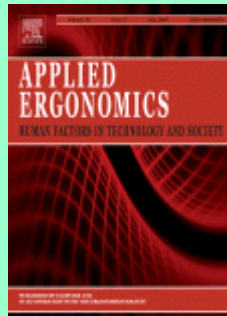


## **Applied Ergonomics - rok 2014, ročník 45**

### **Číslo 4 (July 2014)**



#### **Cheng-Lung Lee, Chih-Yung Chen, Peng-Cheng Sung, Shih-Yi Lu. *Assessment of a simple obstacle detection device for the visually impaired.***

A simple obstacle detection device, based upon an automobile parking sensor, was assessed as a mobility aid for the visually impaired. A questionnaire survey for mobility needs was performed at the start of this study. After the detector was developed, five blindfolded sighted and 15 visually impaired participants were invited to conduct travel experiments under three test conditions: (1) using a white cane only, (2) using the obstacle detector only and (3) using both devices. A post-experiment interview regarding the usefulness of the obstacle detector for the visually impaired participants was performed. The results showed that the obstacle detector could augment mobility performance with the white cane. The obstacle detection device should be used in conjunction with the white cane to achieve the best mobility speed and body protection.

- **Keywords:** Visually impaired; Obstacle detection; Travel aid

#### **Fong-Gong Wu, Yu-Chun Huang, Meng-Long Wu. *New chording text entry methods combining physical and virtual buttons on a mobile phone.***

Traditional mobile phones depend on MultiTap, virtual or physical QWERTY keyboard for text entry, and they had some respective drawbacks include low input performance, occupying too large an area, high error rates, lack of feedbacks, etc. Therefore, some researches utilized the characteristics of the chording keyboard to improve input performance. Yet, as the learning efficiency of the chording keyboard is too low, users are not highly willing to learn. In view of that, this study combines the physical and virtual keys, and develops two chording input methods, MagArea and MemoryTap. After three days of learning, the fourteen experiment participants show effectively reduce error rates on MagArea, and they enhance their input speed on MemoryTap. In addition, excellent learning efficiency is found in the two methods, will be more motivated and willing to employ.

- **Keywords:** Text entry; Chording keyboard; Mobile phones

#### **Gregory P. Slota, Leah R. Enders, Na Jin Seo. *Improvement of hand function using different surfaces and identification of difficult movement post stroke in the Box and Block Test.***

This study determined the impact of changing block surfaces on hand function, as well as identified particularly time-consuming movement components post stroke, measured by the Box and Block Test (BBT). Eight chronic stroke survivors and eight age- and gender-matched control subjects participated in this study. The BBT score (number of blocks moved) and time for seven movement components were compared for three different block surfaces (wood, paper, and rubber). The rubber blocks improved BBT scores 8% (compared to all other conditions) not only for control subjects but also for the paretic and non-paretic hands of stroke survivors, by reducing movement time for finger closing and contact-to-lift. Modifying daily objects' surfaces with rubber could help stroke survivors' hand function. The paretic hand displayed notably slower movement for contact-to-lift, transport-release, reach before barrier, and reach after barrier suggesting that therapies may focus on goal directed reaching and object grasping/releasing.

- **Keywords:** Grip; Stroke; BBT

**Tim A. Bentley, Bevan Catley, Darryl Forsyth, David Tappin.**  
*Understanding workplace violence : the value of a systems perspective.*

Workplace violence is a leading form of occupational injury and fatality, but has received little attention from the ergonomics research community. The paper reports findings from the 2012 New Zealand Workplace Violence Survey, and examines the workplace violence experience of 86 New Zealand organisations and the perceptions of occupational health and safety professionals from a systems perspective. Over 50% of respondents reported violence cases in their organisation, with perpetrators evenly split between co-workers and external sources such as patients. Highest reported levels of violence were observed for agriculture, forestry and construction sectors. Highest risk factor ratings were reported for interpersonal and organisational factors, notably interpersonal communication, time pressure and workloads, with lowest ratings for environmental factors. A range of violence prevention measures were reported, although most organisations relied on single control measures, suggesting unmanaged violence risks were common among the sample.

- **Keywords:** Workplace violence; Occupational health and safety professionals; Psychosocial risk

**Nathan Daniell, Simon Merrett, Gunther Paul.**  
*Effectiveness of powered hospital bed movers for reducing physiological strain and back muscle activation.*

Battery powered bed movers are becoming increasingly common within the hospital setting. The use of powered bed movers is believed to result in reduced physical efforts required by health care workers, which may be associated with a decreased risk of occupation related injuries. However, little work has been conducted assessing how powered bed movers impact on levels of physiological strain and muscle activation for the user. The muscular efforts associated with moving hospital beds using three different methods; powered StaminaLift Bed Mover (PBM1), powered Gzunda Bed Mover (PBM2) and manual pushing were measured on six male subjects. Fourteen muscles were assessed moving a weighted hospital bed along a standardized route in an Australian hospital environment. Trunk inclination and upper spine acceleration were also quantified. Powered bed movers exhibited significantly lower muscle activation levels than manual pushing for the majority of muscles. When using the PBM1, users adopted a more upright posture which was maintained while performing different tasks (e.g. turning a corner, entering a lift), while trunk inclination varied considerably for manual pushing and the PBM2. The reduction in lower back muscular activation levels may result in lower incidence of lower back injury.

- **Keywords:** Hospital bed mover; Occupational injury; Muscle strain

**Jamie McGaha, Kim Miller, Alexis Descatha, Laurie Welch, Bryan Buchholz, Bradley Evanoff, Ann Marie D ale. *Exploring physical exposures and identifying high-risk work tasks within the floor layer trade.***

Introduction: Floor layers have high rates of musculoskeletal disorders yet few studies have examined their work exposures. This study used observational methods to describe physical exposures within floor laying tasks. Methods: We analyzed 45 videos from 32 floor layers using Multimedia-Video Task Analysis software to determine the time in task, forces, postures, and repetitive hand movements for installation of four common flooring materials. We used the WISHA checklists to define exposure thresholds. Results: Most workers (91%) met the caution threshold for one or more exposures. Workers showed high exposures in multiple body parts with variability in exposures across tasks and for different materials. Prolonged exposures were seen for kneeling, poor neck and low back postures, and intermittent but frequent hand grip forces. Conclusions: Floor layers experience prolonged awkward postures and high force physical exposures in multiple body parts, which probably contribute to their high rates of musculoskeletal disorders.

- **Keywords:** Musculoskeletal disorders; Observational assessment; Construction trades

**Hongyi Cai, Linjie Li. *The impact of display angles on the legibility of Sans-Serif 5 × 5 capitalized letters.***

This paper introduced a laboratory study on quantifying the impact of display angles 0.0°–90.0° on the legibility of Sans-Serif 5 × 5 Capitalized Letters C, D, E, F, H, K, N, P, R, U, V, and Z, commonly used for acuity tests. This study addressed three issues not tackled in the previous studies, including (a) extremely large incident angles 82.8°–90°, (b) multiple letters other than a single letter E previously used, and (c) the interference of people's normal reading habit on legibility evaluation. A total of 20 young college students with Snellen acuity 20/20 or better and normal color vision participated in this experiment. They were asked to read viewing materials presented at 15 display angles. This study derived two equations and modified an existing legibility index to correct the interference of people's normal reading habit on legibility evaluation at extreme oblique display angles.

- **Keywords:** Legibility; Display angle; Normal reading habit

**Seunghae Lee, Sibel Seda Dazkir, Hae Sun Paik, Aykut Coskun. *Comprehensibility of universal healthcare symbols for wayfinding in healthcare facilities.***

Healthcare facilities are often complex and overwhelming for visitors, and wayfinding in healthcare facilities can be challenging. As there is an increasing number of global citizens who travel to seek medical care in another country, it is critical to make wayfinding easy for visitors who are not familiar with the language in a foreign country. Among many wayfinding aids, symbols are helpful for those visitors who have limited ability to understand written language. This study tested universal healthcare symbols in the United States, South Korea, and Turkey to compare the comprehension of symbols cross-country and identify predictors of the correct comprehension. To explore statistically significant relationships between symbol comprehension and countries, Pearson's Chi-square tests, logistic regression, and ANOVA were conducted. The test results showed that ten symbols among 14 tested have significant relationship with countries. Results of this study demonstrate that symbol comprehension can be varied significantly in different countries.

- **Keywords:** Symbol comprehension; Universal healthcare symbol; Wayfinding

**Joy Goodman-Deane, James Ward, Ian Hosking, P. John Clarkson. *A comparison of methods currently used in inclusive design.***

Inclusive design has unique challenges because it aims to improve usability for a wide range of users. This typically includes people with lower levels of ability, as well as mainstream users. This paper examines the effectiveness of two methods that are used in inclusive design: user trials and exclusion calculations (an inclusive design inspection method). A study examined three autoinjectors using both methods (n=30 for the user trials). The usability issues identified by each method are compared and the effectiveness of the methods is discussed. The study found that each method identified different kinds of issues, all of which are important for inclusive design. We therefore conclude that a combination of methods should be used in inclusive design rather than relying on a single method. Recommendations are also given for how the individual methods can be used more effectively in this context.

- **Keywords:** Inclusive design; Methods; Exclusion

**J r me Prairie, Philippe Corbeil. *Paramedics on the job : dynamic trunk motion assessment at the workplace.***

Many paramedics' work accidents are related to physical aspects of the job, and the most affected body part is the low back. This study documents the trunk motion exposure of paramedics on the job. Nine paramedics were observed over 12 shifts (120h). Trunk postures were recorded with the computer-assisted CUELA measurement system worn on the back like a knapsack. Average duration of an emergency call was 23.5min. Sagittal trunk flexion of  $\geq 40^\circ$  and twisting rotation of  $\geq 24^\circ$  were observed in 21% and 17% of time-sampled postures. Medical care on the scene (44% of total time) involved prolonged flexed and twisted postures (-10s). The highest extreme sagittal trunk flexion ( $63^\circ$ ) and twisting rotation ( $40^\circ$ ) were observed during lifting activities, which lasted 2% of the total time. Paramedics adopted trunk motions that may significantly increase the risk of low back disorders during medical care and patient-handling activities.

- **Keywords:** Three-dimensional trunk motion; Emergency medical service; Musculoskeletal disorder

**Chia-Fen Chi, Ratna Sari Dewi. *Matching performance of vehicle icons in graphical and textual formats.***

The current research classified 82 vehicle icons into seven categories (image-related, concept-related, semi-abstract, arbitrary, abbreviation, word, and combined) for their matching accuracy, matching sequence, and matching time. These data can be compared and used as a framework for future icon development. Forty participants, all with a university degree, took part in this experiment. Half of the participants had intensive driving experience, while the other half never driven a car. The results indicated that on average, word icons had a significantly greater matching accuracy than the other icon formats; ranging from 4.7 to 20.8% difference. Regarding the matching sequence, participants matched image-related icons before other icon formats. Arbitrary and combined icons took significantly longer to match than other icon formats by 1.4–6.2 s. Based on the high matching accuracy (86.3%) and high ratings on subjective design features, word format can be used for functions describable using simple English for users with English reading ability. Confusion matrices showed that 63.2% of the misunderstandings were caused by similarity in format or function.

- **Keywords:** Image-related; Icon taxonomy; Confusion matrix

**Jenny T. Armand, Thomas S. Redick, Joan R. Poulsen. *Task-specific performance effects with different numeric keypad layouts.***

Two commonly used keypad arrangements are the telephone and calculator layouts. The purpose of this study was to determine if entering different types of numeric information was quicker and more accurate with the telephone or the calculator layout on a computer keyboard numeric keypad. Fifty-seven participants saw a 10-digit numeric stimulus to type with a computer number keypad as quickly and as accurately as possible. Stimuli were presented in either a numerical [1,234,567,890] or phone [(123) 456-7890] format. The results indicated that participants' memory of the layout for the arrangement of keys on a telephone was significantly better than the layout of a calculator. In addition, the results showed that participants were more accurate when entering stimuli using the calculator keypad layout. Critically, participants' response times showed an interaction of stimulus format and keypad layout: participants were specifically slowed when entering numeric stimuli using a telephone keypad layout. Responses made using the middle row of keys were faster and more accurate than responses using the top and bottom row of keys. Implications for keypad design and cell phone usage are discussed.

- **Keywords:** Numeric keypads; Task-specific performance; Interference

**L.B. de M. Guimarães, J.L.D. Ribeiro, J.S. Renner, P.A.B. de Oliveira. *Worker evaluation of a macroergonomic intervention in a Brazilian footwear company.***

This article presents a macroergonomic intervention in a Brazilian footwear company and its evaluation by the workers. Using participatory ergonomics, the traditional Taylor/Ford production system was transformed into a socio-technical one and tested by 100 volunteers working during 3.5 years in a pilot production line. Multiskilling and teamwork were the major changes promoted to enlarge and enrich work and make it more flexible. The workers' evaluation pre- and post-intervention showed an increase in overall satisfaction with the work and more commitment to the results and company targets. Statement of relevance: This study showed that problems and solutions can be identified through participatory ergonomics, that it is easier to involve workers than the managerial staff, and that a macroergonomic intervention, mainly focusing on work organization, led to positive personnel, health and production outcomes, despite management's resistance to changes.

- **Keywords:** Participatory ergonomics; Footwear industry; Workers point of view

**Tae Hoon Kim, Jay P. Mehta, Monica R. Weiler, Steven A. Lavender. *The effects of transfer distance on spine kinematics when placing boxes at different heights.***

Twisting and lateral bending motions in repetitive lifting tasks are associated with occupational low back injuries and can be challenging to reduce with engineering controls. This study tested the hypothesis that twisting and lateral bending can be reduced by changing the transfer distance. Eighteen males, with no material handling experience lifted 10.9 kg boxes from 0.9 m above the floor and placed the boxes at a destination located 0.50, 0.75, 1.00, 1.25, 1.50, or 1.75 m away and at heights of 0.5 m, 0.9 m, and 1.3 m above the floor. Overall, twisting and forward bending decreased with increased transfer distance when placing the box. Conversely, the lateral bending when lifting and placing the box increased with increasing transfer distance. In short, having a transfer distance between 1 and 1.25 m when performing palletizing tasks to different heights may optimally balance spine kinematics, back injury risk, and productivity measures.

- **Keywords:** Lifting; Back injury; Musculoskeletal disorders

**Gregor Harih, Bojan Dolšak. *Comparison of subjective comfort ratings between anatomically shaped and cylindrical handles.***

Most authors have provided diameter recommendations for cylindrical handle design in order to increase performance, avoid discomfort, and reduce the risk of cumulative trauma disorders. None of the studies has investigated the importance of determining the correct handle shape on the subjective comfort ratings, which could further improve the handles' ergonomics. Therefore, new methods based on a virtual hand model in its optimal power grasp posture have been developed in order to obtain customised handles with best fits for targeted subjects. Cylindrical and anatomically shaped handles were evaluated covering ten subjects by means of an extensive subjective comfort questionnaire. The results suggest large impact of the handle shape on the perceived subjective comfort ratings. Anatomically shaped handles were rated as being considerably more comfortable than cylindrical handles for almost all the subjective comfort predictors. They showed that handle shapes based on optimal power grasp postures can improve subjective comfort ratings, thus maximising performance. Future research should consider real conditions, since the comfort ratings can vary based on the specific task and by the tool selected for the task.

- **Keywords:** Tool handle; Handle shape; Comfort rating

**Latif Al-Hakim, Tanaphon Maiping, Nick Sevdalis. *Applying hierarchical task analysis to improving the patient positioning for direct lateral interbody fusion in spinal surgery.***

The present study brings together for the first time the techniques of hierarchical task analysis (HTA), human error identification (HEI), and business process management (BPM) to select practices that can eliminate or reduce potential errors in a surgical setting. We applied the above approaches to the improvement of the patient positioning process for lumbar spine surgery referred to as 'direct lateral interbody fusion' (DLIF). Observations were conducted to gain knowledge on current DLIF positioning practices, and an HTA was constructed. Potential errors associated with the practices specific to DLIF patient positioning were identified. Based on literature review and expert views alternative practices are proposed aimed at improving the DLIF patient positioning process. To our knowledge, this is the first attempt to use BPM in association with HEI/HTA for the purpose of improving the performance and safety of a surgical process – with promising results.

- **Keywords:** Business process management; Hierarchical task analysis; Human error identification

**L.S. Fruhen, K.J. Mearns, R. Flin, B. Kirwan. *Safety intelligence : an exploration of senior managers' characteristics.***

Senior managers can have a strong influence on organisational safety. But little is known about which of their personal attributes support their impact on safety. In this paper, we introduce the concept of 'safety intelligence' as related to senior managers' ability to develop and enact safety policies and explore possible characteristics related to it in two studies. Study 1 (N = 76) involved direct reports to chief executive officers (CEOs) of European air traffic management (ATM) organisations, who completed a short questionnaire asking about characteristics and behaviours that are ideal for a CEO's influence on safety. Study 2 involved senior ATM managers (N = 9) in various positions in interviews concerning their day-to-day work on safety. Both studies indicated six attributes of senior managers as relevant for their safety intelligence, particularly, social competence and safety knowledge, followed by motivation, problem-solving, personality

and interpersonal leadership skills. These results have recently been applied in guidance for safety management practices in a White Paper published by EUROCONTROL.

- **Keywords:** Organisational safety; Strategic management; Air traffic management

**Jose Antonio Diego-Mas, Jorge Alcaide-Marzal. *Using Kinect™ sensor in observational methods for assessing postures at work.***

This paper examines the potential use of Kinect™ range sensor in observational methods for assessing postural loads. Range sensors can detect the position of the joints at high sampling rates without attaching sensors or markers directly to the subject under study. First, a computerized OWAS ergonomic assessment system was implemented to permit the data acquisition from Kinect™ and data processing in order to identify the risk level of each recorded postures. Output data were compared with the results provided by human observers, and were used to determine the influence of the sensor view angle relative to the worker. The tests show high inter-method agreement in the classification of risk categories (Proportion agreement index = 0.89  $\kappa$  = 0.83) when the tracked subject is facing the sensor. The camera's point of view relative to the position of the tracked subject significantly affects the correct classification of the postures. Although the results are promising, some aspects involved in the use of low-cost range sensors should be further studied for their use in real environments.

- **Keywords:** Kinect; OWAS; Ergonomics

**Mirjam Radstaak, Sabine A.E. Geurts, Debby G.J. Beckers, Jos F. Brosschot, Michiel A.J. Kompier. *Recovery and well-being among Helicopter Emergency Medical Service (HEMS) pilots.***

This study investigated the effects of a compressed working week with high cognitive and emotional work demands within the population of Dutch Helicopter Emergency Medical Service (HEMS) pilots. Work stressors were measured and levels of well-being were examined before, during and after a series of day and night shifts. Results revealed that (i) the start of a series of day shifts was more taxing for well-being than the start of a series of night shifts, (ii) there were no differences in the decrease in well-being during day and night shifts, (iii) distress during shifts was more strongly related to a decrease in well-being during night than during day shifts and (iv) it took HEMS pilots more time to recover from a series of night shifts than from a series of day shifts. It is concluded that HEMS pilots should not start earlier during day shifts, nor have longer series of night shifts.

- **Keywords:** Shift work; Distress; Circadian rhythm

**Staffan Davidsson, Håkan Alm. *Context adaptable driver information : or, what do whom need and want when?***

This study deals with a first step towards context adaptive functionality of a Driver Information System. Driving a car is a complex task for which the driver needs appropriate information to fulfil his or her goals. New technologies enable adaptability to driver state, task, personality etcetera and also to the context. The aim of this study was therefore to investigate what information people perceive that they need and want from the car in different contexts and to what extent there is consensus about the function. A new methodology was developed, and 33 private car drivers were interviewed and asked to rate a number of possible abstract functions in a car in different contexts. It was shown that people need and want different types of information in different contexts. It was furthermore indicated that there is sometimes a difference in drivers' opinions about what should be presented by the car and that there is varying consensus over different functions in different contexts. The rating result was illustrated by an easily perceived

Context Function Matrix. The results may be used in the design of a context adaptive driver information system.

- **Keywords:** Adaptable; Driver information; Context

**Marc Arial, Damien Benoît, Pascal Wild.** *Exploring implicit preventive strategies in prehospital emergency workers : a novel approach for preventing back problems.*

Back problems are a major occupational health issue for prehospital emergency care professionals. The goals of this article are to: 1) provide descriptive data about the prevalence and the severity of lower back and upper back disorders in EMTs and paramedics; 2) identify some individual and collective strategies used by EMTs and paramedics to protect their health as they perform prehospital emergency missions; 3) assess the possible effectiveness of strategies in preventing back problems by exploring associations between the use of strategies and the presence and severity of symptoms. Material and methods: The method includes a questionnaire survey (sample n = 334; paramedics and emergency medical technicians) and ergonomics work practice analysis involving shadowing ambulance crews in 12 medical emergency services (over 400 h). Results: A majority of ambulance professionals had experienced back pain in the twelve-month period before the survey. Work practice analysis revealed strategies and tricks of the trade used by ambulance professionals to reduce the chances of back strain while working. Multiple regression analyses showed that self-reported use of such strategies was associated with fewer back symptoms. Conclusions: Preventive strategies should be integrated into specialised training programs for prehospital medical emergency professionals. This approach could also be used in other work settings.

- **Keywords:** Back pain; Emergency care; Prevention

**Romain Pannetier, Xuguang Wang.** *A comparison of clutching movements of freely adjusted and imposed pedal configurations for identifying discomfort assessment criteria.*

This paper focuses on the effects of the free pedal position adjustment on clutching movements of the left lower limb as well as on the perceived discomfort. Six automotive clutch pedal configurations were tested by 20 subjects (5 young females, 5 young males, 5 older females, 5 older males) using a multi-adjustable experimental mock-up. Results showed that the pedal position was adjusted to ensure a good starting pedal position allowing a less flexed ankle and avoiding unnecessary leg displacement from the foot rest to the position at start depression. Pedal position adjustment seemed not motivated by reducing joint torque though discomfort ratings were found significantly correlated with knee and ankle torques at the end of depression. The present work also illustrates that the less-constrained motion concept is helpful for a better understanding of people preference and useful for identifying motion-related biomechanical parameters to be considered for defining assessment criteria.

- **Keywords:** Discomfort; Biomechanics; Clutch pedal

**Su-Young Son, Ilham Bakri, Satoshi Muraki, Yutaka Tochihiro.** *Comparison of firefighters and non-firefighters and the test methods used regarding the effects of personal protective equipment on individual mobility.*

The aims of this study were 1) to evaluate the current pilot test method and ascertain reliable measurements for a standard test method of mobility with personal protective equipment (PPE), such as physical performance and balance ability tests; 2) to compare



two participant groups (firefighters versus non-firefighters) and to investigate whether non-firefighters are appropriate as a standard participant group in the field of PPE or not. Totally, 18 participants (nine professional firefighters and nine untrained males) performed the current pilot test method consisting of a balance test, completed prior to and after a performance test. Significant differences were found between PPE conditions and CON (the control clothing ensemble: T-shirt, shorts, and running shoes) for the functional balance test, physical performance test, heart rate, and subjective evaluations in firefighters group. Therefore, the present pilot test method is valid as a standard test method for assessing mobility while wearing PPE. Moreover, the present result shows that firefighters are more reliable than non-firefighters in testing of PPE with current test methods.

- **Keywords:** Personal protective equipment; Test methods; Mobility

**Marcelo Peduzzi de Castro, Sofia Abreu, Viviana Pinto, Rubim Santos, Leandro Machado, Mario Vaz, João Paulo Vilas-Boas. *Influence of pressure-relief insoles developed for loaded gait (backpackers and obese people) on plantar pressure distribution and ground reaction forces.***

The aims of this study were to test the effects of two pressure relief insoles developed for backpackers and obese people on the ground reaction forces (GRF) and plantar pressure peaks during gait; and to compare the GRF and plantar pressures among normal-weight, backpackers, and obese participants. Based on GRF, plantar pressures, and finite element analysis two insoles were manufactured: flat cork-based insole with (i) corkgel in the rearfoot and forefoot (SLS1) and with (ii) poron foam in the great toe and lateral forefoot (SLS2). Gait data were recorded from 21 normal-weight/backpackers and 10 obese participants. The SLS1 did not influence the GRF, but it relieved the pressure peaks for both backpackers and obese participants. In SLS2 the load acceptance GRF peak was lower; however, it did not reduce the plantar pressure peaks. The GRF and plantar pressure gait pattern were different among the normal-weight, backpackers and obese participants.

- **Keywords:** Orthoses; Obesity; Walking

**Valeria De Giuli, Roberto Zecchin, Livio Corain, Luigi Salmaso. *Measured and perceived environmental comfort : field monitoring in an Italian school.***

Microclimatic conditions were recorded in an Italian school and Fanger's indexes PMV and PPD were calculated under different conditions. Students' sensations were investigated four times by means of two surveys, one related to actual microclimatic conditions and one on overall satisfaction, interaction occupant-building and reactions to discomfort. Pupils' classroom position was considered to look for possible influence on thermal comfort: a difference emerged from PMV and the survey, but the results obtained from the two approaches differ for both the entity of discomfort and its distribution within each classroom. Innovative multivariate nonparametric statistical techniques were applied to compare and rank the classrooms in accordance with students' subjective perceptions; a global ranking has been also calculated, considering thermal and visual comfort and air quality. Comparing pupil-sensation-based ranking with environmental parameters no clear correspondence was found, except for mid-season, where PMV, CO<sub>2</sub> concentration and desk illuminance were similar in all the classrooms.

- **Keywords:** Indoor environmental quality; School; Occupant satisfaction

**Gook-Sup Song. *Influence of indoor and outdoor temperatures on the fingertip blood flow rate.***

A total of 58 healthy subjects participated to elucidate the influence of indoor and outdoor temperatures on blood flow. After walking outdoors for 20 min, the blood flow rate of a subject was measured. The subject then entered a classroom and studied for 120 min, and afterwards, the blood flow rate was measured again. The subjects were exposed to outdoor temperature ranging from  $-2.5$  to  $33.7$  °C. During the summer, the average blood flow rate after walking outdoors was  $45.95 \pm 25.790$  TPU (tissue perfusion units); after the class, this decreased to  $36.14 \pm 21.837$  TPU ( $p < 0.05$ ). During the autumn, the blood flow rate decreased from  $27.69 \pm 12.334$  TPU to  $12.47 \pm 12.255$  TPU ( $p < 0.001$ ). When the outside air temperature was below  $3$  °C, the blood flow rate indoors increased significantly from  $6.74 \pm 3.540$  TPU to  $13.95 \pm 11.522$  TPU ( $p < 0.05$ ). In a comfortable and healthy environment, the blood flow rate was not constant but fluctuated between  $15$  TPU and  $40$  TPU.

- **Keywords:** Thermal comfort; Blood flow; Thermal adaptation behaviour

**Benoît Pierret, Kévin Desbrosses, Jean Paysant, Jean-Pierre Meyer.** *Cardio-respiratory and subjective strains sustained by paraplegic subjects, when travelling on a cross slope in a manual wheelchair (MWC).*

The aim of this study was to quantify cardiac, energetic and subjective strains during manual wheelchair (MWC) travel on cross slopes (Cs). 25 paraplegics achieved eight 300 m propulsion tests combining 4 Cs (0, 2, 8 and 12%) and 2 velocities ( $V_i = 0.97$  m s<sup>-1</sup>,  $V_c$  "comfortable"). Heart rate and oxygen uptake were recorded continuously. Subjective rating (RPE) was made on completion of each test.  $V_c$  exceeds  $V_i$  for all Cs. Cardiac and energetic strains at  $V_c$  also exceed those at  $V_i$  ( $p < 0.01$ ). Mean cardiac cost (in bpm) at  $V_c$  is 34 (SD = 13) bpm for a 0/2% Cs and 55 (18) bpm for a 12% Cs. Mean energetic cost (in J m<sup>-1</sup> kg<sup>-1</sup>) is 1.20 (0.38) and 2.76 (0.97) for respectively 0/2% and 12% Cs at  $V_i$  and, at  $V_c$  1.50 (0.43) and 3.37 (1.43) for 0/2% and 12% Cs respectively. Subjective rating was considered as moderate for a 12% Cs. MWC users with high level injuries travel faster as those with low level injuries. Strain increase is linear for Cs from 0% to 12%. The results suggest that 2% Cs is generally acceptable, while 8% would be a critical threshold.

- **Keywords:** Wheelchair; Cross slope; Strains

**G.J.M. Vandersmissen, R.A.J.R. Verhoogen, A.F.M. Van Cauwenbergh, L. Godderis.** *Determinants of maximal oxygen uptake (VO<sub>2</sub> max) in fire fighter testing.*

The aim of this study was to evaluate current daily practice of aerobic capacity testing in Belgian fire fighters. The impact of personal and test-related parameters on the outcome has been evaluated. Maximal oxygen uptake (VO<sub>2</sub> max) results of 605 male fire fighters gathered between 1999 and 2010 were analysed. The maximal cardio respiratory exercise tests were performed at 22 different centres using different types of tests (tread mill or bicycle), different exercise protocols and measuring equipment. Mean VO<sub>2</sub> max was 43.3 (SD = 9.8) ml/kg.min. Besides waist circumference and age, the type of test, the degree of performance of the test and the test centre were statistically significant determinants of maximal oxygen uptake. Test-related parameters have to be taken into account when interpreting and comparing maximal oxygen uptake tests of fire fighters. It highlights the need for standardization of aerobic capacity testing in the medical evaluation of fire fighters.

- **Keywords:** Aerobic capacity; Maximal oxygen uptake; Fire fighters; Medical evaluation

**Jesper Sandfeld, Christian Rosgaard, Bente Rona Jensen. *L4–L5 compression and anterior/posterior joint shear forces in cabin attendants during the initial push/pull actions of airplane meal carts.***

The aim of the present study was to assess the acute low back load of cabin attendants during cart handling and to identify working situations which present the highest strain on the worker. In a setup, 17 cabin attendants (ten females and seven males) pushed, pulled and turned a 20 kg standard meal cart (L: 0.5 m; W: 0.3 m; H: 0.92 m) loaded with extra 20 kg and 40 kg, respectively on two different surfaces (carpet and linoleum) and at three floor inclinations ( $-2^\circ$ ,  $0^\circ$  and  $+2^\circ$ ). Two force transducers were mounted as handles. Two-dimensional movement analysis was performed and a 4D WATBAK modelling tool was used to calculate the acute L4–L5 load. No working situations created loads greater than the accepted values for single exertions, however compression and anterior/posterior shear forces during pulling and turning were much higher when compared with pushing. There were significant effects of handling the cart on different floor types, at the varying inclinations and with different cart weights. Additionally, when external forces were reduced, the cabin attendants did not decrease push/pull force proportionally and thus the L4–L5 load did not decrease as much as expected.

- **Keywords:** Low back load; Cabin attendants

**María-Jesús Agost, Margarita Vergara. *Relationship between meanings, emotions, product preferences and personal values : application to ceramic tile floorings.***

This work aims to validate a conceptual framework which establishes the main relationships between subjective elements in human–product interaction, such as meanings, emotions, product preferences, and personal values. The study analyzes the relationships between meanings and emotions, and between these and preferences, as well as the influence of personal values on such relationships. The study was applied to ceramic tile floorings. A questionnaire with images of a neutral room with different ceramic tile floorings was designed and distributed via the web. Results from the study suggest that both meanings and emotions must be taken into account in the generation of product preferences. The meanings given to the product can cause the generation of emotions, and both types of subjective impressions give rise to product preferences. Personal reference values influence these relationships between subjective impressions and product preferences. As a consequence, not only target customers' demographic data but specifically their values and criteria must be taken into account from the beginning of the development process. The specific results of this paper can be used directly by ceramic tile designers, who can better adjust product design (and the subjective impressions elicited) to the target market. Consequently, the chance of product success is reinforced.

- **Keywords:** Affective design; Product preferences; Personal values

**Mike Kolich. *Using Failure Mode and Effects Analysis to design a comfortable automotive driver seat.***

Given enough time and use, all designs will fail. There are no fail-free designs. This is especially true when it comes to automotive seating comfort where the characteristics and preferences of individual customers are many and varied. To address this problem, individuals charged with automotive seating comfort development have, traditionally,

relied on iterative and, as a result, expensive build-test cycles. Cost pressures being placed on today's vehicle manufacturers have necessitated the search for more efficient alternatives. This contribution aims to fill this need by proposing the application of an analytical technique common to engineering circles (but new to seating comfort development), namely Design Failure Mode and Effects Analysis (DFMEA). An example is offered to describe how development teams can use this systematic and disciplined approach to highlight potential seating comfort failure modes, reduce their risk, and bring capable designs to life.

- **Keywords:** Word; Automotive seating; Comfort; FMEA (Failure Mode and Effects Analysis)

**Christopher James Vincent, Ann Blandford. *The challenges of delivering validated personas for medical equipment design.***

Representations of archetypal users (personas) have been advocated as a way to avoid designing in isolation. They allow communication of user needs and orient teams towards user experience. One of the challenges for developers of interactive medical devices is that most devices are used by a wide variety of people, and that developers have limited access to those people; personas have the potential to make developers more aware of who they are designing for. But this raises the question of whether it is possible to deliver useful, valid personas of interactive medical device users. The aim of this research was to develop and test a rigorous, empirically grounded process of constructing personas, with the objective of reflecting on that process. Many challenges were encountered: we found that directly linking the personas to a user population was not possible and although personas were a useful tool for supporting communication and elicitation across disciplines, it was hard to make them representative when picking details that were relevant and checking accuracy. Checking the content resulted in disparate, possibly incommensurable, views. Despite this, the personas proved useful in supporting the transfer of knowledge across professional perspectives.

- **Keywords:** Interface; Multidisciplinary communication; Medical device design

**Chih-Chun Lai, Chih-Fu Wu. *Display and device size effects on the usability of mini-notebooks (netbooks)/ultraportables as small form-factor Mobile PCs.***

A balance between portability and usability made the 10.1" diagonal screens popular in the Mobile PC market (e.g., 10.1" mini-notebooks/netbooks, convertible/hybrid ultraportables); yet no academic research rationalizes this phenomenon. This study investigated the size effects of display and input devices of 4 mini-notebooks (netbooks) ranged in size on their performances in 2 simple and 3 complex applied tasks. It seemed that the closer the display and/or input devices (touchpad/touchscreen/keyboard) sizes to those sizes of a generic notebook, the shorter the operation times (there was no certain phenomenon for the error rates). With non-significant differences, the 10.1" and 8.9" mini-notebooks (netbooks) were as fast as the 11.6" one in almost all the tasks, except for the 8.9" one in the typing tasks. The 11.6" mini-notebook (netbook) was most preferred; while the difference in the satisfactions was not significant between the 10.1" and 11.6" ones but between the 7" and 11.6" ones.

- **Keywords:** Input device; Size effect; Mobile PC

**Remko Soer, Niek Hollak, Marieke Deijs, Lucas H. van der Woude, Michiel F. Reneman. *Matching physical work demands with functional capacity in healthy workers: Can it be more efficient?***

Objectives: To determine if functional capacity (FC) and physical work demands can be matched and to determine the validity of normative values for FC related to physical work demands as a screening instrument for work ability. Methods: Forty healthy working subjects were included in this study. Subjects were categorized into four physical work demand categories (sedentary, light, moderate and heavy). FC was tested with a standardized Functional Capacity Evaluation (FCE) following the WorkWell Protocol and physical work demands were determined with an onsite Work Load Assessment (WLA) according to the Task Recording and Analyses on Computer (TRAC) method. Physical work demands were compared to FC and normative values derived from previous research. Results: 88% of the subjects scored higher on FCE than observed during WLA. The tenth percentile of normative values appeared valid in 98% for sedentary/light work for the subjects tested in this study. For moderate or heavy work, the thirtieth percentile of normative values appeared valid in 78% of all cases. Conclusion: Functional capacity and physical work demands can be matched in most instances, but exceptions should be kept in mind with regards to professions classified as moderate or heavy physical work, especially concerning lifting high. Normative values may be considered as an additional screening tool for balancing workload and capacity. It is recommended to further validate normative values in a broader and more extensive working population.

- **Keywords:** Physical workload; Normative values; Work ability

**H.I. Castellucci, P.M. Arezes, J.F.M. Molenbroek. *Applying different equations to evaluate the level of mismatch between students and school furniture.***

The mismatch between students and school furniture is likely to result in a number of negative effects, such as uncomfortable body posture, pain, and ultimately, it may also affect the learning process. This study's main aim is to review the literature describing the criteria equations for defining the mismatch between students and school furniture, to apply these equations to a specific sample and, based on the results, to propose a methodology to evaluate school furniture suitability. The literature review comprises one publications database, which was used to identify the studies carried out in the field of the abovementioned mismatch. The sample used for testing the different equations was composed of 2261 volunteer subjects from 14 schools. Fifteen studies were found to meet the criteria of this review and 21 equations to test 6 furniture dimensions were identified. Regarding seat height, there are considerable differences between the two most frequently used equations. Although seat to desk clearance was evaluated by knee height, this condition seems to be based on the false assumption that students are sitting on a chair with a proper seat height. Finally, the proposed methodology for suitability evaluation of school furniture should allow for a more reliable analysis of school furniture.

- **Keywords:** School; Furniture; Mismatch

**Patricia M. Rosati, Jaclyn N. Chopp, Clark R. Dickerson. *Investigating shoulder muscle loading and exerted forces during wall painting tasks : influence of gender, work height and paint tool design.***

The task of wall painting produces considerable risk to the workers, both male and female, primarily in the development of upper extremity musculoskeletal disorders. Insufficient information is currently available regarding the potential benefits of using different paint roller designs or the possible adverse effects of painting at different work heights. The aim of this study was to investigate the influence of gender, work height, and paint tool design on shoulder muscle activity and exerted forces during wall painting. Ten young adults, five male and five female, were recruited to perform simulated wall painting at three different work heights with three different paint roller designs while upper extremity muscle activity and horizontal push force were recorded. Results demonstrated that for female participants, significantly greater total average ( $p = 0.007$ )

and integrated ( $p = 0.047$ ) muscle activity was present while using the conventional and curly flex paint roller designs compared to the proposed design in which the load was distributed between both hands. Additionally, for both genders, the high working height imposed greater muscular demands compared to middle and low heights. These findings suggest that, if possible, avoid painting at extreme heights (low or high) and that for female painters, consider a roller that requires the use of two hands; this will reduce fatigue onset and subsequently mitigate potential musculoskeletal shoulder injury risks.

- **Keywords:** Shoulder load; Wall painting; Muscular demand

**M. Jagannath, Venkatesh Balasubramanian. *Assessment of early onset of driver fatigue using multimodal fatigue measures in a static simulator.***

Driver fatigue is an important contributor to road accidents. This paper reports a study that evaluated driver fatigue using multimodal fatigue measures, i.e., surface electromyography (sEMG), electroencephalography (EEG), seat interface pressure, blood pressure, heart rate and oxygen saturation level. Twenty male participants volunteered in this study by performing 60 min of driving on a static simulator. Results from sEMG showed significant physical fatigue ( $p < 0.05$ ) in back and shoulder muscle groups. EEG showed significant ( $p < 0.05$ ) increase of alpha and theta activities and a significant decrease of beta activity during monotonous driving. Results also showed significant change in bilateral pressure distribution on thigh and buttocks region during the study. These findings demonstrate the use of multimodal measures to assess early onset of fatigue. This will help us understand the influence of physical and mental fatigue on driver during monotonous driving.

- **Keywords:** Driver fatigue; Multimodal fatigue measures; Static simulator

**Farzan Sasangohar, Stacey D. Scott, M.L. Cummings. *Supervisory-level interruption recovery in time-critical control tasks.***

This paper investigates the effectiveness of providing interruption recovery assistance in the form of an interactive visual timeline of historical events on a peripheral display in support of team supervision in time-critical settings. As interruptions can have detrimental effects on task performance, particularly in time-critical work environments, there is growing interest in the design of tools to assist people in resuming their pre-interruption activity. A user study was conducted to evaluate the use of an interactive event timeline that provides assistance to human supervisors in time-critical settings. The study was conducted in an experimental platform that emulated a team of operators and a mission commander performing a time-critical unmanned aerial vehicle (UAV) mission. The study results showed that providing interruption assistance enabled people to recover from interruptions faster and more accurately. These results have implications for interface design that could be adopted in similar time-critical environments such as air-traffic control, process control, and first responders.

- **Keywords:** Interruption; Supervisory control; Unmanned vehicles

**Ryan Olson, Brad Wipfli, Robert R. Wright, Layla Garrigues, Thuan Nguyen, Borja López de Castro. *Reliability and validity of the Home Care STAT (Safety Task Assessment Tool).***

Home care workers are a priority population for ergonomic assessment and intervention, but research on caregivers' exposures to hazards is limited. The current project evaluated the reliability and validity of an ergonomic self-assessment tool called Home Care STAT (Safety Task Assessment Tool). Participants ( $N = 23$ ) completed a background survey followed by 10–14 days of self-monitoring with the STAT. Results showed that the most frequent task was house cleaning, and that participants regularly performed

dangerous manual client moving and transferring tasks. Researcher in-home observations of 14 workers (duration  $\leq 2$  h) demonstrated that workers' self-assessments were moderately reliable. Correlational and multi-level analyses of daily self-assessment data revealed that several task exposures were significantly related to daily fatigue and/or pain. Other associations have implications for Total Worker Health™; for example, daily stress was positively associated with both pain and consumption of high calorie snacks. Findings support the STAT as a reliable and potentially valid tool for measuring home care workers' exposures to physically demanding tasks.

- **Keywords:** Home care workers; Hazard exposure; Self-assessment

**Malte Risto, Marieke H. Martens. *Supporting driver headway choice : the effects of discrete headway feedback when following headway instructions.***

With specific headway instructions drivers are not able to attain the exact headways as instructed. In this study, the effects of discrete headway feedback (and the direction of headway adjustment) on headway accuracy for drivers carrying out time headway instructions were assessed experimentally. Two groups of each 10 participants (one receiving headway feedback; one control) carried out headway instructions in a driving simulator; increasing and decreasing their headway to a target headway of 2 s at speeds of 50, 80, and 100 km/h. The difference between the instructed and chosen headway was a measure for headway accuracy. The feedback group heard a sound signal at the moment that they crossed the distance of the instructed headway. Unsupported participants showed no significant difference in headway accuracy when increasing or decreasing headways. Discrete headway feedback had varying effects on headway choice accuracy. When participants decreased their headway, feedback led to higher accuracy. When increasing their headway, feedback led to a lower accuracy, compared to no headway feedback. Support did not affect driver's performance in maintaining the chosen headway. The present results suggest that (a) in its current form discrete headway feedback is not sufficient to improve the overall accuracy of chosen headways when carrying out headway instructions; (b) the effect of discrete headway feedback depends on the direction of headway adjustment.

- **Keywords:** Headway instructions; Headway feedback; Headway choice accuracy

**Kirsten Nabe-Nielsen, Karsten Thielen, Else Nygaard, Sannie Vester Thorsen, Finn Diderichsen. *Demand-specific work ability, poor health and working conditions in middle-aged full-time employees.***

We investigated the prevalence of reduced demand-specific work ability, its association with age, gender, education, poor health, and working conditions, and the interaction between poor health and working conditions regarding reduced demand-specific work ability. We used cross-sectional questionnaire data from 3381 full-time employees responding to questions about vocational education, job demands and social support (working conditions), musculoskeletal pain (MSP) and major depression (MD) (poor health) and seven questions about difficulty managing different job demands (reduced demand-specific work ability). Reduced demand-specific work ability varied from 9% to 19% among the 46-year old and from 11% to 21% among the 56-year old. Age was associated with two, gender with four, and education with all measures of reduced demand-specific work ability. MSP was associated with four and MD was associated with six measures of reduced demand-specific work ability. We found no interaction between working conditions and poor health regarding reduced demand-specific work ability.

- **Keywords:** Depression; Job demands; Musculoskeletal pain

**Yi-Lang Chen, Yi-Nan Liu. *Optimal protruding node length of bicycle seats determined using cycling postures and subjective ratings.***

This study examined body posture, subjective discomfort, and stability, requiring the participants to ride a stationary bicycle for 20 min (cadence: 60 rpm; workrate: 120 W), using various combinations of two handle heights and five seat-protruding node lengths (PNLs). The results indicated that bicycle handle height significantly influenced body posture, and that seat PNL caused differences in the riders' subjective discomfort and stability scores. The various PNLs affected only the trunk angle (approximately 6°), but had significantly positive ( $r = 0.994$ ,  $p < .005$ ) and negative ( $r = -0.914$ ,  $p < .05$ ) correlations with the subjective discomfort rating for perineum and ischial tuberosity, respectively. When the participants were seated at PNL = 0 or 3 cm, cycling using dropped handles was less stable compared with using straight handles; however, the handle height did not affect the cycling stability when the PNL was  $\geq 6$  cm. The results suggest that a 6-cm PNL is the optimal reference for bicycle seat designs.

- **Keywords:** Protruding node of saddle; Posture recording; Subjective assessment

**Mary E. Mossey, Yubin Xi, Shayne K. McConomy, Johnell O. Brooks, Patrick J. Rosopa, Paul J. Venhovens. *Evaluation of four steering wheels to determine driver hand placement in a static environment.***

While much research exists on occupant packaging both proprietary and in the literature, more detailed research regarding user preferences for subjective ratings of steering wheel designs is sparse in published literature. This study aimed to explore the driver interactions with production steering wheels in four vehicles by using anthropometric data, driver hand placement, and driver grip design preferences for Generation-Y and Baby Boomers. In this study, participants selected their preferred grip diameter, responded to a series of questions about the steering wheel grip as they sat in four vehicles, and rank ordered their preferred grip design. Thirty-two male participants (16 Baby Boomers between ages 47 and 65 and 16 Generation-Y between ages 18 and 29) participated in the study. Drivers demonstrated different gripping behavior between vehicles and between groups. Recommendations for future work in steering wheel grip design and naturalistic driver hand positioning are discussed.

- **Keywords:** Steering wheel grip; Ergonomics; Driving

**Eunjung Choi, Sunghyuk Kwon, Donghun Lee, Hogin Lee, Min K. Chung. *Towards successful user interaction with systems : focusing on user-derived gestures for smart home systems.***

Various studies that derived gesture commands from users have used the frequency ratio to select popular gestures among the users. However, the users select only one gesture from a limited number of gestures that they could imagine during an experiment, and thus, the selected gesture may not always be the best gesture. Therefore, two experiments including the same participants were conducted to identify whether the participants maintain their own gestures after observing other gestures. As a result, 66% of the top gestures were different between the two experiments. Thus, to verify the changed gestures between the two experiments, a third experiment including another set of participants was conducted, which showed that the selected gestures were similar to those from the second experiment. This finding implies that the method of using the frequency in the first step does not necessarily guarantee the popularity of the gestures.

- **Keywords:** Hand gesture; User-derived hand gestures; Gesture-command association



**Iman Dianat, Christine M. Haslegrave, Alex W. Stedmon. *Design options for improving protective gloves for industrial assembly work.***

The study investigated the effects of wearing two new designs of cotton glove on several hand performance capabilities and compared them against the effects of barehanded, single-layered and double cotton glove conditions when working with hand tools (screwdriver and pliers). The new glove designs were based on the findings of subjective hand discomfort assessments for this type of work and aimed to match the glove thickness to the localised pressure and sensitivity in different areas of the hand as well as to provide adequate dexterity for fine manipulative tasks. The results showed that the first prototype glove and the barehanded condition were comparable and provided better dexterity and higher handgrip strength than double thickness gloves. The results support the hypothesis that selective thickness in different areas of the hand could be applied by glove manufacturers to improve the glove design, so that it can protect the hands from the environment and at the same time allow optimal hand performance capabilities.

- **Keywords:** Glove; Screwdriver; Pliers; Hand tool

**Tibor Petzoldt, Josef F. Krems. *How does a lower predictability of lane changes affect performance in the Lane Change Task?***

The Lane Change Task (LCT) is an established method to assess driver distraction caused by secondary tasks. In the LCT ISO standard, "course following and maneuvering" and "event detection" are mentioned as central task properties. Especially event detection seems to be a reasonable feature, as research suggests that distraction has profound effects on drivers' reactions to sudden, unexpected events. However, closer inspection of the LCT reveals that the events to be detected (lane change signs) and the required response are highly predictable. To investigate how the LCT's distraction assessment of secondary tasks might change if lane change events and responses were less predictable, we implemented three different versions of the LCT – an "original" one, a second one with lowered predictability of event position, and a third one with lowered predictability of event position and response. We tested each of these implementations with the same set of visual and cognitive secondary tasks of varying demand. The results showed that a decrease in predictability resulted in overall degraded performance in the LCT when using the basic lane change model for analysis. However, all secondary task conditions suffered equally. No differential effects were found. We conclude that although an ISO conforming implementation of the LCT might not be excessively valid regarding its depiction of safety relevant events, the results obtained are nevertheless comparable to what would be found in settings of higher validity.

- **Keywords:** Inattention; In-vehicle information systems; Evaluation methods

**Ivan Bolis, Claudio M. Brunoro, Laerte I. Sznclwar. *Mapping the relationships between work and sustainability and the opportunities for ergonomic action.***

A map was drawn up of the relationships between work (in its multiple interpretations) and sustainability (sustainable development and corporate sustainability) based on a bibliographic analysis of articles that discuss these themes jointly in the current academic literature. The position of the discipline of ergonomics focused on work was identified from this map and, based on its specific academic literature, it was possible to identify where this discipline could contribute so that work and workers can be included in the discourse of sustainable development and considered in corporate sustainability policies. Ergonomics can be actively influential within the organization on issues relating to work improvements; it may boost integrated increases in the organization's performance and in workers' well-being; it can provide support for changes and new (environmental)

sustainability-related work requirements to be considered; and it can contribute to the definition of the concept of work in a context of sustainable development.

- **Keywords:** Work; Sustainable development; Corporate sustainability

**Steven J. Elmer, James C. Martin. *A cycling workstation to facilitate physical activity in office settings.***

Facilitating physical activity during the workday may help desk-bound workers reduce risks associated with sedentary behavior. We 1) evaluated the efficacy of a cycling workstation to increase energy expenditure while performing a typing task and 2) fabricated a power measurement system to determine the accuracy and reliability of an exercise cycle. Ten individuals performed 10 min trials of sitting while typing (SITtype) and pedaling while typing (PEDtype). Expired gases were recorded and typing performance was assessed. Metabolic cost during PEDtype was 2.5× greater compared to SITtype ( $255 \pm 14$  vs.  $100 \pm 11$  kcal h<sup>-1</sup>,  $P < 0.01$ ). Typing time and number of typing errors did not differ between PEDtype and SITtype ( $7.7 \pm 1.5$  vs.  $7.6 \pm 1.6$  min,  $P = 0.51$ ,  $3.3 \pm 4.6$  vs.  $3.8 \pm 2.7$  errors,  $P = 0.80$ ). The exercise cycle overestimated power by 14–138% compared to actual power but actual power was reliable ( $r = 0.998$ ,  $P < 0.01$ ). A cycling workstation can facilitate physical activity without compromising typing performance. The exercise cycle's inaccuracy could be misleading to users.

- **Keywords:** Workplace activity; Energy expenditure; Ergometer calibration

**A.J. Filtness, E. Mitsopoulos-Rubens, C.M. Rudin-Brown. *Police officer in-vehicle discomfort : appointments carriage method and vehicle seat features.***

Musculoskeletal pain is commonly reported by police officers. A potential cause of officer discomfort is a mismatch between vehicle seats and the method used for carrying appointments. Twenty-five police officers rated their discomfort while seated in: (1) a standard police vehicle seat, and (2) a vehicle seat custom-designed for police use. Discomfort was recorded in both seats while wearing police appointments on: (1) a traditional appointments belt, and (2) a load-bearing vest/belt combination (LBV). Sitting in the standard vehicle seat and carrying appointments on a traditional appointments belt were both associated with significantly elevated discomfort. Four vehicle seat features were most implicated as contributing to discomfort: back rest bolster prominence; lumbar region support; seat cushion width; and seat cushion bolster depth. Authorising the carriage of appointments using a LBV is a lower cost solution with potential to reduce officer discomfort. Furthermore, the introduction of custom-designed vehicle seats should be considered.

- **Keywords:** Occupational injury; Vehicle seat design; Automotive seating discomfort questionnaire (ASDQ)

**Pieter Coenen, Margriet Formanoy, Marjolein Douwes, Tim Bosch, Heleen de Kraker. *Validity and inter-observer reliability of subjective hand-arm vibration assessments.***

Exposure to mechanical vibrations at work (e.g., due to handling powered tools) is a potential occupational risk as it may cause upper extremity complaints. However, reliable and valid assessment methods for vibration exposure at work are lacking. Measuring hand-arm vibration objectively is often difficult and expensive, while often used information provided by manufacturers lacks detail. Therefore, a subjective hand-arm vibration assessment method was tested on validity and inter-observer reliability. In an experimental protocol, sixteen tasks handling powered tools were executed by two

workers. Hand-arm vibration was assessed subjectively by 16 observers according to the proposed subjective assessment method. As a gold standard reference, hand-arm vibration was measured objectively using a vibration measurement device. Weighted  $\kappa$ 's were calculated to assess validity, intra-class-correlation coefficients (ICCs) were calculated to assess inter-observer reliability. Inter-observer reliability of the subjective assessments depicting the agreement among observers can be expressed by an ICC of 0.708 (0.511–0.873). The validity of the subjective assessments as compared to the gold-standard reference can be expressed by a weighted  $\kappa$  of 0.535 (0.285–0.785). Besides, the percentage of exact agreement of the subjective assessment compared to the objective measurement was relatively low (i.e., 52% of all tasks). This study shows that subjectively assessed hand-arm vibrations are fairly reliable among observers and moderately valid. This assessment method is a first attempt to use subjective risk assessments of hand-arm vibration. Although, this assessment method can benefit from some future improvement, it can be of use in future studies and in field-based ergonomic assessments.

- **Keywords:** Hand-arm vibration; Risk assessment; Validity