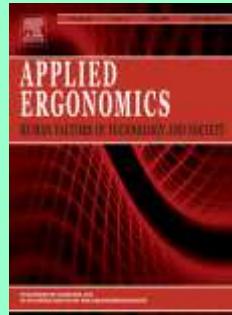


Applied Ergonomics - rok 2016, Volume 56

September 2016



Christine M. Mulvihill, Paul M. Salmon, Vanessa Beanland, Michael G. Lenné, Gemma J.M. Read, Guy H. Walker, Neville A. Stanton. *Using the decision ladder to understand road user decision making at actively controlled rail level crossings.* Pages 1-10.

Rail level crossings (RLXs) represent a key strategic risk for railways worldwide. Despite enforcement and engineering countermeasures, user behaviour at RLXs can often confound expectations and erode safety. Research in this area is limited by a relative absence of insights into actual decision making processes and a focus on only a subset of road user types. One-hundred and sixty-six road users (drivers, motorcyclists, cyclists and pedestrians) completed a diary entry for each of 457 naturalistic encounters with RLXs when a train was approaching. The final eligible sample comprised 94 participants and 248 encounters at actively controlled crossings where a violation of the active warnings was possible. The diary incorporated Critical Decision Method probe questions, which enabled user responses to be mapped onto Rasmussen's decision ladder. Twelve percent of crossing events were non-compliant. The underlying decision making was compared to compliant events and a reference decision model to reveal important differences in the structure and type of decision making within and between road user groups. The findings show that engineering countermeasures intended to improve decision making (e.g. flashing lights), may have the opposite effect for some users because the system permits a high level of flexibility for circumvention. Non-motorised users were more likely to access information outside of the warning signals because of their ability to achieve greater proximity to the train tracks and the train itself. The major conundrum in resolving these issues is whether to restrict the amount of time and information available to users so that it cannot be used for circumventing the system or provide more information to help users make safe decisions.

- **Keywords:** Rail level crossings; Road users; Decision making; Decision ladder; Safety

Susanna Aromaa, Kaisa Väänänen. *Suitability of virtual prototypes to support human factors/ergonomics evaluation during the design.* Pages 11-18.

In recent years, the use of virtual prototyping has increased in product development processes, especially in the assessment of complex systems targeted at end-users. The purpose of this study was to evaluate the suitability of virtual prototyping to support human factors/ergonomics evaluation (HFE) during the design phase. Two different

virtual prototypes were used: augmented reality (AR) and virtual environment (VE) prototypes of a maintenance platform of a rock crushing machine. Nineteen designers and other stakeholders were asked to assess the suitability of the prototype for HFE evaluation. Results indicate that the system model characteristics and user interface affect the experienced suitability. The VE system was valued as being more suitable to support the assessment of visibility, reach, and the use of tools than the AR system. The findings of this study can be used as a guidance for the implementing virtual prototypes in the product development process.

- **Keywords:** Virtual prototyping; Human factors/ergonomics; Virtual environment

Mahboobeh Ghesmaty Sangachin, Lora A. Cavuoto. *Obesity-related changes in prolonged repetitive lifting performance.* Pages 19-26.

Despite the rising prevalence of obesity, little is known about its moderating effects on injury risk factors, such as fatigue, in occupational settings. This study investigated the effect of obesity, prolonged repetitive lifting and their interaction on lifting performance of 14 participants, 7 obese (mean body mass index (BMI): 33.2 kg m⁻²) and 7 non-obese (mean BMI: 22.2 kg m⁻²) subjects. To present a physically challenging task, subjects performed repetitive lifting for 1 h at 120% of their maximum acceptable weight of lift. Generalized linear mixed models were fit to posture and acceleration data. The obese group bent to a ~10° lower peak trunk sagittal flexion angle, had 17% lower root mean square (RMS) jerk and took 0.8 s longer per lift. Over time, the obese group increased their trunk transverse and sagittal posterior accelerations while the non-obese maintained theirs. Although the majority of lifting variables were unaffected by BMI or its interaction with prolonged lifting duration, the observed differences, combined with a greater upper body mass, necessitate a more cautious use of existing psychophysical lifting limits for individuals who are obese, particularly when fatigued.

- **Keywords:** Class I obesity; Fatigue; Manual material handling

Steven P. Davidson, Stephen M. Cain, Ryan S. McGinnis, Rachel R. Vitali, Noel C. Perkins, Scott G. McLean. *Quantifying warfighter performance in a target acquisition and aiming task using wireless inertial sensors.* Pages 27-33.

An array of inertial measurement units (IMUS) was experimentally employed to analyze warfighter performance on a target acquisition task pre/post fatigue. Eleven participants (5M/6F) repeated an exercise circuit carrying 20 kg of equipment until fatigued. IMUs secured to the sacrum, sternum, and a rifle quantified peak angular velocity magnitude (PAVM) and turn time (TT) on a target acquisition task (three aiming events with two 180° turns) within the exercise circuit. Turning performance of two turns was evaluated pre/post fatigue. Turning performance decreased with fatigue. PAVMs decreased during both turns for the sternum ($p < 0.001$), sacrum ($p = 0.007$) and rifle ($p = 0.002$). TT increased for the sternum ($p = 0.001$), sacrum ($p = 0.003$), and rifle ($p = 0.02$) during turn 1, and for the rifle ($p = 0.04$) during turn 2. IMUs detected and quantified changes in warfighter aiming performance after fatigue. Similar methodologies can be applied to many movement tasks, including quantifying movement performance for load, fatigue, and equipment conditions.

- **Keywords:** Aiming performance; Warfighter performance; Inertial measurement units; Fatigue

N. Jarque-Bou, V. Gracia-Ibáñez, J.L. Sancho-Bru, M. Vergara, A. Pérez-González, F.J. Andrés. *Using kinematic reduction for studying grasping*

postures: An application to power and precision grasp of cylinders.
Pages 52-61.

The kinematic analysis of human grasping is challenging because of the high number of degrees of freedom involved. The use of principal component and factorial analyses is proposed in the present study to reduce the hand kinematics dimensionality in the analysis of posture for ergonomic purposes, allowing for a comprehensive study without losing accuracy while also enabling velocity and acceleration analyses to be performed. A laboratory study was designed to analyse the effect of weight and diameter in the grasping posture for cylinders. This study measured the hand posture from six subjects when transporting cylinders of different weights and diameters with precision and power grasps. The hand posture was measured using a Vicon® motion-tracking system, and the principal component analysis was applied to reduce the kinematics dimensionality. Different ANOVAs were performed on the reduced kinematic variables to check the effect of weight and diameter of the cylinders, as well as that of the subject. The results show that the original twenty-three degrees of freedom of the hand were reduced to five, which were identified as digit arching, closeness, palmar arching, finger adduction and thumb opposition. Both cylinder diameter and weight significantly affected the precision grasping posture: diameter affects closeness, palmar arching and opposition, while weight affects digit arching, palmar arching and closeness. The power-grasping posture was mainly affected by the cylinder diameter, through digit arching, closeness and opposition. The grasping posture was largely affected by the subject factor and this effect couldn't be attributed only to hand size. In conclusion, this kinematic reduction allowed identifying the effect of the diameter and weight of the cylinders in a comprehensive way, being diameter more important than weight.

- **Keywords:** Hand posture; Principal components analysis; Cylindrical objects; Grasp analysis

Emma Zijlstra, Mariët Hagedoorn, Wim P. Krijnen, Cees P. van der Schans, Mark P. Mobach. Route complexity and simulated physical ageing negatively influence wayfinding. Pages 62-67.

The aim of this age-simulation field experiment was to assess the influence of route complexity and physical ageing on wayfinding. Seventy-five people (aged 18–28) performed a total of 108 wayfinding tasks (i.e., 42 participants performed two wayfinding tasks and 33 performed one wayfinding task), of which 59 tasks were performed wearing gerontologic ageing suits. Outcome variables were wayfinding performance (i.e., efficiency and walking speed) and physiological outcomes (i.e., heart and respiratory rates). Analysis of covariance showed that persons on more complex routes (i.e., more floor and building changes) walked less efficiently than persons on less complex routes. In addition, simulated elderly participants perform worse in wayfinding than young participants in terms of speed ($p < 0.001$). Moreover, a linear mixed model showed that simulated elderly persons had higher heart rates and respiratory rates compared to young people during a wayfinding task, suggesting that simulated elderly consumed more energy during this task.

- **Keywords:** Hospital environment; Route complexity; Physical ageing; Simulation; Wayfinding

Leandro Miletto Tonetto, Pieter M.A. Desmet. Why we love or hate our cars: A qualitative approach to the development of a quantitative user experience survey. Pages 68-74.

This paper presents a more ecologically valid way of developing theory-based item questionnaires for measuring user experience. In this novel approach, items were

generated using natural and domain-specific language of the research population, what seems to have made the survey much more sensitive to real experiences than theory-based ones. The approach was applied in a survey that measured car experience. Ten in-depth interviews were conducted with drivers inside their cars. The resulting transcripts were analysed with the aim of capturing their natural utterances for expressing their car experience. This analysis resulted in 71 categories of answers. For each category, one sentence was selected to serve as a survey-item. In an online platform, 538 respondents answered the survey. Data reliability, tested with Cronbach alpha index, was 0.94, suggesting a survey with highly reliable results to measure drivers' appraisals of their cars.

- **Keywords:** User experience; Design and emotion; Survey development; Appraisal theory; Car industry

Kaitlin M. Gallagher, Jack P. Callaghan. *Standing on a declining surface reduces transient prolonged standing induced low back pain development. Pages 76-83.*

While alternating standing position on a sloped surface has proven successful at reducing low back pain during standing, the purpose of this study was to evaluate standing solely on a declining surface to isolate the influence of the postural change. Seventeen participants performed two 75-min prolonged standing occupational simulations- level ground and declining surface. Fifty-three percent of participants (9/17) were categorized as pain developers during the level ground standing condition. For these same pain developers, their average maximum pain scores were 58% lower during sloped standing. All participants showed greater hip flexion, trunk-to-thigh angle flexion, and posterior translation of the trunk center of gravity when standing on the sloped surface. These postural changes could cause the muscles crossing the hip posteriorly to increase passive stiffness and assist with stabilizing the pelvis. This study stresses the importance of hip kinematics, not just lumbar spine posture, in reducing prolonged standing induced low back pain.

- **Keywords:** Occupational standing; Standing aid; Static; Lumbar spine; Posture; Movement

Roland Zemp, Michael Fliesser, Pia-Maria Wippert, William R. Taylor, Silvio Lorenzetti. *Occupational sitting behaviour and its relationship with back pain: A pilot study. Pages 84-91.*

Nowadays, working in an office environment is ubiquitous. At the same time, progressively more people suffer from occupational musculoskeletal disorders. Therefore, the aim of this pilot study was to analyse the influence of back pain on sitting behaviour in the office environment. A textile pressure mat (64-sensor-matrix) placed on the seat pan was used to identify the adopted sitting positions of 20 office workers by means of random forest classification. Additionally, two standardised questionnaires (Korff, BPI) were used to assess short and long-term back pain in order to divide the subjects into two groups (with and without back pain). Independent t-test indicated that subjects who registered back pain within the last 24 h showed a clear trend towards a more static sitting behaviour. Therefore, the developed sensor system has successfully been introduced to characterise and compare sitting behaviour of subjects with and without back pain.

- **Keywords:** Office chair; Pressure distribution; Musculoskeletal disorders

J. Karlton, K. Vogel, M. Bergstrand, J. Eklund. *Maintaining knife sharpness in industrial meat cutting: A matter of knife or meat cutter ability.* Pages 92-100.

Knife sharpness is imperative in meat cutting. The aim of this study was to compare the impact of knife blade steel quality with meat cutters' individual ability to maintain the cutting edge sharp in an industrial production setting. Twelve meat cutters in two different companies using three different knives during normal production were studied in this quasi-experimental study. Methods included were measuring knife cutting force before and after knife use, time knives were used, ratings of sharpness and discomfort and interviews. Results showed that the meat cutters' skill of maintaining sharpness during work had a much larger effect on knife sharpness during work than the knife steel differences. The ability was also related to feelings of discomfort and to physical exertion. It was found that meat cutters using more knives were more likely to suffer from discomfort in the upper limbs, which is a risk for developing MSD.

- **Keywords:** Steel quality; MSD; Individual skill; Sharpness analyser

Feng-Wen Hsu, Chiuhsiang Joe Lin, Yung-Hui Lee, Hung-Jen Chen. *Effects of elevation change on mental stress in high-voltage transmission tower construction workers.* Pages 101-107.

High-voltage transmission tower construction is a high-risk operation due to the construction site locations, extreme climatic factors, elevated working surfaces, and narrow working space. To comprehensively enhance our understanding of the psychophysiological phenomena of workers in extremely high tower constructions, we carried out a series of field experiments to test and compare three working surface heights in terms of frequency-domain heart rate variability (HRV) measurements. Twelve experienced male workers participated in this experiment. The dependent variables, namely, heart rate (HR), normalized low-frequency power (nLF), normalized high-frequency power (nHF), and LF-to-HF power ratio (LF/HF), were measured with the Polar RS800CX heart rate monitor. The experimental results indicated that the task workload was similar between working surface heights. Tower construction workers perceived an increased level of mental stress as working surface height increased.

- **Keywords:** High-voltage transmission tower; Heart rate variability; Working surface height

S.-K. Stavrakos, S. Ahmed-Kristensen, T. Goldman. *Using archetypes to create user panels for usability studies: Streamlining focus groups and user studies.* Pages 108-116.

Designers at the conceptual phase of products such as headphones, stress the importance of comfort, e.g. executing comfort studies and the need for a reliable user panel. This paper proposes a methodology to issue a reliable user panel to represent large populations and validates the proposed framework to predict comfort factors, such as physical fit. Data of 200 heads was analyzed by forming clusters, 9 archetypal people were identified out of a 200 people's ear database. The archetypes were validated by comparing the archetypes' responses on physical fit against those of 20 participants interacting with 6 headsets. This paper suggests a new method of selecting representative user samples for prototype testing compared to costly and time consuming methods which relied on the analysis of human geometry of large populations.

- **Keywords:** Comfort; Anthropometry; Ergonomics; Archetypes

Zachary Katsulis, Awatef Ergai, Wai Yin Leung, Laura Schenkel, Amisha Rai, Jason Adelman, James Benneyan, David W. Bates, Patricia C. Dykes. *Iterative user centered design for development of a patient-centered fall prevention toolkit. Pages 117-126.*

Due to the large number of falls that occur in hospital settings, inpatient fall prevention is a topic of great interest to patients and health care providers. The use of electronic decision support that tailors fall prevention strategy to patient-specific risk factors, known as Fall T.I.P.S (Tailoring Interventions for Patient Safety), has proven to be an effective approach for decreasing hospital falls. A paper version of the Fall T.I.P.S toolkit was developed primarily for hospitals that do not have the resources to implement the electronic solution; however, more work is needed to optimize the effectiveness of the paper version of this tool. We examined the use of human factors techniques in the redesign of the existing paper fall prevention tool with the goal of increasing ease of use and decreasing inpatient falls. The inclusion of patients and clinical staff in the redesign of the existing tool was done to increase adoption of the tool and fall prevention best practices. The redesigned paper Fall T.I.P.S toolkit showcased a built in clinical decision support system and increased ease of use over the existing version.

- **Keywords:** Evidence-based fall prevention; Patient-centered design; Patient safety; RE-AIM; Usability

James Shippen, Barbara May. *Constitutive kinematic modes and shapes during vehicle ingress/egress. Pages 127-135.*

A study was undertaken to investigate the kinematics of older users of passenger vehicles during ingress/egress and to seek correlations between their movement and comfort rating assigned by the subjects to the ease of vehicle ingress and egress. A principal component analysis was performed on the subjects' kinematics to identify the underlying modes of movement employed by the subjects. It was found that a small number of modes could describe the movements of all the subjects across all of the vehicles. Within the subspace defined by the modal vectors, shapes were found which correlated to the comfort rating for ease of ingress and egress which the subjects had assigned to each of the cars. Knowledge of these shapes which correspond to good and poor ingress and egress will be useful to the designers of interiors and exteriors of passenger vehicles for the older person. It is recommended that vehicle designs for the older person should attempt to avoid body positions which require excessive ankle articulation and lumbar flexion/extension during ingress and egress.

- **Keywords:** Ingress/egress; Principal component analysis; Comfort; Motion analysis; Older users; Vehicles; Cars; Ergonomics

Mohammed Said Obeidat, Malgorzata J. Rys, Andrew Rys, Juan Du. *Evaluation of overhead guide sign sheeting materials to increase visibility and safety for drivers. Pages 136-143.*

Overhead guide sign visibility must increase to improve driver safety on roadways. Two methods increase overhead guide sign visibility: sign illumination and use of retroreflective sheeting materials. This paper compares three types of retroreflective sheeting: Engineering Grade (type I), Diamond Grade (type XI), and High Intensity (type IV). A field experiment was conducted at night using licensed drivers to determine the optimum retroreflective sheeting material that increases sign visibility and legibility. Results showed that, of the three types of retroreflective sheeting, Diamond Grade (type XI) sheeting requires minimum illuminance to be visible, followed by High Intensity (type IV) sheeting. Cost analysis, including labor, maintenance, and material cost components of the three retroreflective sheeting materials, showed that High Intensity (type IV) could

increase sign visibility and legibility at night for Departments of Transportation with limited budgets, consequently increasing driver safety on roadways.

- **Keywords:** Overhead guide sign; Retroreflectivity; Retroreflective sheeting; Safety; Cost analysis

Francesca Dotti, Ada Ferri, Matteo Moncalero, Martino Colonna. *Thermo-physiological comfort of soft-shell back protectors under controlled environmental conditions. Pages 144-152.*

The aim of the study was to investigate thermo-physiological comfort of three back protectors identifying design features affecting heat loss and moisture management. Five volunteers tested the back protectors in a climatic chamber during an intermittent physical activity. Heart rate, average skin temperature, sweat production, microclimate temperature and humidity have been monitored during the test. The sources of heat losses have been identified using infrared thermography and the participants answered a questionnaire to express their subjective sensations associated with their thermo-physiological condition. The results have shown that locally torso skin temperature and microclimate depended on the type of back protector, whose design allowed different extent of perspiration and thermal insulation. Coupling physiological measurements with the questionnaire, it was found that overall comfort was dependent more on skin wetness than skin temperature: the participants preferred the back protector with the highest level of ventilation through the shell and the lowest level of microclimate humidity.

- **Keywords:** Snow sports; Polymeric; Foams; Skin temperature; Microclimate

K.L. Yick, L.T. Tse, W.T. Lo, S.P. Ng, J. Yip. *Effects of indoor slippers on plantar pressure and lower limb EMG activity in older women. Pages 153-159.*

Open-toe mule slippers are popular footwear worn at home especially by older women. However, their biomechanical effects are still poorly understood. The objective of this study is to therefore evaluate the physical properties of two typical types of open-toe mule slippers and the changes in plantar pressure and lower limb muscle activity of older women when wearing these slippers. Five walking trials have been carried out by ten healthy women. The results indicate that compared to barefoot, wearing slippers results in significant increases in the contact area of the mid-foot regions which lead to plantar pressure redistribution from metatarsal heads 2-3 and the lateral heel to the midfoot regions. However, there is no significant difference in the selected muscle activity across all conditions. The findings enhance our understanding of slipper features associated with changes in biomechanical measures thereby providing the basis of slipper designs for better foot protection and comfort.

- **Keywords:** Slippers; Plantar pressure; Electromyography

Marie-Lys Deschamps, Penelope Sanderson, Kelly Hinckfuss, Caitlin Browning, Robert G. Loeb, Helen Liley, David Liu. *Improving the detectability of oxygen saturation level targets for preterm neonates: A laboratory test of tremolo and beacon sonifications. Pages 160-169.*

Recent guidelines recommend oxygen saturation (SpO_2) levels of 90%–95% for preterm neonates on supplemental oxygen but it is difficult to discern such levels with current pulse oximetry sonifications. We tested (1) whether adding levels of tremolo to a conventional log-linear pulse oximetry sonification would improve identification of SpO_2 ranges, and (2) whether adding a beacon reference tone to conventional pulse oximetry confuses listeners about the direction of change. Participants using the Tremolo (94%) or

Beacon (81%) sonifications identified SpO₂ range significantly more accurately than participants using the LogLinear sonification (52%). The Beacon sonification did not confuse participants about direction of change. The Tremolo sonification may have advantages over the Beacon sonification for monitoring SpO₂ of preterm neonates, but both must be further tested with clinicians in clinically representative scenarios, and with different levels of ambient noise and distractions.

- **Keywords:** Patient monitoring; Pulse oximetry; Sonification; Auditory display

Peter Le, William S. Marras. *Evaluating the low back biomechanics of three different office workstations: Seated, standing, and perching.* Pages 170-178.

The objective of this study was to evaluate how different workstations may influence physical behavior in office work through motion and how that may affect spinal loads and discomfort. Twenty subjects performed a typing task in three different workstations (seated, standing, and perching) for one hour each. Measures of postural transitions, spinal loads, discomfort, and task performance were assessed in order to understand the effects of workstation interaction over time. Results indicated that standing had the most amount of motion (6–8 shifts/min), followed by perching (3–7 shifts/min), and then seating (<1 shift/min). Standing had the highest reports of discomfort and seating the least. However, spinal loads were highest in A/P shear during standing (190N posterior shear, 407N anterior shear) compared to perching (65N posterior shear, 288N anterior shear) and seating (106N posterior shear, 287 anterior shear). These loads are below the risk threshold for shear, but may still elicit a cumulative response. Perching may induce motion through supported mobility in the perching stool, whereas standing motion may be due to postural discomfort. Office workstation designs incorporating supported movement may represent a reasonable trade-off in the costs-benefits between seating and standing.

- **Keywords:** Dynamic seating; Sedentary work; Seating discomfort; Sitting

Jodi Oakman, Paul Rothmore, David Tappin. *Intervention development to reduce musculoskeletal disorders: Is the process on target?* Pages 179-186.

Work related musculoskeletal disorders remain an intractable OHS problem. In 2002, Haslam proposed applying the stage of change model to target ergonomics interventions and other health and safety prevention activities. The stage of change model proposes that taking into account an individual's readiness for change in developing intervention strategies is likely to improve uptake and success. This paper revisits Haslam's proposal in the context of interventions to reduce musculoskeletal disorders. Effective MSD interventions require a systematic approach and need to take into account a combination of measures. Research evidence suggests that in practice, those charged with the management of MSDs are not consistently adopting such an approach. Consequently, intervention development may not represent contemporary best practice. We propose a potential method of addressing this gap is the stage of change model, and use a case study to illustrate this argument in tailoring intervention development for managing MSDs.

- **Keywords:** Musculoskeletal disorders; Stage of change; Transtheoretical; Interventions; Systems approach

Laura Morales, Brittany M. McEachern, Renée S. MacPhee, Steven L. Fischer. *Patient acuity as a determinant of paramedics' frequency of being exposed to physically demanding work activities.* Pages 187-193.

Background: The purpose of this investigation was to examine if paramedics' frequency of being exposed to highly physically demanding activities, or their perception of physical, clinical, and emotional demands were altered by patients' acuity level, operationalized using the Canadian Triage and Acuity Scale (CTAS). **Methods:** Physical demands descriptions (PDD) were compiled from thirteen services across Canada. The observation sessions took place during a minimum of two full-shift (12-h) ride-outs at each service. Data were obtained from 53 ride-outs, which included a total of 190 calls.

Results: Higher urgency calls (CTAS level I or II) required significantly more stretcher handling, equipment handling, and intravenous (IV) work, also prompting higher ratings of perceived clinical, physical, and emotional demand. Independent of CTAS level, stretcher loading with patient (15.0%), horizontal patient transfer (13.7%), and pushing/pulling the stretcher with patient (13.1%) were identified as the most physically demanding tasks. **Conclusions:** Patient acuity is an important determinant affecting the frequency for which paramedics are exposed to work tasks with inherent ergonomic hazards (e.g., handling a stretcher with a patient). Patient acuity also affects paramedics' perceived clinical, physical, and emotional demands of a call.

- **Keywords:** Emergency medical services; Paramedics; Physical demands; Injury prevention

Faming Wang, Hui Peng, Wen Shi. *The relationship between air layers and evaporative resistance of male Chinese ethnic clothing.* Pages 194-202.

In this study, the air layer distribution and evaporative resistances of 39 sets of male Chinese ethnic clothing were investigated using a sweating thermal manikin and the three-dimensional (3D) body scanning technique. Relationships between the evaporative resistance and air layers (i.e., air gap thickness and air volume) were explored. The results demonstrated that the clothing total evaporative resistance increases with the increasing air gap size/air volume, but the rate of increase gradually decreases as the mean air gap size or the total air volume becomes larger. The clothing total evaporative resistance reaches its maximum when the average air gap size and the total air volume are 41.6 mm and 69.9 dm³, respectively. Similar general trends were also found between local mean air gap size and clothing local evaporative resistance at different body parts. However, different body parts show varied rates of increase and decrease in the local evaporative resistance. The research findings provide a comprehensive database for predicting overall and local human thermal comfort while wearing male Chinese ethnic clothing.

- **Keywords:** Air gap; Air volume; Local evaporative resistance; Non-western clothing; Thermal manikin

Hardy A. van de Ven, Sandra Brouwer, Wendy Koolhaas, Anneke Goudswaard, Michiel P. de Looze, Göran Kecklund, Josue Almansa, Ute Bültmann, Jac J.L. van der Klink. *Associations between shift schedule characteristics with sleep, need for recovery, health and performance measures for regular (semi-)continuous 3-shift systems.* Pages 203-212.

In this cross-sectional study associations were examined between eight shift schedule characteristics with shift-specific sleep complaints and need for recovery and generic health and performance measures. It was hypothesized that shift schedule characteristics meeting ergonomic recommendations are associated with better sleep, need for recovery, health and performance. Questionnaire data were collected from 491 shift workers of 18 companies with 9 regular (semi)-continuous shift schedules. The shift schedule characteristics were analyzed separately and combined using multilevel linear regression models. The hypothesis was largely not confirmed. Relatively few associations

were found, of which the majority was in the direction as expected. In particular early starts of morning shifts and many consecutive shifts seem to be avoided. The healthy worker effect, limited variation between included schedules and the cross-sectional design might explain the paucity of significant results.

- **Keywords:** Work schedule tolerance; Shift work; Sleep; Need for recovery; Fatigue; Health; Work functioning

Heikki Mansikka, Kai Virtanen, Don Harris, Petteri Simola. *Fighter pilots' heart rate, heart rate variation and performance during an instrument flight rules proficiency test. Pages 213-219.*

Increased task demand will increase the pilot mental workload (PMWL). When PMWL is increased, mental overload may occur resulting in degraded performance. During pilots' instrument flight rules (IFR) proficiency test, PMWL is typically not measured. Therefore, little is known about workload during the proficiency test and pilots' potential to cope with higher task demands than those experienced during the test. In this study, fighter pilots' performance and PMWL was measured during a real IFR proficiency test in an F/A-18 simulator. PMWL was measured using heart rate (HR) and heart rate variation (HRV). Performance was rated using Finnish Air Force's official rating scales. Results indicated that HR and HRV differentiate varying task demands in situations where variations in performance are insignificant. It was concluded that during a proficiency test, PMWL should be measured together with the task performance measurement.

- **Keywords:** Pilot mental workload; Heart rate; Pilot performance

Mieke A.A. De Bruyne, Benedikt Van Renterghem, Andrew Baird, Tanneke Palmans, Lieven Danneels, Mieke Dolphens. *Influence of different stool types on muscle activity and lumbar posture among dentists during a simulated dental screening task. Pages 220-226.*

Whereas in the past dental stools typically facilitated a 90° hip angle, a number of currently available alternative designs allow for a more extended hip posture. The present study investigated the influence of different stool types on muscle activity and lumbar posture. Twenty five participants completed a simulated dental procedure on a standard stool, a saddle and the Ghopec. The latter stool comprises a seat pan consisting of a horizontal rear part for the pelvis and an inclinable sloping down front part for the upper legs, with a vertically and horizontally adjustable back rest. Lumbar posture was most close to neutral on the Ghopec, whereas sitting on a standard/saddle stool resulted in more flexed/extended postures respectively. Sitting with a 90° angle (standard stool) resulted in higher activation of back muscles while sitting with a 125° angle (saddle and Ghopec) activated abdominal muscles more, although less in the presence of a backrest (Ghopec). To maintain neutral posture during dental screening, the Ghopec is considered the most suitable design for the tasks undertaken.

- **Keywords:** Dental ergonomics; Posture; Sitting; Muscle activity

Priscila Wachs, Tarcisio Abreu Saurin, Angela Weber Righi, Robert Lewis Wears. *Resilience skills as emergent phenomena: A study of emergency departments in Brazil and the United States. Pages 227-237.*

Although the use of resilience skills (RSs) by emergency department (ED) front-line staff is ubiquitous, the nature and origin of these skills tend to be taken for granted. This study investigates the research question "where do RSs come from"? Case studies in two EDs were undertaken in order to answer the research question: one in Brazil and the other in the United States. The case studies adopted the same data collection and

analysis procedures, involving interviews, questionnaires, observations, and analysis of documents. A model for describing RSs as emergent phenomena is proposed. The model indicates that RSs arise from interactions between: work constraints, hidden curriculum, gaps in standardized operating procedures, organizational support for resilience, and RSs themselves. An instantiation of the model is illustrated by a critical event identified from the American ED. The model allows the identification of leverage points for influencing the development of RSs, instead of leaving their evolution purely to chance.

- **Keywords:** Resilience skills; Resilience engineering; Complexity; Emergency department

Setia Hermawati, Glyn Lawson. *Establishing usability heuristics for heuristics evaluation in a specific domain: Is there a consensus? Pages 34-51.*

Heuristics evaluation is frequently employed to evaluate usability. While general heuristics are suitable to evaluate most user interfaces, there is still a need to establish heuristics for specific domains to ensure that their specific usability issues are identified. This paper presents a comprehensive review of 70 studies related to usability heuristics for specific domains. The aim of this paper is to review the processes that were applied to establish heuristics in specific domains and identify gaps in order to provide recommendations for future research and area of improvements. The most urgent issue found is the deficiency of validation effort following heuristics proposition and the lack of robustness and rigour of validation method adopted. Whether domain specific heuristics perform better or worse than general ones is inconclusive due to lack of validation quality and clarity on how to assess the effectiveness of heuristics for specific domains. The lack of validation quality also affects effort in improving existing heuristics for specific domain as their weaknesses are not addressed.

- **Keywords:** Heuristics evaluation; Specific domain; Usability