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Roland Zemp, William R. Taylor, Silvio Lorenzetti. *Seat pan and backrest pressure distribution while sitting in office chairs.* Pages 1-9.

Nowadays, an increasing amount of time is spent seated, especially in office environments, where sitting comfort and support are increasingly important due to the prevalence of musculoskeletal disorders. The aim of this study was to develop a methodology for chair-specific sensor mat calibration, to evaluate the interconnections between specific pressure parameters and to establish those that are most meaningful and significant in order to differentiate pressure distribution measures between office chairs. The shape of the exponential calibration function was highly influenced by the material properties and geometry of the office chairs, and therefore a chair-specific calibration proved to be essential. High correlations were observed between the eight analysed pressure parameters, whereby the pressure parameters could be reduced to a set of four and three parameters for the seat pan and the backrest respectively. In order to find significant differences between office chairs, gradient parameters should be analysed for the seat pan, whereas for the backrest almost all parameters are suitable.

- **Keywords:** Pressure distribution; Chair-specific calibration; Sitting behaviour

Jacquelyn M. Maciukiewicz, Alan C. Cudlip, Jaclyn N. Chopp-Hurley, Clark R. Dickerson. *Effects of overhead work configuration on muscle activity during a simulated drilling task.* Pages 10-16.

Overhead work is a known catalyst for occupational shoulder injury. Industrial workers must often adopt awkward overhead postures and loading profiles to complete required tasks, potentially elevating injury risk. This research examined the combined influence of multiple overhead working parameters on upper extremity muscular demands for an industrial drilling application. Twenty-two right-handed males completed 24 unilateral and bilateral overhead work exertions stratified by direction (upward, forward), point of force application (15, 30 and 45 cm in front of the body), and whole-body posture (seated, standing). The dependency of electromyographic (EMG) activity on several factors was established. Significant two-way interactions existed between point of force application and direction ($p < 0.0001$) and direction and whole body posture ($p < 0.0001$). An average increase in muscular activity of 6.5% maximal voluntary contraction (MVC) occurred for the contralateral limb when the bilateral task was completed, compared to unilateral tasks, with less than a 1% MVC increase for the active limb. These findings assist evidence-based approaches to overhead tasks, specifically in the construction industry. A bilateral task configuration is recommended to reduce

glenohumeral stability demands. As well, particularly for tasks with a far reach distance, design tasks to promote a forward directed exertion. The considerable inter-subject variability suggests that fixed heights are not ideal, and should be avoided, and where this is not possible reaches should be reduced.

- **Keywords:** Shoulder; Fatigue; Bilateral tasks

Yinsheng Tian, Li Ding, Heqing Liu, Yan Li, Deyu Li, Li Wang. *Effects of EVA gloves on grip strength and fatigue under low temperature and low pressure. Pages 17-24.*

Objective: To study the effects of wearing extravehicular activity (EVA) gloves on grip strength and fatigue in low temperature, low pressure and mixing of two factors (low temperature and low pressure). **Methods:** The maximum grip strength and fatigue tests were performed with 10 healthy male subjects wearing gloves in a variety of simulated environments. The data was analysed using the normalization method. **Results:** The results showed that wearing gloves significantly affected the maximum grip strength and fatigue. Pressure (29.6, 39.2 kPa) had more influence on the maximum grip compared with control group while low temperatures (-50, -90, -110 °C) had no influence on grip but affected fatigue dramatically. The results also showed that the maximum grip strength and fatigue were influenced significantly in a compound environment. **Conclusions:** Space environment remarkably reduced strength and endurance of the astronauts. However, the effects brought by the compound environment cannot be understood as the superimposition of low temperature and pressure effects.

- **Keywords:** EVA glove; Low temperature; Pressure; Maximum grip; Fatigue

Yunyan Andrea Jia, Steve Rowlinson, Marina Ciccarelli. *Climatic and psychosocial risks of heat illness incidents on construction site. Pages 25-35.*

The study presented in this paper aims to identify prominent risks leading to heat illness in summer among construction workers that can be prioritised for developing effective interventions. Samples are 216 construction workers' cases at the individual level and 26 construction projects cases at the organisation level. A grounded theory is generated to define the climatic heat and psychosocial risks and the relationships between risks, timing and effectiveness of interventions. The theoretical framework is then used to guide content analysis of 36 individual onsite heat illness cases to identify prominent risks. The results suggest that heat stress risks on construction site are socially constructed and can be effectively managed through elimination at supply chain level, effective engineering control, proactive control of the risks through individual interventions and reactive control through mindful recognition and response to early symptoms. The role of management infrastructure as a base for effective interventions is discussed.

- **Keywords:** Occupational heat stress; Climatic heat risk; Construction workers; Effective interventions; Socio-ergonomic model

Nerrolyn Ramstrand, Roland Zügner, Louise Bæk Larsen, Roy Tranberg. *Evaluation of load carriage systems used by active duty police officers: Relative effects on walking patterns and perceived comfort. Pages 36-43.*

Objectives: This study aimed to examine the effects of two different load carriage systems on gait kinematics, temporospatial gait parameters and self-reported comfort in Swedish police. **Methods:** 21 active duty police officers were recruited for this crossover

study design. Biomechanical and self-report data was collected on two testing occasions. On occasion 1, three dimensional kinematic data was collected while police wore a/no equipment (control), b/their standard issues belt and ballistic protection vest and c/a load bearing vest with ballistic protection vest. Police then wore the load bearing vest for a minimum of 3 months before the second testing occasion. **Results:** The load bearing vest was associated with a significant reduction in range of motion of the trunk, pelvis and hip joints. Biomechanical changes associated with the load bearing vest appeared to reduce with increased wear time. In both the standard issue belt condition and the load bearing vest condition, police walked with the arms held in a significantly greater degree of abduction. Self-report data indicated a preference for the load bearing vest. **Conclusion:** The two load carriage designs tested in this study were found to significantly alter gait kinematics. The load bearing vest design was associated with the greatest number of kinematic compensations however these reduced over time as police became more accustomed to the design. Results from this study do not support selection of one load carriage design over the other and providing individuals with the option to choose a load carriage design is considered appropriate.

- **Keyterms:** Load bearing vest; Equipment; Kinematics; Temporospacial; Musculoskeletal disorders; Biomechanics; Ergonomics; Law enforcement

Markus Koch, Lars-Kristian Lunde, Michael Ernst, Stein Knardahl, Kaj Bo Veiersted. *Validity and reliability of pressure-measurement insoles for vertical ground reaction force assessment in field situations. Pages 44-51.*

This study aimed to test the validity and reliability of pressure-measurement insoles (medilogic® insoles) when measuring vertical ground reaction forces in field situations. Various weights were applied to and removed from the insoles in static mechanical tests. The force values measured simultaneously by the insoles and force plates were compared for 15 subjects simulating work activities. Reliability testing during the static mechanical tests yielded an average interclass correlation coefficient of 0.998. Static loads led to a creeping pattern of the output force signal. An individual load response could be observed for each insole. The average root mean square error between the insoles and force plates ranged from 6.6% to 17.7% in standing, walking, lifting and catching trials and was 142.3% in kneeling trials. The results show that the use of insoles may be an acceptable method for measuring vertical ground reaction forces in field studies, except for kneeling positions.

- **Keywords:** Pressure-measurement insoles; Vertical force measurement; Work

Lu Yuan, Bryan Buchholz, Laura Punnett, David Kriebel. *An integrated biomechanical modeling approach to the ergonomic evaluation of drywall installation. Pages 52-63.*

Three different methodologies: work sampling, computer simulation and biomechanical modeling, were integrated to study the physical demands of drywall installation. PATH (Posture, Activity, Tools, and Handling), a work-sampling based method, was used to quantify the percent of time that the drywall installers were conducting different activities with different body segment (trunk, arm, and leg) postures. Utilizing Monte-Carlo simulation to convert the categorical PATH data into continuous variables as inputs for the biomechanical models, the required muscle contraction forces and joint reaction forces at the low back (L4/L5) and shoulder (glenohumeral and sternoclavicular joints) were estimated for a typical eight-hour workday. To demonstrate the robustness of this modeling approach, a sensitivity analysis was conducted to examine the impact of some quantitative assumptions that have been made to facilitate the modeling approach. The results indicated that the modeling approach seemed to be the most sensitive to both the

distribution of work cycles for a typical eight-hour workday and the distribution and values of Euler angles that are used to determine the "shoulder rhythm." Other assumptions including the distribution of trunk postures did not appear to have a significant impact on the model outputs. It was concluded that the integrated approach might provide an applicable examination of physical loads during the non-routine construction work, especially for those operations/tasks that have certain patterns/sequences for the workers to follow.

- **Keywords:** Work sampling; Monte-Carlo simulation; Biomechanical model

Peter J. Sheahan, Tara L. Diesbourg, Steven L. Fischer. *The effect of rest break schedule on acute low back pain development in pain and non-pain developers during seated work.* Pages 64-70.

A significant portion of the population (25–50%) is known to develop acute low back pain (LBP) within a bout of prolonged sitting. Previous research has supported the use of frequent rest breaks, from seated office work, in order to reduce self-reported LBP, however, there is limited consensus about the recommended frequency and duration of rest breaks. This may be due to the limited consideration of individual differences in acute LBP development. The purpose of this study was to examine the effect of three different standing rest-break conditions on a group of pain developers (PD) and non-pain developers (NPD) engaged in prolonged seated work. Twenty participants completed four one-hour-long bouts of seated typing: Condition A – no rest; Condition B – 5 min of standing rest every 30 min; Condition C – 2.5 min of standing rest every 15 min; Condition D – 50 s of standing rest every 5 min. Self-reported LBP, self-reported mental fatigue and 30-s samples of EMG were collected every 10 min throughout each session. Eight out of 20 participants (40%) reported LBP during Condition A (classified as PD). Only PD demonstrated clinically relevant increases in LBP across conditions where Conditions B, C, or D provided some relief, but did not restore pain scores to their original level, prior to sitting. PD and NPD developed mental fatigue equally, with Conditions B and D helping to reduce fatigue. No differences in productivity were observed between conditions or groups and no main effects were observed for muscle activity, median power frequency or co-contraction. These data suggests that frequent, short, standing rest breaks may help to reduce symptoms of LBP, however they are only a temporary solution as PD still developed clinically important LBP, even with frequent rest breaks.

- **Keywords:** Low back pain; Standing rest breaks; Prolonged sitting

Tracey J. Dickson, Stephen Trathen, Gordon Waddington, F.Anne Terwiel, Daniel Baltis. *A human factors approach to snowsport safety: Novel research on pediatric participants' behaviors and head injury risk.* Pages 79-86.

Objective: This study applied a human factors approach to snowsport resort systems to contribute to the understanding of the incidence and severity of pediatric snowsport head accelerations. **Background:** Previous research indicates low magnitude head accelerations are common among snowsport participants. This study adds to the knowledge of snowsport safety by measuring aspects of participants' snowsport behavior and linking this with head acceleration data. **Method:** School-aged students (n = 107) wore telemetry-fitted helmets and Global Positioning System (GPS) devices during snowsport activity. Data was collected over 159 sessions (total hours 701). Head accelerations recorded by the telemetry units were compared with GPS-generated data. **Results:** This study found speeds attained normally exceed the testing rating for which helmets are designed; lower rates of head accelerations compared to earlier studies and that when head accelerations did occur they were generally below the threshold for

concussions. **Conclusion:** Pediatric snowsport head accelerations are rare and are generally of low magnitude. Those most at risk of a head acceleration >40 g were male snowboarders. Given the recorded speeds in first time participants, increased targeting of novice snowsport participants to encourage education about the use of protective equipment, including helmets, is warranted. Post event recall was not a good indicator of having experienced a head impact. Consideration should be given to raising the standard design speed testing for snowsport helmet protective devices to reflect actual snowsport behaviors.

- **Keywords:** Snowsports; Helmet design; Head injury; Participant behavior; Methods

Jonathan Power, Peter Tikuisis, António Simões Ré, Martin Barwood, Michael Tipton. *Correction factors for assessing immersion suits under harsh conditions.* Pages 87-94.

Many immersion suit standards require testing of thermal protective properties in calm, circulating water while these suits are typically used in harsher environments where they often underperform. Yet it can be expensive and logistically challenging to test immersion suits in realistic conditions. The goal of this work was to develop a set of correction factors that would allow suits to be tested in calm water yet ensure they will offer sufficient protection in harsher conditions. Two immersion studies, one dry and the other with 500 mL of water within the suit, were conducted in wind and waves to measure the change in suit insulation. In both studies, wind and waves resulted in a significantly lower immersed insulation value compared to calm water. The minimum required thermal insulation for maintaining heat balance can be calculated for a given mean skin temperature, metabolic heat production, and water temperature. Combining the physiological limits of sustainable cold water immersion and actual suit insulation, correction factors can be deduced for harsh conditions compared to calm. The minimum in-situ suit insulation to maintain thermal balance is $1.553 - 0.0624 \cdot TW + 0.00018 \cdot TW^2$ for a dry calm condition. Multiplicative correction factors to the above equation are 1.37, 1.25, and 1.72 for wind + waves, 500 mL suit wetness, and both combined, respectively. Calm water certification tests of suit insulation should meet or exceed the minimum in-situ requirements to maintain thermal balance, and correction factors should be applied for a more realistic determination of minimum insulation for harsh conditions.

- **Keywords:** Immersion suits; Hypothermia; Correction factors

Zanyar Karimi, Teimour Allahyari, Mahmood Reza Azghani, Hamidreza Khalkhali. *Influence of unstable footwear on lower leg muscle activity, volume change and subjective discomfort during prolonged standing.* Pages 95-102.

Purpose: The present study was an attempt to investigate the effect of unstable footwear on lower leg muscle activity, volume change and subjective discomfort during prolonged standing. **Methods:** Ten healthy subjects were recruited to stand for 2 h in three footwear conditions: barefoot, flat-bottomed shoe and unstable shoe. During standing, lower leg discomfort and EMG activity of medial gastrocnemius (MG) and tibialis anterior (TA) muscles were continuously monitored. Changes in lower leg volume over standing time also were measured. **Results:** Lower leg discomfort rating reduced significantly while subjects standing on unstable shoe compared to the flat-bottomed shoe and barefoot condition. For lower leg volume, less changes also were observed with unstable shoe. The activity level and variation of right MG muscle was greater with unstable shoe compared to the other footwear conditions; however regarding the left MG muscle, significant difference was found between unstable shoe and flat-bottomed shoe only for activity level. Furthermore no significant differences were observed for the

activity level and variation of TA muscles (right/left) among all footwear conditions. **Conclusions:** The findings suggested that prolonged standing with unstable footwear produces changes in lower leg muscles activity and leads to less volume changes. Perceived discomfort also was lower for this type of footwear and this might mean that unstable footwear can be used as ergonomic solution for employees whose work requires prolonged standing.

- **Keywords:** Unstable footwear; Discomfort; Prolonged standing; Muscle activity; Leg volume

Mark C. Schall Jr., Nathan B. Fethke, Howard Chen. *Evaluation of four sensor locations for physical activity assessment.* Pages 103-109.

Direct measurements of physical activity (PA) obtained with inertial measurement units (IMUs) secured to the upper arms and trunk of 36 registered nurses working a full shift were compared to measurements obtained with a commercially-available PA monitor (ActiGraph wGT3X-BT) worn at the waist. Raw accelerations from each device were summarized into PA counts/min and metabolic equivalent (METs) categories using standard definitions. Differences between measurements were examined using repeated measures one-way analyses of variance (ANOVA) and agreement was assessed using Bland-Altman plots. Statistically significant differences were observed between all sensor locations for all PA summary metrics except for between the left and right arm for percentages of work time in the light and moderate counts/min categories. Bland-Altman plots suggested limited agreement between measurements obtained with the IMUs and measurements obtained with the wGT3X-BT waist-worn PA monitor. Results indicate that PA measurements vary substantially based on sensor location.

- **Keywords:** Musculoskeletal disorders; Posture; Physical activity; Accelerometer; Low back; Shoulder

A.L.R. Santos, L.S.G.L. Wauben, S. Guilavogui, J.C. Brezet, R. Goossens, P.M.J. Rosseel. *Safety challenges of medical equipment in nurse anaesthetist training in Haiti.* Pages 110-121.

Safety challenges related to the use of medical equipment were investigated during the training of nurse anaesthetists in Haiti, using a systems approach to Human Factors and Ergonomics (HFE). The Observable Performance Obstacles tool, based on the Systems Engineering Initiative for Patient Safety (SEIPS) model, was used in combination with exploratory observations during 13 surgical procedures, to identify performance obstacles created by the systemic interrelationships of medical equipment. The identification of performance obstacles is an effective way to study the accumulation of latent factors and risk hazards, and understand its implications in practice and behaviour of healthcare practitioners. In total, 123 performance obstacles were identified, of which the majority was related to environmental and organizational aspects. These findings show how the performance of nurse anaesthetists and their relation to medical equipment is continuously affected by more than user-related aspects. The contribution of systemic performance obstacles and coping strategies to enrich system design interventions and improve healthcare system is highlighted. In addition, methodological challenges of HFE research in low-resource settings related to professional culture and habits, and the potential of community ergonomics as a problem-managing approach are described.

- **Keywords:** Human factors and ergonomics; Medical equipment; Low-income countries

Fanxing Meng, Shuling Li, Lingzhi Cao, Qijia Peng, Musen Li, Chunhui Wang, Wei Zhang. *Designing Fatigue Warning Systems: The perspective of professional drivers*. Pages 122-130.

Professional drivers have been characterized as experiencing heavy fatigue resulting from long driving time in their daily work. This study aimed to explore the potential demand of Fatigue Warning Systems (FWSs) among professional drivers as a means of reducing the danger of fatigue driving and to examine their opinions regarding the design of FWSs. Six focus groups with 35 participants and a questionnaire survey with 600 respondents were conducted among Chinese truck and taxi drivers to collect qualitative and quantitative data concerning the current situation of fatigue driving and opinions regarding the design of FWSs. The results revealed that both truck and taxi drivers had a positive attitude toward FWSs, and they hoped this system could not only monitor and warn them regarding their fatigue but also somewhat relieve their fatigue before they could stop and rest. As for warning signals, participants preferred auditory warnings, as opposed to visual, vibrotactile or electric stimuli. Interestingly, it was proposed that verbal warnings involving the information regarding consequences of fatigue driving or the wishes of drivers' family members would be more effective. Additionally, different warning patterns, including graded, single and continuous warnings, were discussed in the focus group. Finally, the participants proposed many other suggestions, as well as their concerns regarding FWSs, which will provide valuable information for companies who wish to develop FWSs for professional drivers.

- **Keywords:** In-vehicle technology; Truck drivers; Taxi drivers; Focus group; Warning signal

I. Gonzalez, P. Morer. *Ergonomics for the inclusion of older workers in the knowledge workforce and a guidance tool for designers*. Pages 131-142.

The ageing of the population and the inverted population pyramid is bringing important changes to society as a whole. These changes are associated with the inclusion of an older workforce in knowledge work and the challenge they represent in adapting the work environment accordingly. In order to approach a more universal design of the work environment, industrial designers need support from user-sensitive inclusive design studies. While there are plenty of guidelines and tools containing relevant information, there is a need to develop more appropriate tools for Industrial Designers that cover the initial phase of the design process. This study provides a review of the available tools and guidelines and proposes a theoretical framework intended for developing a design guidance tool for inclusive workstation design.

- **Keywords:** Inclusivity; Older workers; Knowledge work

I. Balogh, K. Ohlsson, C. Nordander, J. Björk, G.-Å. Hansson. *The importance of work organization on workload and musculoskeletal health – Grocery store work as a model*. Pages 143-151.

We have evaluated the consequences of work organization on musculoskeletal health. Using a postal questionnaire, answered by 1600 female grocery store workers, their main work tasks were identified and four work groups were defined (cashier, picking, and delicatessen work, and a mixed group, who performed a mix of these tasks). The crude odds ratios (ORs) for neck/shoulder complaints were 1.5 (95% CI 1.0–2.2), 1.1 (0.7–1.5) and 1.6 (1.1–2.3), respectively, compared to mixed work. Adjusting for individual and psychosocial factors had no effect on these ORs. For elbows/hands, no significant differences were found. Technical measurements of the workload showed large differences between the work groups. Picking work was the most strenuous, while cashier

work showed low loads. Quantitative measures of variation revealed for mixed work high between minutes variation and the highest between/within minutes variation. Combining work tasks with different physical exposure levels increases the variation and may reduce the risk of musculoskeletal complaints.

- **Keywords:** Variation; Physical exposure; Job rotation

Katherine Plewa, Jim R. Potvin, James P. Dickey. *Wrist rotations about one or two axes affect maximum wrist strength. Pages 152-160.*

Most wrist strength studies evaluate strength about one axis, and postural deviations about that same axis. The purpose of this study was to determine if wrist posture deviations about one axis (e.g. flexion/extension), or two axes (e.g. flexion/extension and pronation/supination), affect the strength about another axis (e.g. ulnar deviation). A custom-built instrumented handle was used to measure maximum static isometric torque exertions at 18 wrist postures (combinations of flexion/extension, radial/ulnar deviation, and pronation/supination). Ulnar deviation torques were highest when the wrist was in neutral. This pattern was not maintained for the other torque directions; the generated torque tended to be highest when the wrist posture was not neutral. The effects were similar for male and female subjects, although male subjects exerted significantly larger torques in all directions. This study illustrates that there is a complex relationship between wrist posture and maximal wrist torques.

- **Keywords:** Wrist strength; Wrist torque; Wrist motion

Andrew P. Claus, Julie A. Hides, G. Lorimer Moseley, Paul W. Hodges. *Thoracic and lumbar posture behaviour in sitting tasks and standing: Progressing the biomechanics from observations to measurements. Pages 161-168.*

Few studies quantify spinal posture behaviour at both the thoracolumbar and lumbar spinal regions. This study compared spontaneous spinal posture in 50 asymptomatic participants (21 males) during three conditions: 10-min computer task in sitting (participants naïve to the measure), during their perceived 'correct' sitting posture, and standing. Three-dimensional optical tracking quantified surface spinal angles at the thoracolumbar and lumbar regions, and spinal orientation with respect to the vertical. Despite popular belief that lordotic lumbar angles are 'correct' for sitting, this was rarely adopted for 10-min sitting. In 10-min sitting, spinal angles flexed 24(7–9)deg at lumbar and 12(6–8)deg at thoracolumbar regions relative to standing ($P < 0.001$). When participants 'corrected' their sitting posture, their thoracolumbar angle $-2(7)$ deg was similar to the angle in standing $-1(6)$ deg ($P = 1.00$). Males were flexed at the lumbar angle relative to females for 10-min sitting, 'correct' sitting and standing, but showed no difference at the thoracolumbar region.

- **Keywords:** Spine; Sitting; Posture

Martin Cherniack, Jeffrey Dussetschleger, Alicia Dugan, Dana Farr, Sara Namazi, Mazen El Ghaziri, Robert Henning. *Participatory action research in corrections: The HITEC 2 program. Pages 169-180.*

Background: HITEC 2 (Health Improvement through Employee Control 2) is the follow-up to HITEC, a participatory action research (PAR) program that integrates health and work conditions interventions designed by the workforce. HITEC 2 compares intervention programs between two correctional sites, one using a pure workforce level design team and the other using a more structured and time delineated labor-management kaizen effectiveness team. **Methods:** HITEC 2 utilizes a seven step participatory Intervention

Design and Analysis Scorecard (IDEAS) for planning interventions. Consistent with PAR, process and intervention efficacy measures are developed and administered through workforce representation. **Results:** Participation levels, robustness of participatory structures and sophistication of interventions have increased at each measured interval. Health comparisons between 2008 and 2013 showed increased hypertension, static weight maintenance, and increased 'readiness to change'. **Conclusions:** The PAR approaches are robust and sustained. Their long-term effectiveness in this population is not yet clear.

- **Keywords:** Participatory action research; IDEAS; Worksite health promotion

Ivan Bolis, Laerte I. Sznalwar. *A case study of the implementation of an ergonomics improvement committee in a Brazilian hospital – Challenges and benefits.* Pages 181-189:

This article discusses the creation of an improvement committee (IC) to implement policies aimed at improving working conditions in a public health institution in the city of São Paulo. Suggestions were proposed for future implementations of this organizational mechanism, pursuant to the presentation of the process of its formation and the main results achieved. The findings led to the conclusion that good outcomes require autonomy and support from management, and the adoption of effective measures to improve and legitimize the improvement committee's existence. Another important issue is facilitating worker involvement and creating a locus for dialog among people with different visions within the organization. Thus, two approaches converge: a top-down approach in which policies are defined and improvement actions are actually implemented based on a general outlook of the production and work system, and a bottom-up approach specific to employees who are also engaged in improvement policies and in putting them into practice. It is also possible to point out problems and opportunities arising from actual work situations to the higher levels of management. This kind of approach fits with macroergonomics, because it integrates strategy, organization and work issues. It is possible to discuss the benefits of this approach for companies and provide conditions for workers to engage effectively in these processes. In conclusion, these proposals can be considered from an emancipatory perspective, given that different actors should be able to codetermine working conditions and work content, thus directly influencing their individual and collective experiences. The support and commitment of upper management are essential elements of success in maximizing the effectiveness of this organizational approach.

- **Keywords:** Macroergonomics; Improvement committees; Work organization

James Steele, Stewart Bruce-Low, Dave Smith, David Jessop, Neil Osborne. *Determining the reliability of a custom built seated stadiometry set-up for measuring spinal height in participants with chronic low back pain.* Pages 203-208.

Indirect measurement of disc hydration can be obtained through measures of spinal height using stadiometry. However, specialised stadiometers for this are often custom-built and expensive. Generic wall-mounted stadiometers alternatively are common in clinics and laboratories. This study examined the reliability of a custom set-up utilising a wall-mounted stadiometer for measurement of spinal height using custom built wall mounted postural rods. Twelve participants with non-specific chronic low back pain (CLBP; females n = 5, males n = 7) underwent measurement of spinal height on three separate consecutive days at the same time of day where 10 measurements were taken at 20 s intervals. Comparisons were made using repeated measures analysis of variance for 'trial' and 'gender'. There were no significant effects by trial or interaction effects of trial x gender. Intra-individual absolute standard error of measurement (SEM) was

calculated for spinal height using the first of the 10 measures, the average of 10 measures, the total shrinkage, and the rate of shrinkage across the 10 measures examined as the slope of the curve when a linear regression was fitted. SEMs were 3.1 mm, 2.8 mm, 2.6 mm and 0.212, respectively. Absence of significant differences between trials and the reported SEMs suggests this custom set-up for measuring spinal height changes is suitable use as an outcome measure in either research or clinical practice in participants with CLBP.

- **Keywords:** Disc hydration; Spinal height; Stadiometer; Shrinkage

Gemma J.M. Read, Paul M. Salmon, Michael G. Lenné, Neville A. Stanton. *Walking the line: Understanding pedestrian behaviour and risk at rail level crossings with cognitive work analysis. Pages 209-227.*

Pedestrian fatalities at rail level crossings (RLXs) are a public safety concern for governments worldwide. There is little literature examining pedestrian behaviour at RLXs and no previous studies have adopted a formative approach to understanding behaviour in this context. In this article, cognitive work analysis is applied to understand the constraints that shape pedestrian behaviour at RLXs in Melbourne, Australia. The five phases of cognitive work analysis were developed using data gathered via document analysis, behavioural observation, walk-throughs and critical decision method interviews. The analysis demonstrates the complex nature of pedestrian decision making at RLXs and the findings are synthesised to provide a model illustrating the influences on pedestrian decision making in this context (i.e. time, effort and social pressures). Further, the CWA outputs are used to inform an analysis of the risks to safety associated with pedestrian behaviour at RLXs and the identification of potential interventions to reduce risk.

- **Keywords:** Rail level crossings; Pedestrians; Cognitive work analysis; Constraints; Systems approach; Risk

Jun-Ming Lu, Mitsunori Tada, Yui Endo, Masaaki Mochimaru. *Ingress and egress motion strategies of elderly and young passengers for the rear seat of minivans with sliding doors. Pages 228-240.*

This study investigates the motion strategies performed by elderly and young passengers while entering and exiting the rear seat of minivans with sliding doors. A minivan mock-up was constructed with four adjustable parameters to represent nine different conditions of vehicle geometry. Ten elderly male participants (66.8 ± 3.8 years old) and ten young male participants (31.5 ± 6.6 years old) were recruited. Each of them entered and exited the minivan mock-up for five times under each condition, and the motion data were acquired by the optical motion capture system. Based on the criteria derived from previous studies, all motions were automatically categorized into seven ingress motion strategies and seven egress motion strategies. Further, the differences among motion strategies are discussed in terms of vehicle factors and passenger factors, which provide clues for future studies.

- **Keywords:** Ingress; Egress; Motion strategies; Passengers; Minivans

Alain Chavaillaz, David Wastell, Jürgen Sauer. *Effects of extended lay-off periods on performance and operator trust under adaptable automation. Pages 241-251.*

Little is known about the long-term effects of system reliability when operators do not use a system during an extended lay-off period. To examine threats to skill maintenance, 28 participants operated twice a simulation of a complex process control system for 2.5 h, with an 8-month retention interval between sessions. Operators were provided

with an adaptable support system, which operated at one of the following reliability levels: 60%, 80% or 100%. Results showed that performance, workload, and trust remained stable at the second testing session, but operators lost self-confidence in their system management abilities. Finally, the effects of system reliability observed at the first testing session were largely found again at the second session. The findings overall suggest that adaptable automation may be a promising means to support operators in maintaining their performance at the second testing session.

- **Keywords:** Lay-off period; Skill retention; System reliability; Adaptable automation; Trust

Ismail Maakip, Tessa Keegel, Jodi Oakman. *Prevalence and predictors for musculoskeletal discomfort in Malaysian office workers: Investigating explanatory factors for a developing country.* Pages 252-257.

Musculoskeletal disorders (MSDs) are a major occupational health issue for workers in developed and developing countries, including Malaysia. Most research related to MSDs has been undertaken in developed countries; given the different regulatory and cultural practices it is plausible that contributions of hazard and risk factors may be different. A population of Malaysian public service office workers were surveyed (N = 417, 65.5% response rate) to determine prevalence and associated predictors of MSD discomfort. The 6-month period prevalence of MSD discomfort was 92.8% (95%CI = 90.2–95.2%). Akaike's Information Criterion (AIC) analyses was used to compare a range of models and determine a model of best fit. Contributions associated with MSD discomfort in the final model consisted of physical demands (61%), workload (14%), gender (13%), work-home balance (9%) and psychosocial factors (3%). Factors associated with MSD discomfort were similar in developed and developing countries but the relative contribution of factors was different, providing insight into future development of risk management strategies.

- **Keywords:** Musculoskeletal disorders; Risk; Discomfort; Office workers; Prevalence rate

Simon Y.W. Li, Anna L. Cox, Calvin Or, Ann Blandford. *Effects of monetary reward and punishment on information checking behaviour.* Pages 258-266.

Two experiments were conducted to examine whether checking one's own work can be motivated by monetary reward and punishment. Participants were randomly assigned to one of three conditions: a flat-rate payment for completing the task (Control); payment increased for error-free performance (Reward); payment decreased for error performance (Punishment). Experiment 1 (N = 90) was conducted with liberal arts students, using a general data-entry task. Experiment 2 (N = 90) replicated Experiment 1 with clinical students and a safety-critical 'cover story' for the task. In both studies, Reward and Punishment resulted in significantly fewer errors, more frequent and longer checking, than Control. No such differences were obtained between the Reward and Punishment conditions. It is concluded that error consequences in terms of monetary reward and punishment can result in more accurate task performance and more rigorous checking behaviour than errors without consequences. However, whether punishment is more effective than reward, or vice versa, remains inconclusive.

- **Keywords:** Error; Reward; Punishment

Stephen Summerskill, Russell Marshall, Sharon Cook, James Lenard, John Richardson. *The use of volumetric projections in Digital Human*

Modelling software for the identification of Large Goods Vehicle blind spots. Pages 267-280.

The aim of the study is to understand the nature of blind spots in the vision of drivers of Large Goods Vehicles caused by vehicle design variables such as the driver eye height, and mirror designs. The study was informed by the processing of UK national accident data using cluster analysis to establish if vehicle blind spots contribute to accidents. In order to establish the cause and nature of blind spots six top selling trucks in the UK, with a range of sizes were digitized and imported into the SAMMIE Digital Human Modelling (DHM) system. A novel CAD based vision projection technique, which has been validated in a laboratory study, allowed multiple mirror and window aperture projections to be created, resulting in the identification and quantification of a key blind spot. The identified blind spot was demonstrated to have the potential to be associated with the scenarios that were identified in the accident data. The project led to the revision of UNECE Regulation 46 that defines mirror coverage in the European Union, with new vehicle registrations in Europe being required to meet the amended standard after June of 2015.

- **Keywords:** Digital human modelling; Trucks; Vehicles; Blind spot; Class V mirror; Heavy goods vehicle; Vulnerable road user; Field of vision; Vehicle ergonomics; Accident data; Cluster analysis

Denny Yu, Cooper Green, Steven J. Kasten, Michael E. Sackllah, Thomas J. Armstrong. Effect of alternative video displays on postures, perceived effort, and performance during microsurgery skill tasks. Pages 281-289.

Physical work demands and posture constraint from operating microscopes may adversely affect microsurgeon health and performance. Alternative video displays were developed to reduce posture constraints. Their effects on postures, perceived efforts, and performance were compared with the microscope. Sixteen participants performed microsurgery skill tasks using both stereo and non-stereoscopic microscopes and video displays. Results showed that neck angles were 9–13° more neutral and shoulder flexion were 9–10° more elevated on the video display than the microscope. Time observed in neck extension was higher (30% vs. 17%) and neck movements were 3x more frequent on the video display than microscopes. Ratings of perceived efforts did not differ among displays, but usability ratings were better on the microscope than the video display. Performance times on the video displays were 66–110% slower than microscopes. Although postures improved, further research is needed to improve task performance on video displays.

- **Keywords:** Microsurgery displays; Posture patterns; Biomechanics

C. Gaudes, M.A. Gilles, J. Savin. Intrinsic movement variability at work. How long is the path from motor control to design engineering? Pages 71-78.

For several years, increasing numbers of studies have highlighted the existence of movement variability. Before that, it was neglected in movement analysis and it is still almost completely ignored in workstation design. This article reviews motor control theories and factors influencing movement execution, and indicates how intrinsic movement variability is part of task completion. These background clarifications should help ergonomists and workstation designers to gain a better understanding of these concepts, which can then be used to improve design tools. We also question which techniques - kinematics, kinetics or muscular activity - and descriptors are most appropriate for describing intrinsic movement variability and for integration into design tools. By this way, simulations generated by designers for workstation design should be

closer to the real movements performed by workers. This review emphasises the complexity of identifying, describing and processing intrinsic movement variability in occupational activities.

- **Keywords:** Intrinsic movement variability; Motor control; Workstation design

Marialena Vagia, Aksel A. Transeth, Sigurd A. Fjerdings. *A literature review on the levels of automation during the years. What are the different taxonomies that have been proposed?* Pages 190-202.

In this paper we present a literature review of the evolution of the levels of autonomy from the end of the 1950s up until now. The motivation of this study was primarily to gather and to compare the literature that exists, on taxonomies on levels of automation. Technical developments within both computer hardware and software have made it possible to introduce autonomy into virtually all aspects of human-machine systems. The current study, is focusing on how different authors treat the problem of different levels of automation. The outcome of this study is to present the differences between the proposed levels of automation and the various taxonomies, giving the potential users a number of choices in order to decide which taxonomy satisfies their needs better. In addition, this paper surveys deals with the term adaptive automation, which seems to be a new trend in the literature on autonomy.

- **Keywords:** Levels of autonomy; Autonomy/automation; Taxonomies; Adaptive automation