

## **Applied Ergonomics - rok 2016, Volume 54**

**May 2016**



**Xu Sun, Andrew May, Qingfeng Wang. *The impact of user- and system-initiated personalization on the user experience at large sports events.* Pages 1-9.**

This article describes an experimental study investigating the impact on user experience of two approaches of personalization of content provided on a mobile device, for spectators at large sports events. A lab-based experiment showed that a system-driven approach to personalization was generally preferable, but that there were advantages to retaining some user control over the process. Usability implications for a hybrid approach, and design implications are discussed, with general support for countermeasures designed to overcome recognised limitations of adaptive systems.

- **Keywords:** User studies; Personalization; User experience; UX; Large sports event

**S. Eaves, D.E. Gyi, A.G.F. Gibb. *Building healthy construction workers: Their views on health, wellbeing and better workplace design.* Pages 10-18.**

Construction is a heavy manual industry where working into later life can be a challenge. An interview study was conducted to explore workers' understanding of their health at work and ways of making their jobs easier, safer or more comfortable. Using purposive sampling, 80 trades' workers were selected from construction sites in the UK. The Nordic Musculoskeletal Questionnaire and Work Ability Index were used to explore aches and pains and reducing strain on the body. A high prevalence of symptoms was reported and ratings of work ability were high. Workers were aware of the physical demands of their work and had over 250 ideas around health and wellbeing e.g. rucksacks for tools, bespoke benches, adapting PPE, and higher cost solutions e.g. mechanical lifting aids. Engagement of the workforce should be encouraged and feed into change processes in the industry to enable all workers stay fit for work for longer.

- **Keywords:** Ageing; Construction ergonomics; Health and wellbeing; Participatory ergonomics

**Linsey M. Steege, Jessica G. Dykstra. *A macroergonomic perspective on fatigue and coping in the hospital nurse work system.* Pages 19-26.**

Occupational fatigue in hospital nurses is associated with increased nurse turnover, and decreased nurse health and patient safety. The goal of this study was to explore the factors contributing to or preventing fatigue, and barriers and facilitators to individual nurse coping in hospital work systems. Interviews were conducted and analyzed using a directed qualitative content analysis approach guided by the Systems Engineering Initiative for Patient Safety (SEIPS) model. Themes related to sources of fatigue within each of the five primary components of the SEIPS work system were identified, along with barriers and facilitators to nurses' experiences and strategies for coping with fatigue. Findings from this study provide guidance on what nurses perceive as contributing to fatigue and factors that are helpful and harmful to coping with fatigue within their work system. Implications for fatigue risk management systems (FRMS) are also discussed, in particular the importance of maintaining nurse autonomy in decision-making when implementing fatigue interventions or countermeasures.

**Kazue Okamoto-Mizuno, Koh Mizuno, Motoko Tanabe, Katsuko Niwano. *Effect of cardboard under a sleeping bag on sleep stages during daytime nap. Pages 27-32.***

Fourteen healthy male subjects slept from 13:30 to 15:30 under ambient temperature and relative humidity maintained at 15 °C and 60%, respectively. They slept under two conditions: in a sleeping bag on wooden flooring (Wood) and in a sleeping bag with corrugated cardboard between the bag and the flooring (CC). Polysomnography, skin temperature (Tsk), microclimate, bed climate, and subjective sensations were obtained. The number of awakenings in the CC had significantly decreased compared to that in the Wood. The mean, back, and thigh Tsk, and bed climate temperature were significantly higher in the CC than that in the Wood. Subjective thermal sensations were warmer in the CC than in the Wood. These results suggest that using corrugated cardboard under a sleeping bag may reduce cold stress, thereby decreasing the number of awakenings and increasing subjective warmth; the mean, back, and thigh Tsk; and bed climate temperature.

- **Keywords:** Sleep; Sleeping bag; Mild cold

**Brendan Coffey, Curtis VanderGriendt, Steven L. Fischer. *Evaluating the ability of novices to identify and quantify physical demand elements following an introductory education session: A pilot study. Pages 33-40.***

A Physical Demands Description (PDD) is a resource that describes the physical demands of a job in a systematic way. PDD data are commonly used to make legal, medical, and monetary decisions related to work. Despite the fundamental importance of a PDD, data are often gathered by novice or early career ergonomists, where we have limited knowledge regarding their proficiency in performing PDDs. The purpose of this pilot study was to evaluate novices' proficiency in identifying and quantifying physical demands elements embedded within three job simulations, following a formal PDD education session. The education session was based on the revised Occupational Health Clinics for Ontario Workers (OHCOW, 2014) PDD Handbook. Participants were able to identify physical demands elements with an average success rate of 80%, but were often unable to accurately quantify measures related to each element within a prescribed error threshold of 10%. These data suggest that practitioners should exercise caution when sending novice ergonomists out on their own to complete PDDs.

- **Keywords:** Physical demands description; Job demands; Observation

**Katharine R. Parkes. *Age and work environment characteristics in relation to sleep: Additive, interactive and curvilinear effects. Pages 41-50.***

Although additive combinations of age and work environment characteristics have been found to predict sleep impairment, possible age x work environment interactions have been largely disregarded. The present study examined linear and curvilinear interactions of age with work environment measures in relation to sleep quality and duration. Survey data were collected from offshore day-shift personnel (N = 901). Main effects and interactions of the age terms with work environment measures (job demand, control, and social support, physical environment and strenuous work) were evaluated. Sleep duration was predicted by a curvilinear interaction, age<sup>2</sup> x job demand (p < .005), and by the age x social support interaction (p < .002); sleep quality was predicted by age x job demand (p < .002). Job control and physical environment showed significant additive effects. At a time when older employees are encouraged to remain in the workforce, the findings serve to increase understanding of how ageing and work demands jointly contribute to sleep impairment.

- **Keywords:** Sleep; Age; Psychosocial/physical work characteristics; Offshore workers; Interactions

**George F. Beard, Michael J. Griffin. *Discomfort of seated persons exposed to low frequency lateral and roll oscillation: Effect of backrest height.* Pages 51-61.**

Backrests influence the comfort of seated people. With 21 subjects sitting with three backrest heights (no backrest, short backrest, high backrest) discomfort caused by lateral, roll, and fully roll-compensated lateral oscillation was investigated at frequencies between 0.25 and 1.0 Hz. With lateral oscillation, the short backrest reduced discomfort at frequencies less than 0.63 Hz and the high backrest reduced discomfort at frequencies less than 1.0 Hz. With roll oscillation, the high backrest reduced discomfort at frequencies less than 0.63 Hz, but increased discomfort at 1.0 Hz. With fully roll-compensated lateral oscillation, the short backrest reduced discomfort at 0.4 Hz and the high backrest reduced discomfort at 0.5 and 0.63 Hz. As predicted by current standards, a backrest can increase discomfort caused by high frequencies of vibration. However, a backrest can reduce discomfort caused by low frequencies, with the benefit depending on the frequency and direction of oscillation and backrest height.

- **Keywords:** Discomfort; Vibration; Backrest

**Qi Ma, Alan H.S. Chan, Ke Chen. *Personal and other factors affecting acceptance of smartphone technology by older Chinese adults.* Pages 62-71.**

It has been well documented that in the 21st century, there will be relatively more older people around the world than in the past. Also, it seems that technology will expand in this era at an unprecedented rate. Therefore, it is of critical importance to understand the factors that influence the acceptance of technology by older people. The positive impact that the use of mobile applications can have for older people was confirmed by a previous study (Plaza et al., 2011). The study reported here aimed to explore and confirm, for older adults in China, the key influential factors of smartphone acceptance, and to describe the personal circumstances of Chinese older adults who use smartphone. A structured questionnaire and face to face individual interviews were used with 120 Chinese older adults (over 55). Structural Equation Modeling was used to confirm a proposed smartphone acceptance model based on Technology Acceptance Model (TAM), and the Unified Theory of Acceptance and Use of Technology (UTAUT). The results showed that those who were younger, with higher education, non-widowed, with better economic condition related to salary or family support were more likely to use smartphone. Also, cost was found to be a critical factor influencing behavior intention. Self-satisfaction and facilitating conditions were proved to be important factors influencing perceived usefulness and perceived ease of use.

- **Keywords:** Chinese older adults; Smartphone; Technology acceptance; Mobile apps; Personal factors

**Michelle A. Short, Stephanie Centofanti, Cassie Hilditch, Siobhan Banks, Kurt Lushington, Jillian Dorrian. *The effect of split sleep schedules (6h-on/6h-off) on neurobehavioural performance, sleep and sleepiness. Pages 72-82.***

Shorter, more frequent rosters, such as 6h-on/6h-off split shifts, may offer promise to sleep, subjective sleepiness and performance by limiting shift length and by offering opportunities for all workers to obtain some sleep across the biological night. However, there exists a paucity of studies that have examined these shifts using objective measures of sleep and performance. The present study examined neurobehavioural performance, sleepiness and sleep during 6h-on/6h-off split sleep schedules. Sixteen healthy adults (6 males, 26.13y ± 4.46) participated in a 9-day laboratory study that included two baseline nights (BL, 10h time in bed (TIB), 2200h-0800h), 4 days on one of two types of 6h-on/6h-off split sleep schedules with 5h TIB during each 'off' period (6h early: TIB 0300h-0800h and 1500h-2000h, or 6-h late: TIB 0900h-1400h and 2100h-0200h), and two recovery nights (10h TIB per night, 2200h-0800h). Participants received 10h TIB per 24h in total across both shift schedules. A neurobehavioural test bout was completed every 2 h during wake, which included the Psychomotor Vigilance Task (PVT) and the Karolinska Sleepiness Scale (KSS). Linear mixed effects models were used to assess the effect of day (BL, shift days 1-4), schedule (6h early, 6h late) and trial (numbers 1-6) on PVT lapses (operationalised as the number of reaction times >500 ms), PVT total lapse time, PVT fastest 10% of reaction times and KSS. Analyses were also conducted examining the effect of day and schedule on sleep variables. Overall, PVT lapses and total lapse time did not differ significantly between baseline and shift days, however, peak response speeds were significantly slower on the first shift day when compared to baseline, but only for those in the 6h-late condition. Circadian variations were apparent in performance outcomes, with individuals in the 6h-late condition demonstrated significantly more and longer lapses and slower peak reaction times at the end of their night shift (0730h) than at any other time during their shifts. In the 6h-early condition, only response speed significantly differed across trials, with slower response speeds occurring at trial 1 (0930h) than in trials 3 (1330h) or 4 (2130h). While subjective sleepiness was higher on shift days than at baseline, sleepiness did not accumulate across days. Total sleep was reduced across split sleep schedules compared to baseline. Overall, these results show that while there was not a cumulative cost to performance across days of splitting sleep, participants obtained less sleep and reported lowered alertness on shift days. Tests near the circadian nadir showed higher sleepiness and increased performance deficits. While this schedule did not produce cumulative impairment, the performance deficits witnessed during the biological night are still of operational concern for industry and workers alike.

- **Keywords:** Split sleep; Shiftwork; Sustained operations; Continuous operations; Attention; Performance

**Katja Koren, Rado Pišot, Boštjan Šimunič. *Active workstation allows office workers to work efficiently while sitting and exercising moderately. Pages 83-89.***

**Objective:** To determine the effects of a moderate-intensity active workstation on time and error during simulated office work. **Methods:** The aim of the study was to analyse simultaneous work and exercise for non-sedentary office workers. We monitored oxygen uptake, heart rate, sweating stains area, self-perceived effort, typing test time with typing error count and cognitive performance during 30 min of exercise with no cycling or cycling at 40 and 80 W. **Results:** Compared baseline, we found increased physiological

responses at 40 and 80 W, which corresponds to moderate physical activity (PA). Typing time significantly increased by 7.3% ( $p = 0.002$ ) in C40W and also by 8.9% ( $p = 0.011$ ) in C80W. Typing error count and cognitive performance were unchanged. **Conclusions:** Although moderate intensity exercise performed on cycling workstation during simulated office tasks increases working task execution time with, it has moderate effect size; however, it does not increase the error rate. Participants confirmed that such a working design is suitable for achieving the minimum standards for daily PA during work hours.

- **Keywords:** Active sitting; Active workstation; Physical activity

**Mark W. Becker, Raghav Prashant Sundar, Nora Bello, Reem Alzahabi, Lorraine Weatherspoon, Laura Bix. *Assessing attentional prioritization of front-of-pack nutrition labels using change detection.* Pages 90-99.**

We used a change detection method to evaluate attentional prioritization of nutrition information that appears in the traditional "Nutrition Facts Panel" and in front-of-pack nutrition labels. Results provide compelling evidence that front-of-pack labels attract attention more readily than the Nutrition Facts Panel, even when participants are not specifically tasked with searching for nutrition information. Further, color-coding the relative nutritional value of key nutrients within the front-of-pack label resulted in increased attentional prioritization of nutrition information, but coding using facial icons did not significantly increase attention to the label. Finally, the general pattern of attentional prioritization across front-of-pack designs was consistent across a diverse sample of participants. Our results indicate that color-coded, front-of-pack nutrition labels increase attention to the nutrition information of packaged food, a finding that has implications for current policy discussions regarding labeling change.

- **Keywords:** Nutritional labeling; Front-of-pack labels; Change detection; Attention; Color-coding; Attentional allocation; Information search

**Vincenzo Cascioli, Zhuofu Liu, Andrew Heusch, Peter W. McCarthy. *A methodology using in-chair movements as an objective measure of discomfort for the purpose of statistically distinguishing between similar seat surfaces.* Pages 100-109.**

This study presents a method for objectively measuring in-chair movement (ICM) that shows correlation with subjective ratings of comfort and discomfort. Employing a cross-over controlled, single blind design, healthy young subjects ( $n = 21$ ) sat for 18 min on each of the following surfaces: contoured foam, straight foam and wood. Force sensitive resistors attached to the sitting interface measured the relative movements of the subjects during sitting. The purpose of this study was to determine whether ICM could statistically distinguish between each seat material, including two with subtle design differences. In addition, this study investigated methodological considerations, in particular appropriate threshold selection and sitting duration, when analysing objective movement data. ICM appears to be able to statistically distinguish between similar foam surfaces, as long as appropriate ICM thresholds and sufficient sitting durations are present. A relationship between greater ICM and increased discomfort, and lesser ICM and increased comfort was also found.

- **Keywords:** Discomfort; Comfort; In-chair movement; Sitting

**Stéphanie Cœugnet, Justine Forrierre, Janick Naveteur, Catherine Dubreucq, Françoise Anceaux. *Time pressure and regulations on hospital-in-the-home (HITH) nurses: An on-the-road study.* Pages 110-119.**

This study investigated both causal factors and consequences of time pressure in hospital-in-the-home (HITH) nurses. These nurses may experience additional stress from the time pressure they encounter while driving to patients' homes, which may result in greater risk taking while driving. From observation in natural settings, data related to the nurses' driving behaviours and emotions were collected and analysed statistically; semi-directed interviews with the nurses were analysed qualitatively. The results suggest that objective time constraints alone do not necessarily elicit subjective time pressure. The challenges and uncertainty associated with healthcare and the driving period contribute to the emergence of this time pressure, which has a negative impact on both the nurses' driving and their emotions. Finally, the study focuses on anticipated and in situ regulations. These findings provide guidelines for organizational and technical solutions allowing the reduction of time pressure among HITH nurses.

- **Keywords:** Time pressure; Driving; Nurses

**Jérôme Vaulerin, Fabienne d'Arripe-Longueville, Mélanie Emile, Serge S. Colson. *Physical exercise and burnout facets predict injuries in a population-based sample of French career firefighters. Pages 131-135.***

Although firefighting is known to engender a high rate of injury, few studies have examined the contribution of physical exercise, burnout and coping strategies to firefighting-related injuries. Data were collected from a population-based sample of 220 male firefighters. In a descriptive study, the nature and site of the injuries and the relationships among firefighter injuries, physical exercise, burnout and coping strategies were examined. Sprains were the most prevalent type of injury (98%), followed by tendinitis (40%) and muscle tears (30%). More than two thirds of these injuries were located at the ankle. Weekly hours of physical exercise, cognitive weariness at work, social support seeking, problem-focused coping and emotional exhaustion were significantly related to these injuries. The findings suggest that physical exercise and cognitive weariness can be considered as risk factors for French firefighter injuries, whereas problem-focused coping can be seen as a protective factor. More research is needed to explain the relationship between social support seeking and injury.

- **Keywords:** Physical activity; Emergency workers; Occupational burnout; Coping strategies

**Ming-Chuan Chiu, Min-Chih Hsieh. *Latent human error analysis and efficient improvement strategies by fuzzy TOPSIS in aviation maintenance tasks. Pages 136-147.***

The purposes of this study were to develop a latent human error analysis process, to explore the factors of latent human error in aviation maintenance tasks, and to provide an efficient improvement strategy for addressing those errors. First, we used HFACS and RCA to define the error factors related to aviation maintenance tasks. Fuzzy TOPSIS with four criteria was applied to evaluate the error factors. Results show that 1) adverse physiological states, 2) physical/mental limitations, and 3) coordination, communication, and planning are the factors related to airline maintenance tasks that could be addressed easily and efficiently. This research establishes a new analytic process for investigating latent human error and provides a strategy for analyzing human error using fuzzy TOPSIS. Our analysis process complements shortages in existing methodologies by incorporating improvement efficiency, and it enhances the depth and broadness of human error analysis methodology.

- **Keywords:** Aviation; Human error; MCDM; TOPSIS; Fuzzy set theory

**Philippe-Antoine Dubé, Daniel Imbeau, Denise Dubeau, Luc Lebel, Ahmet Kolus. *Removing the thermal component from heart rate provides an accurate estimation in forest work.* Pages 148-157.**

Heart rate (HR) was monitored continuously in 41 forest workers performing brushcutting or tree planting work. 10-min seated rest periods were imposed during the workday to estimate the HR thermal component ( $\Delta\text{HRT}$ ) per Vogt et al. (1970, 1973).  $\dot{V}O_2$  was measured using a portable gas analyzer during a morning submaximal step-test conducted at the work site, during a work bout over the course of the day (range: 9–74 min), and during an ensuing 10-min rest pause taken at the worksite. The  $\dot{V}O_2$  estimated, from measured HR and from corrected HR (thermal component removed), were compared to  $\dot{V}O_2$  measured during work and rest. Varied levels of HR thermal component ( $\Delta\text{HRT}_{\text{avg}}$  range: 0–38 bpm) originating from a wide range of ambient thermal conditions, thermal clothing insulation worn, and physical load exerted during work were observed. Using raw HR significantly overestimated measured work  $\dot{V}O_2$  by 30% on average (range: 1%–64%). 74% of  $\dot{V}O_2$  prediction error variance was explained by the HR thermal component.  $\dot{V}O_2$  estimated from corrected HR, was not statistically different from measured  $\dot{V}O_2$ . Work  $\dot{V}O_2$  can be estimated accurately in the presence of thermal stress using Vogt et al.'s method, which can be implemented easily by the practitioner with inexpensive instruments.

- **Keywords:** Work metabolism; Heart rate; Heat stress; Prediction bias

**Ahmet Kolus, Daniel Imbeau, Philippe-Antoine Dubé, Denise Dubeau. *Classifying work rate from heart rate measurements using an adaptive neuro-fuzzy inference system.* Pages 158-168.**

In a new approach based on adaptive neuro-fuzzy inference systems (ANFIS), field heart rate (HR) measurements were used to classify work rate into four categories: very light, light, moderate, and heavy. Inter-participant variability (physiological and physical differences) was considered. Twenty-eight participants performed Meyer and Flenghi's step-test and a maximal treadmill test, during which heart rate and oxygen consumption ( $\dot{V}O_2$ ) were measured. Results indicated that heart rate monitoring (HR, HR<sub>max</sub>, and HR<sub>rest</sub>) and body weight are significant variables for classifying work rate. The ANFIS classifier showed superior sensitivity, specificity, and accuracy compared to current practice using established work rate categories based on percent heart rate reserve (%HRR). The ANFIS classifier showed an overall 29.6% difference in classification accuracy and a good balance between sensitivity (90.7%) and specificity (95.2%) on average. With its ease of implementation and variable measurement, the ANFIS classifier shows potential for widespread use by practitioners for work rate assessment.

- **Keywords:** Work rate; Heart rate; Adaptive neuro-fuzzy inference system (ANFIS)

**Nur Dalilah Dahlan, Yakubu Yau Gital. *Thermal sensations and comfort investigations in transient conditions in tropical office.* Pages 169-176.**

The study was done to identify affective and sensory responses observed as a result of hysteresis effects in transient thermal conditions consisting of warm-neutral and neutral - warm performed in a quasi-experiment setting. Air-conditioned building interiors in hot-humid areas have resulted in thermal discomfort and health risks for people moving into and out of buildings. Reports have shown that the instantaneous change in air temperature can cause abrupt thermoregulation responses. Thermal sensation vote (TSV) and thermal comfort vote (TCV) assessments as a consequence of moving through spaces with distinct thermal conditions were conducted in an existing single-story office

in a hot-humid microclimate, maintained at an air temperature 24 °C ( $\pm 0.5$ ), relative humidity 51% ( $\pm 7$ ), air velocity 0.5 m/s ( $\pm 0.5$ ), and mean radiant temperature (MRT) 26.6 °C ( $\pm 1.2$ ). The measured office is connected to a veranda that showed the following semi-outdoor temperatures: air temperature 35 °C ( $\pm 2.1$ ), relative humidity 43% ( $\pm 7$ ), air velocity 0.4 m/s ( $\pm 0.4$ ), and MRT 36.4 °C ( $\pm 2.9$ ). Subjective assessments from 36 college-aged participants consisting of thermal sensations, preferences and comfort votes were correlated against a steady state predicted mean vote (PMV) model. Local skin temperatures on the forehead and dorsal left hand were included to observe physiological responses due to thermal transition. TSV for veranda-office transition showed that no significant means difference with TSV office-veranda transition were found. However, TCV collected from warm-neutral ( $-0.24$ ,  $\pm 1.2$ ) and neutral-warm ( $-0.72$ ,  $\pm 1.3$ ) conditions revealed statistically significant mean differences ( $p < 0.05$ ). Sensory and affective responses as a consequence of thermal transition after travel from warm-neutral-warm conditions did not replicate the hysteresis effects of brief, slightly cool, thermal sensations found in previous laboratory experiments. These findings also indicate that PMV is an acceptable alternative to predict thermal sensation immediately after a down-step thermal transition ( $\leq 1$  min exposure duration) for people living in a hot-humid climate country.

- **Keywords:** Semi-outdoor and indoor; Tropical microclimate; Thermal transition; Thermal perception; Skin temperatures; Thermal preference; Thermal sensation vote; PMV; Hysteresis effect

**Dana J. Mugisa, Abia Katimbo, John E. Sempiira, William S. Kisaalita. *Anthropometric characteristics of female smallholder farmers of Uganda: Toward design of labor-saving tools. Pages 177-185.***

Sub-Saharan African women on small-acreage farms carry a disproportionately higher labor burden, which is one of the main reasons they are unable to produce for both home and the market and realize higher incomes. Labor-saving interventions such as hand-tools are needed to save time and/or increase productivity in, for example, land preparation for crop and animal agriculture, post-harvest processing, and meeting daily energy and water needs. Development of such tools requires comprehensive and content-specific anthropometric data or body dimensions and existing databases based on Western women may be less relevant. We conducted measurements on 89 women to provide preliminary results toward answering two questions. First, how well existing databases are applicable in the design of hand-tools for sub-Saharan African women. Second, how universal body dimension predictive models are among ethnic groups. Our results show that, body dimensions between Bantu and Nilotic ethnolinguistic groups are different and both are different from American women. These results strongly support the need for establishing anthropometric databases for sub-Saharan African women, toward hand-tool design.

- **Keywords:** Hand-tool design; Mechanization; Anthropometric data; Ethnic difference

**P.S. Sheppard, J.M. Stevenson, R.B. Graham. *Sex-based differences in lifting technique under increasing load conditions: A principal component analysis. Pages 186-195.***

The objective of the present study was to determine if there is a sex-based difference in lifting technique across increasing-load conditions. Eleven male and 14 female participants ( $n = 25$ ) with no previous history of low back disorder participated in the study. Participants completed freestyle, symmetric lifts of a box with handles from the floor to a table positioned at 50% of their height for five trials under three load conditions (10%, 20%, and 30% of their individual maximum isometric back strength). Joint kinematic data for the ankle, knee, hip, and lumbar and thoracic spine were collected

using a two-camera Optotrak motion capture system. Joint angles were calculated using a three-dimensional Euler rotation sequence. Principal component analysis (PCA) and single component reconstruction were applied to assess differences in lifting technique across the entire waveforms. Thirty-two PCs were retained from the five joints and three axes in accordance with the 90% trace criterion. Repeated-measures ANOVA with a mixed design revealed no significant effect of sex for any of the PCs. This is contrary to previous research that used discrete points on the lifting curve to analyze sex-based differences, but agrees with more recent research using more complex analysis techniques. There was a significant effect of load on lifting technique for five PCs of the lower limb (PC1 of ankle flexion, knee flexion, and knee adduction, as well as PC2 and PC3 of hip flexion) ( $p < 0.005$ ). However, there was no significant effect of load on the thoracic and lumbar spine. It was concluded that when load is standardized to individual back strength characteristics, males and females adopted a similar lifting technique. In addition, as load increased male and female participants changed their lifting technique in a similar manner.

- **Keywords:** Lifting kinematics; Sex differences; Principal component analysis; Single component reconstruction

**N. Louveton, R. McCall, V. Koenig, T. Avanesov, T. Engel. *Driving while using a smartphone-based mobility application: Evaluating the impact of three multi-choice user interfaces on visual-manual distraction. Pages 196-204.***

Innovative in-car applications provided on smartphones can deliver real-time alternative mobility choices and subsequently generate visual-manual demand. Prior studies have found that multi-touch gestures such as kinetic scrolling are problematic in this respect. In this study we evaluate three prototype tasks which can be found in common mobile interaction use-cases. In a repeated-measures design, 29 participants interacted with the prototypes in a car-following task within a driving simulator environment. Task completion, driving performance and eye gaze have been analysed. We found that the slider widget used in the filtering task was too demanding and led to poor performance, while kinetic scrolling generated a comparable amount of visual distraction despite it requiring a lower degree of finger pointing accuracy. We discuss how to improve continuous list browsing in a dual-task context.

- **Keywords:** Driving simulator; Multi-touch application; Visual-manual distraction

**Robert G. Radwin, Amrish Chourasia, Frank J. Fronczak, Yashpal Subedi, Robert Howery, Thomas Y. Yen, Mary E. Sesto, Curtis B. Irwin. *Predicting tool operator capacity to react against torque within acceptable handle deflection limits in automotive assembly. Pages 205-211.***

The proportion of tool operators capable of maintaining published psychophysically derived threaded fastener tool handle deflection limits were predicted using a biodynamic tool operator model, interacting with the tool, task and workstation. Tool parameters, including geometry, speed and torque were obtained from the specifications for 35 tools used in an auto assembly plant. Tool mass moments of inertia were measured for these tools using a novel device that engages the tool in a rotating system of known inertia. Task parameters, including fastener target torque and joint properties (soft, medium or hard), were ascertained from the vehicle design specifications. Workstation parameters, including vertical and horizontal distances from the operator were measured using a laser rangefinder for 69 tool installations in the plant. These parameters were entered into the model and tool handle deflection was predicted for each job. While handle deflection for most jobs did not exceed the capacity of 75% females and 99% males, six jobs exceeded the deflection criterion. Those tool installations were examined and modifications in tool

speed and operator position improved those jobs within the deflection limits, as predicted by the model. We conclude that biodynamic tool operator models may be useful for identifying stressful tool installations and interventions that bring them within the capacity of most operators.

- **Keywords:** Power hand tool; Upper limb biomechanics; Tool operator biodynamic model; Work related musculoskeletal disorders; Nutrunner; Dynamic strength

**Tim Bosch, Jennifer van Eck, Karlijn Knitel, Michiel de Looze. *The effects of a passive exoskeleton on muscle activity, discomfort and endurance time in forward bending work.* Pages 212-217.**

Exoskeletons may form a new strategy to reduce the risk of developing low back pain in stressful jobs. In the present study we examined the potential of a so-called passive exoskeleton on muscle activity, discomfort and endurance time in prolonged forward-bended working postures. Eighteen subjects performed two tasks: a simulated assembly task with the trunk in a forward-bended position and static holding of the same trunk position without further activity. We measured the electromyography for muscles in the back, abdomen and legs. We also measured the perceived local discomfort. In the static holding task we determined the endurance, defined as the time that people could continue without passing a specified discomfort threshold. In the assembly task we found lower muscle activity (by 35–38%) and lower discomfort in the low back when wearing the exoskeleton. Additionally, the hip extensor activity was reduced. The exoskeleton led to more discomfort in the chest region. In the task of static holding, we observed that exoskeleton use led to an increase in endurance time from 3.2 to 9.7 min, on average. The results illustrate the good potential of this passive exoskeleton to reduce the internal muscle forces and (reactive) spinal forces in the lumbar region. However, the adoption of an over-extended knee position might be, among others, one of the concerns when using the exoskeleton.

- **Keywords:** Exoskeleton; Industry; Electromyography; Discomfort; Endurance; Trunk bending

**Mark C. Schall Jr., Nathan B. Fethke, Howard Chen. *Working postures and physical activity among registered nurses.* Pages 243-250.**

Nurses report a high prevalence of musculoskeletal discomfort, particularly of the low back and neck/shoulder. This study characterized the full-shift upper arm and trunk postures and movement velocities of registered nurses using inertial measurement units (IMUs). Intensity of occupational physical activity (PA) was also ascertained using a waist-worn PA monitor and using the raw acceleration data from each IMU. Results indicated that nurses spent a relatively small proportion of their work time with the arms or trunk in extreme postures, but had few opportunities for rest and recovery in comparison to several other occupational groups. Comparisons between nurses in different PA groups suggested that using a combination of accelerometers secured to several body locations may provide more representative estimates of physical demands than a single, waist-worn PA monitor. The findings indicate a need for continued field-based research with larger sample sizes to facilitate the development of maximally effective intervention strategies.

- **Keywords:** Musculoskeletal disorders; Posture; Physical activity; Low back; Shoulder; Inertial measurement unit

**Enrique Valero, Aparajithan Sivanathan, Frédéric Bosché, Mohamed Abdel-Wahab. *Musculoskeletal disorders in construction: A review and a***

***novel system for activity tracking with body area network. Pages 120-130.***

Human body motions have been analysed for decades with a view on enhancing occupational well-being and performance of workers. On-going progresses in miniaturised wearable sensors are set to revolutionise biomechanical analysis by providing accurate and real-time quantitative motion data. The construction industry has a poor record of occupational health, in particular with regard to work-related musculoskeletal disorders (WMSDs). In this article, we therefore focus on the study of human body motions that could cause WMSDs in construction-related activities. We first present an in-depth review of existing assessment frameworks used in practice for the evaluation of human body motion. Subsequently different methods for measuring working postures and motions are reviewed and compared, pointing out the technological developments, limitations and gaps; Inertial Measurement Units (IMUs) are particularly investigated. Finally, we introduce a new system to detect and characterise unsafe postures of construction workers based on the measurement of motion data from wearable wireless IMUs integrated in a body area network. The potential of this system is demonstrated through experiments conducted in a laboratory as well as in a college with actual construction trade trainees.

- **Keywords:** WMSDs; Construction; Health; Well-being; Biomechanics; Inertial measurement unit

Morgan J. Thompson, Jeremiah D. Reilly, Rupa S. Valdez. Work system barriers to patient, provider, and caregiver use of personal health records: A systematic review. Pages 218-242.

**Objectives:** This review applied a human factors/ergonomics (HF/E) paradigm to assess individual, work system/unit, organization, and external environment factors generating barriers to patient, provider, and informal caregiver personal health record (PHR) use. **Methods:** The literature search was conducted using five electronic databases for the timeframe January 2000 to October 2013, resulting in 4865 citations. Two authors independently coded included articles (n = 60). **Results:** Fifty-five, ten and five articles reported barriers to patient, provider and caregiver PHR use, respectively. Barriers centered around 20 subfactors. The most frequently noted were needs, biases, beliefs, and mood (n = 35) and technology functions and features (n = 32). **Conclusions:** The HF/E paradigm was effective in framing the assessment of factors creating barriers to PHR use. Design efforts should address literacy, interoperability, access to health information, and secure messaging. A deeper understanding of the interactions between work systems and the role of organization and external environment factors is required.

- **Keywords:** Systematic review; Personal health records; Human factors and ergonomics