negative effects on spinal shrinkage.

- **Keywords:** Sit-stand workstation, spinal shrinkage, muscle inactivity and muscle activity, office workers

Thomas Karakolis, Jeff Barrett & Jack P. Callaghan. *A comparison of trunk biomechanics, musculoskeletal discomfort and productivity during simulated sit-stand office work.* Pages 1275-1287.

Sedentary office work has been shown to cause low back discomfort and potentially cause injury. Prolonged standing work has been shown to cause discomfort. The implementation of a sit-stand paradigm is hypothesised to mitigate discomfort and prevent injury induced by prolonged exposure to each posture in isolation. This study

explored the potential of sit-stand to reduce discomfort and prevent injury, without adversely affecting productivity. Twenty-four participants performed simulated office work in three different conditions: sitting, standing and sit-stand. Variables measured included: perceived discomfort, L4-L5 joint loading and typing/mousing productivity. Working in a sit-stand paradigm was found to have the potential to reduce discomfort when compared to working in a sitting or standing only configuration. Sit-stand was found to be associated with reduced lumbar flexion during sitting compared to sitting only. Increasing lumbar flexion during prolonged sitting is a known injury mechanism. Therefore, sit-stand exhibited a potentially beneficial response of reduced lumbar flexion that could have the potential to prevent injury. Sit-stand had no significant effect on productivity. **Practitioner Summary:** This study has contributed foundational elements to guide usage recommendations for sit-stand workstations. The sit-stand paradigm can reduce discomfort; however, working in a sit-stand ratio of 15:5 min may not be the most effective ratio. More frequent posture switches may be necessary to realise the full benefit of sit-stand.

- **Keywords:** Posture, injury, low back, performance, pain, sedentary

Angela DiDomenico, Raymond W. McGorry & Jacob J. Banks. *Stabilisation times after transitions to standing from different working postures.* Pages 1288-1293.

Transitioning to standing after maintaining working postures may result in imbalance and could elicit a fall. The objective of this study was to quantify the magnitude of imbalance using a stabilisation time metric. Forty-five male participants completed three replications of conditions created by one of four working postures (bent at waist, squat, forward kneel, reclined kneel) and three durations within posture. Participants transitioned to quiet standing at a self-selected pace. Stabilisation time, based on changes in centre of pressure velocity, was used to indicate the initiation of steady state while standing. Stabilisation time was significantly affected by static postures but not duration within posture. The largest stabilisation times resulted from transitions initiated from a bent at waist posture. The smallest were associated with the kneeling postures, which were not significantly different from each other. Findings may lead to recommendations for redesign of tasks, particularly in high-risk environments such as construction. **Statement of Relevance:** Task performance on the jobsite often requires individuals to maintain non-erect postures. This study suggests that working posture affects stabilisation during transition to a standing position. Bending at the waist and squatting resulted in longer stabilisation times, whereas both kneeling postures evaluated resulted in greater imbalance but for a shorter duration.

- **Keywords:** Falls, balance, centre of pressure, perturbations

Alicia L. Nadon, Meghan E. Vidt, Amy Y. Chow & Clark R. Dickerson. *The spatial dependency of shoulder muscular demands during upward and downward exertions.* Pages 1294-1306.

Lifting and lowering are common occupational tasks contributing to shoulder injury risk. Quantifying task interaction with physical demand can precipitate better workstation designs. Nineteen university-aged males performed one-handed, submaximal upward/downward manual force exertions at 70 hand locations; unilateral electromyography (EMG) of 14 muscles was recorded. EMG across planes was evaluated with ANOVA. Predictive equations for muscle activity throughout the reach envelope were developed with stepwise regression. Total muscle activity (sum of individual muscle activity) was most sensitive to vertical hand location for upward exertions, where activation at superior locations was 192% of values for inferior locations. For upward exertions, activation differences for hand location occurred along all anatomical axes, and along anterior/posterior and superior/inferior axes for downward exertions. Predictive

equations were non-linear, reflecting complex muscular demand with three-dimensional hand location. This work details foundational exposure data for lifting/lowering exertions. Results are applicable to workstation design to minimise occupational shoulder muscular demands. **Practitioner Summary:** Lifting and lowering in the workplace contribute to shoulder injury risk. Shoulder muscle activity magnitudes revealed a dependence on three-dimensional hand location in the reach envelope for a defined hand force. This information can inform evidence-based workstation designs that reduce shoulder muscular demands for numerous materials handling scenarios.

- **Keywords:** Upper extremity, electromyography, reach envelope, hand force, occupational

Carolyn M. Sommerich, Steven A. Lavender, Kevin D. Evans, Elizabeth Sanders, Sharon Joines, Sabrina Lamar, Radin Zaid Radin Umar, Wei-Ting Yen & SangHyun Park. *Collaborating with mammographers to address their work-related musculoskeletal discomfort. Pages 1307-1317.*

Mammographers are an understudied group of health care workers, yet the prevalence of musculoskeletal (MSK) symptoms in mammographers appears to be elevated, similar to many occupations in health care. In this study, we used a participatory approach to identify needs and opportunities for developing interventions to reduce mammographers' exposures to risk factors that lead to the development of MSK symptoms. In this paper, we present a number of those needs and several intervention concepts along with evaluations of those concepts from experienced mammographers. We include findings from a preliminary field test of a novel intervention concept to reduce the need to adopt awkward postures while positioning patients for a screening or diagnostic mammogram. **Practitioner Summary:** This paper discusses needs, opportunities and methods for working with mammographers in order to develop interventions to reduce their exposure to risk factors for work-related musculoskeletal discomfort. Results from a field test of a novel intervention to reduce mammographers' awkward work postures while positioning patients are presented.

- **Keywords:** Mammographer, musculoskeletal discomfort, design, intervention, healthcare

In Sik Jeon, Byung Yong Jeong & Ji Hyun Jeong. *Preferred 11 different job rotation types in automotive company and their effects on productivity, quality and musculoskeletal disorders: comparison between subjective and actual scores by workers' age. Pages 1318-1326.*

This study investigates workers' favoured rotation types by their age and compares means between subjective and actual scores on productivity, quality and musculoskeletal disorders (MSDs). The subjects of research were 422 assembly line units in Hyundai Motor Company. The survey of 422 units focused on the workers' preference for 11 different rotation types and subjective scores for each type's perceived benefits, both by the workers' age. Then, actual scores on production-related indices were traced over a five-year period. The results suggest that different rotation types lead to different results in productivity, product quality and MSDs. Workers tend to perceive job rotation as a helpful method to enhance satisfaction, productivity and product quality more so than the actual production data suggests. Job rotation was especially effective in preventing MSDs for workers aged under 45, while its effects were not clear for the workers aged 45 years or older. **Practitioner's Summary:** This research presents appropriate rotation type for different age groups. Taking workers' age into account, administrators can use the

paper's outcomes to select and implement the suitable rotation type to attain specific goals such as enhancing productivity, improving product quality or reducing MSDs.

- **Keywords:** Autonomous job rotation, satisfaction, productivity and quality, musculoskeletal disorders, automotive industry

Alexis Herbaut, Emilie Simoneau-Buessinger, Franck Barbier, Francis Cannard & Nils Guéguen. *A reliable measure of footwear upper comfort enabled by an innovative sock equipped with textile pressure sensors.* Pages 1327-1334.

Footwear comfort is essential and pressure distribution on the foot was shown as a relevant objective measurement to assess it. However, asperities on the foot sides, especially the metatarsals and the instep, make its evaluation difficult with available equipment. Thus, a sock equipped with textile pressure sensors was designed. Results from the mechanical tests showed a high linearity of the sensor response under incremental loadings and allowed to determine the regression equation to convert voltage values into pressure measurements. The sensor response was also highly repeatable and the creep under constant loading was low. Pressure measurements on human feet associated with a perception questionnaire exhibited that significant relationships existed between pressure and comfort perceived on the first, the third and the fifth metatarsals and top of the instep. **Practitioner Summary:** A sock equipped with textile sensors was validated for measuring the pressure on the foot top, medial and lateral sides to evaluate footwear comfort. This device may be relevant to help individuals with low sensitivity, such as children, elderly or neuropathic, to choose the shoes that fit the best.

- **Keywords:** Foot, sensitivity, shoe fit, discomfort assessment

A. G. Siddall, R. D. M. Stevenson, P. F. J. Turner, K. A. Stokes & J. L. J. Bilzon. *Development of role-related minimum cardiorespiratory fitness standards for firefighters and commanders.* Pages 1335-1343.

A minimum cardiorespiratory fitness standard was derived for firefighters following a metabolic demands analysis. Design and minimal acceptable performance of generic firefighting task simulations (i.e. hose running, casualty evacuation, stair climb, equipment carry, wild-land fire) were endorsed by a panel of operationally experienced experts. Sixty-two UK firefighters completed these tasks wearing a standard protective firefighting ensemble while being monitored for peak steady-state metabolic demand and cardiovascular strain. Four tasks, endorsed as valid operational simulations by $\geq 90\%$ of participants (excluding wild-land fire; 84%), were deemed to be a sufficiently valid and reliable basis for a fitness standard. These tasks elicited an average peak steady-state metabolic cost of 38.1 ± 7.8 ml kg^{-1} min^{-1} . It is estimated that healthy adults can sustain the total duration of these tasks (~ 16 min) at $\leq 90\%$ maximum oxygen uptake and a cardiorespiratory fitness standard of ≥ 42.3 ml kg^{-1} min^{-1} would be required to sustain work. **Practitioner Summary:** A cardiorespiratory fitness standard for firefighters of ≥ 42.3 ml kg^{-1} min^{-1} was derived from monitoring minimum acceptable performance of essential tasks. This study supports the implementation of a routine assessment of this fitness standard for all UK operational firefighters, to ensure safe physical preparedness for occupational performance.

- **Keywords:** Physical demands analysis, metabolic cost, oxygen uptake, firefighting, role-related fitness, physical employment standards

Heikki Mansikka, Petteri Simola, Kai Virtanen, Don Harris & Lauri Oksama. *Fighter pilots' heart rate, heart rate variation and performance during instrument approaches*. Pages 1344-1352.

Fighter pilots' heart rate (HR), heart rate variation (HRV) and performance during instrument approaches were examined. The subjects were required to fly instrument approaches in a high-fidelity simulator under various levels of task demand. The task demand was manipulated by increasing the load on the subjects by reducing the range at which they commenced the approach. HR and the time domain components of HRV were used as measures of pilot mental workload (PMWL). The findings of this study indicate that HR and HRV are sensitive to varying task demands. HR and HRV were able to distinguish the level of PMWL after which the subjects were no longer able to cope with the increasing task demands and their instrument landing system performance fell to a sub-standard level. The major finding was the HR/HRV's ability to differentiate the sub-standard performance approaches from the high-performance approaches. **Practitioner Summary:** This paper examined if HR and HRV were sensitive to varying task demands in a fighter aviation environment and if these measures were related to variations in pilot's performance.

- **Keywords:** pilot mental workload, heart rate, heart rate variation, performance

Katherine L. Plant & Neville A. Stanton. *Distributed cognition in Search and Rescue: loosely coupled tasks and tightly coupled roles*. Pages 1353-1376.

The perceptual cycle model (PCM) underpins much Ergonomics research, particularly in a team context, for example in its theoretical underpinning of distributed situation awareness. Despite this, the PCM framework it has not been explicitly applied to explore team processes, which is surprising given the prevalence of teamwork in safety critical systems. This paper explores team processes in the context of search and rescue (SAR) by applying the PCM and an association classification scheme with a network analysis approach utilising the event analysis of systemic teamwork (EAST) method. Data were collected via observations and communication recordings during training flights with SAR crews and were amalgamated into a representative case study. The analysis demonstrates how the SAR team function within a distributed perceptual cycle whereby the actions of one team member become world information for another team member. Advancements to the EAST method are proposed and the implications of the research are discussed. **Practitioner Summary:** This paper explores the perceptual cycle interactions of SAR crews using a novel EAST approach. The analysis demonstrates how the crew function as a distributed cognitive unit and applications in terms of training and design are discussed.

- **Keywords:** Distributed cognition, Perceptual Cycle Model, EAST method, networks

Jonathan Dobres, Nadine Chahine, Bryan Reimer, David Gould, Bruce Mehler & Joseph F. Coughlin. [Utilising psychophysical techniques to investigate the effects of age, typeface design, size and display polarity on glance legibility](#). Pages 1377-1391.

Psychophysical research on text legibility has historically investigated factors such as size, colour and contrast, but there has been relatively little direct empirical evaluation of typographic design itself, particularly in the emerging context of glance reading. In the present study, participants performed a lexical decision task controlled by an adaptive staircase method. Two typefaces, a 'humanist' and 'square grotesque' style, were tested. Study I examined positive and negative polarities, while Study II examined two text

sizes. Stimulus duration thresholds were sensitive to differences between typefaces, polarities and sizes. Typeface also interacted significantly with age, particularly for conditions with higher legibility thresholds. These results are consistent with previous research assessing the impact of the same typefaces on interface demand in a simulated driving environment. This simplified methodology of assessing legibility differences can be adapted to investigate a wide array of questions relevant to typographic and interface designs. **Practitioner Summary:** A method is described for rapidly investigating relative legibility of different typographical features. Results indicate that during glance-like reading induced by the psychophysical technique and under the lighting conditions considered, humanist-style type is significantly more legible than a square grotesque style, and that black-on-white text is significantly more legible than white-on-black.

- **Keywords:** Measurement, HMI design, reading, psychophysics, typography

Kirsten Nabe-Nielsen, Marie Aarrebo Jensen, Åse Marie Hansen, Jesper Kristiansen & Anne Helene Garde. *What is the preferred number of consecutive night shifts?: results from a crossover intervention study among police officers in Denmark. Pages 1392-1402.*

Among police officers in Denmark, we studied (i) how many consecutive night shifts participants preferred at baseline; (ii) preferences regarding three intervention conditions (two, four, and seven consecutive night shifts followed by the same number of days off/day shifts: '2 + 2', '4 + 4', '7 + 7') at follow-up; (iii) characteristics of participants preferring each of these intervention conditions. Questionnaire data from a crossover intervention study were used (baseline: n = 73; follow-up: n = 68). At baseline, 49% preferred four consecutive night shifts. At follow-up, 57% preferred '4 + 4', 26% preferred '2 + 2' and 26% preferred '7 + 7'. Participants, who preferred longer spells of night work experienced that night work was less demanding, found it easier to sleep at different times of the day, and were more frequently evening types compared with participants who preferred shorter spells of night work. The participants' preferences are likely to be influenced by their previous shift work experience. **Practitioner Summary:** We investigated police officers' preferences regarding the number of consecutive night shifts. The majority preferred four consecutive night shifts. Those who preferred the longer spells of night work found night work less demanding, found it easier to sleep at different times of the day, and were more frequently evening types.

- **Keywords:** Chronotype, employee preferences, shift work, schedule fit, sleep flexibility