
Hand operation accompanied with any combination of large forces, awkward positions and repetition may lead to upper limb injury or illness and may be exacerbated by vibration. Commercial lawn mowers expose operators to these factors during actuation of hand controls and therefore may be a health concern. A nontraditional lawn mower control system may decrease upper limb illnesses and injuries through more neutral hand and body positioning. This study compared maximum grip strength in twelve different orientations (3 grip spans and 4 positions) and evaluated self-described comfortable handle positions. The results displayed force differences between nontraditional (X) and both vertical (V) and pistol (P) positions (p < 0.0001) and among the different grip spans (p < 0.0001). Based on these results, recommended designs should incorporate a tilt between 45 and 70°, handle rotations between 48 and 78°, and reduced force requirements or decreased grip spans to improve user health and comfort.

- **Keywords:** Lawn mowing; Grip force; Grip span

Takeshi Yamaguchi, Jennifer Hsu, Yue Li, Brian E. Maki. *Efficacy of a rubber outsole with a hybrid surface pattern for preventing slips on icy surfaces.* Pages 9-17.

Conventional winter-safety footwear devices, such as crampons, can be effective in preventing slips on icy surfaces but the protruding studs can lead to other problems such as trips. A new hybrid (rough and smooth) rubber outsole was designed to provide high slip resistance without use of protruding studs or asperities. In the present study, we examined the slip resistance of the hybrid rubber outsole on both dry (−10 °C) and wet (0 °C) icy surfaces, in comparison to three conventional strap-on winter anti-slip devices: 1) metal coils ("Yaktrax Walker"), 2) gritted (sandpaper-like) straps ("Rough Grip"), and 3) crampons ("Altagrips-Lite"). Drag tests were performed to measure static (SCOF) and dynamic (DCOF) coefficients of friction, and gait trials were conducted on both level and sloped ice surfaces (16 participants). The drag-test results showed relatively high SCOF (≧0.37) and DCOF (≧0.31) values for the hybrid rubber sole, at both temperatures. The other three footwear types exhibited lower DCOF values (0.06–0.20) when compared with the hybrid rubber sole at 0 °C (p < 0.01). Slips were more frequent when wearing the metal coils, in comparison to the other footwear types, when descending a slope at −10 °C (6% of trials vs 0%; p < 0.05). There were no other significant footwear-
related differences in slip frequency, distance or velocity. These results indicate that the slip-resistance of the hybrid rubber sole on icy surfaces was comparable to conventional anti-slip footwear devices. Given the likely advantages of the hybrid rubber sole (less susceptibility to tripping, better slip resistance on non-icy surfaces), this type of sole should contribute to a decrease in fall accidents; however, further research is needed to confirm its effectiveness under a wider range of test conditions.

- **Keywords:** Hybrid rubber sole; Slip and fall; Ice

**Guy Walker, Malcolm Calvert. Driver behaviour at roadworks. Pages 18-29.**

There is an incompatibility between how transport engineers think drivers behave in roadworks and how they actually behave. As a result of this incompatibility we are losing approximately a lane's worth of capacity in addition to those closed by the roadworks themselves. The problem would have little significance were it not for the fact a lane of motorway costs approx. £30 m per mile to construct and £43 k a year to maintain, and that many more roadworks are planned as infrastructure constructed 40 or 50 years previously reaches a critical stage in its lifecycle. Given current traffic volumes, and the sensitivity of road networks to congestion, the effects of roadworks need to be accurately assessed. To do this requires a new ergonomic approach. A large-scale observational study of real traffic conditions was used to identify the issues and impacts, which were then mapped to the ergonomic knowledge-base on driver behaviour, and combined to developed practical guidelines to help in modelling future roadworks scenarios with greater behavioural accuracy. Also stemming from the work are novel directions for the future ergonomic design of roadworks themselves.

- **Keywords:** Roadworks; Driver behaviour; Microsimulation

**A.-C. Macquet, C. Ferrand, N.A. Stanton. Divide and rule: a qualitative analysis of the debriefing process in elite team sports. Pages 30-38.**

This article aimed to gain an understanding of the process of debriefing during major competitions in elite team sports. Debrief interviews were conducted with 9 head coaches. The interview data were used to identify how head coaches divided up the tasks given to staff and team members prior to, and during the post-match debriefing. Results showed that debriefing consisted of two steps: preparation and presentation. Preparation referred to four successive tasks. Presentation to the team of players consisted of eight tasks relating to transformational and transactional styles of leadership. Coaches were shown to divide the labor within the staff and team. The data tend to support the view that in elite team sports, coaches are both transformational and transactional leaders, adapting their style of leadership to the situation, athletes and time available. This study provides insights into the task-work and team-work underlying team functioning and division of labor.

- **Keywords:** Team-work versus task-work expertise; Transformational versus transactional leadership

**Linjie Wang, Wenbin Li, Jinglian Chen. Ergonomic evaluation of the operating characteristics of the 6MF-30 portable pneumatic extinguisher. Pages 39-43.**

The 6MF-30 portable pneumatic extinguisher, which is one of the most widely used pieces of equipment for fighting forest fires in China, can produce great physical discomfort for the wearer. To mitigate the physical discomfort associated with the use of the 6MF-30, the operating characteristics of this machine were ergonomically evaluated. Fourteen subjects were instructed to operate the 6MF-30 portable pneumatic
extinguisher using three different carrying postures (oblique strap, vertical strap and no strap) two different motions (stationary and swinging) during a simulated firefighting task. Dependent measures included heart rate (HR), electromyography (EMG) data and a subjective assessment (measured as the degree of fatigue in the left arm, right arm and waist). The EMG data were acquired from the palmaris longus and the biceps brachii of the left arm of each subject. Variance analysis indicated that the effects of the carrying posture on the HR \( (p < 0.001) \), the EMG data of the left arm \( (p = 0.001) \) of the palmaris longus and \( (p = 0.015) \) of the biceps brachii, and the degree of fatigue of the left and right arms \( (p < 0.001) \) were significant, while the effects of motion on all of the dependent measures, and the effects of carrying posture on the degree of fatigue of the waist were not significant. The effect of an oblique strap on the whole-body load is minimal, and the use of the equipment without a strap produced significantly greater physical discomfort for the wearer than did the oblique strap and the vertical strap. The results suggest that the strap of the 6MF-30 can help Chinese forest firefighters to lessen physical stress when operating the 6MF-30, and the use of the oblique strap should be adopted as the standard position.

Keywords: Portable pneumatic extinguisher; Ergonomics; Heart rate

Sigal Portnoy, Orli Halaby, Dotan Dekel-Chen, Frédéric Dierick. Effect of an auditory feedback substitution, tactilo-kinesthetic, or visual feedback on kinematics of pouring water from kettle into cup. Pages 44-49.

Pouring hot water from a kettle into a cup may prove a hazardous task, especially for the elderly or the visually-impaired. Individuals with deteriorating eyesight may endanger their hands by performing this task with both hands, relying on tactilo-kinesthetic feedback (TKF). Auditory feedback (AF) may allow them to perform the task singlehandedly, thereby reducing the risk for injury. However since relying on an AF is not intuitive and requires practice, we aimed to determine if AF supplied during the task of pouring water can be used naturally as visual feedback (VF) following practice. For this purpose, we quantified, in young healthy sighted subjects \((n = 20)\), the performance and kinematics of pouring water in the presence of three isolated feedbacks: visual, tactilo-kinesthetic, or auditory. There were no significant differences between the weights of spilled water in the AF condition compared to the TKF condition in the first, fifth or thirteenth trials. The subjectively-reported difficulty levels of using the TKF and the AF were significantly reduced between the first and thirteenth trials for both TKF \((p = 0.01)\) and AF \((p = 0.001)\). Trunk rotation during the first trial using the TKF was significantly lower than the trunk rotation while using VF. Also, shoulder adduction during the first trial using the TKF was significantly higher than the shoulder adduction while using the VF. During the AF trials, the median travel distance of the tip of the kettle was significantly reduced in the first trials so that in the thirtieth trial it did not differ significantly from the median travel distance during the thirtieth trial using TKF and VF. The maximal velocity of the tip of the kettle was constant for each of the feedback conditions but was higher in 10 cm s\(^{-1}\) using VF than TKF, which was higher in 10 cm s\(^{-1}\) from using AF. The smoothness of movement of the TKF and AF conditions, expressed by the normalized jerk score (NJSM), was one and two orders of magnitude higher from the VF, respectively. The median NJSM then decreased significantly by the fifth trial. Monitoring in-house activity via motion capture and classification of movements, i.e. liquid pouring, can assist with daily activities via AF. As a built-in feature in a smart home, this task-specific AF may prevent burn injuries of the visually-impaired.

Keywords: Motion capture; Smart home; Visual impairment

We assessed the thermal environment of eight recently built low-energy houses and twelve conventional Finnish houses. We monitored living room, bedroom and outdoor air temperatures and room air relative humidity from June 2012 to September 2013. Perceived thermal environment was evaluated using a questionnaire survey during the heating, cooling and interim seasons. We compared the measured and perceived thermal environments of the low-energy and conventional houses. The mean air temperature was 22.8 °C (21.9–23.8 °C) in the low-energy houses, and 23.3 °C (21.4–26.5 °C) in the conventional houses during the summer (1. June 2013–31. August 2013). In the winter (1. December 2012–28. February 2013), the mean air temperature was 21.3 °C (19.8–22.5 °C) in the low-energy houses, and 21.6 °C (18.1–26.4 °C) in the conventional houses. The variation of the air temperature was less in the low-energy houses than that in the conventional houses. In addition, the occupants were on average slightly more satisfied with the indoor environment in the low-energy houses. However, there was no statistically significant difference between the mean air temperature and relative humidity of the low-energy and conventional houses. Our measurements and surveys showed that a good thermal environment can be achieved in both types of houses.

- **Keywords:** Air temperature; Relative humidity; Measurements

**Hsueh-Fen Liu, Fang-Suey Lin, Chien-Ju Chang. The effectiveness of using pictures in teaching young children about burn injury accidents. Pages 60-68.**

This study utilized the “story grammar” approach (Stein and Glenn, 1979) to analyze the within-corpus differences in recounting of sixty 6- and 7-year-old children, specifically whether illustrations (5-factor accident sequence) were or were not resorted to as a means to assist their narration of a home accident in which a child received a burn injury from hot soup. Our investigation revealed that the message presentation strategy “combining oral and pictures” better helped young children to memorize the story content (sequence of events leading to the burn injury) than “oral only.” Specifically, the content of “the dangerous objects that caused the injury”, “the unsafe actions that people involved took”, and “how the people involved felt about the severity of the accident” differed significantly between the two groups.

- **Keywords:** Young children burn injury; 5-Factor accident sequence; Storytelling

**Shih-Wen Hsiao, Rong-Qi Chen, Wan-Lee Leng. Applying riding-posture optimization on bicycle frame design. Pages 69-79.**

Customization design is a trend for developing a bicycle in recent years. Thus, the comfort of riding a bike is an important factor that should be paid much attention to while developing a bicycle. From the viewpoint of ergonomics, the concept of “fitting object to the human body” is designed into the bicycle frame in this study. Firstly, the important feature points of riding posture were automatically detected by the image processing method. In the measurement process, the best riding posture was identified experimentally, thus the positions of feature points and joint angles of human body were obtained. Afterwards, according to the measurement data, three key points: the handlebar, the saddle and the crank center, were identified and applied to the frame design of various bicycle types. Lastly, this study further proposed a frame size table for common bicycle types, which is helpful for the designer to design a bicycle.

- **Keywords:** Riding posture optimization; Bicycle frame design; Image processing

**Clifford P. Mao, Brandon R. Macias, Alan R. Hargens. Shoulder skin and muscle hemodynamics during backpack carriage. Pages 80-84.**
The purpose of this study was to quantify the effects of loaded backpacks on shoulder muscle oxygenation, skin blood flow, and pain. We hypothesized that backpack load carriage is associated with lower shoulder muscle oxygenation and skin microvascular flow. Near-infrared spectroscopy quantified shoulder tissue oxygenation and laser Doppler flow measured skin microvascular flow. Eight adult volunteers donned a standard backpack without added load, 5 kg load, and 10 kg load for 5 min while standing. An 8 min rest period before each backpack donning condition ensured that all measured parameters returned to baseline. Data were analyzed using a repeated measures ANOVA and significance set at p < 0.05. Donning a 10 kg backpack significantly reduced shoulder muscle oxygenation by 22 ± 23% as compared to the empty backpack control condition (p = 0.023). In addition, a 10 kg backpack load reduced skin microvascular flow by 82 ± 22%, as compared to the empty backpack control condition (p = 0.024). Perceived pain was significantly higher when wearing the 10 kg backpack (level 4 on a 10-maximal pain scale) as compared to the empty backpack (0, 0–no pain) (p < 0.05). In conclusion, backpack loads of 10 kg decrease shoulder muscle oxygenation and skin microvascular flow.

- Keywords: Blood flow; Oxygenation; Pain


In this paper, we study the arrangement of displays in flight instrument panels of multi-purpose civil helicopters following a user-centered design method based on ergonomics principles. Our methodology can also be described as a user-interface arrangement methodology based on user opinions and preferences. This study can be outlined as gathering user-centered data using two different research methods and then analyzing and integrating the collected data to come up with an optimal instrument panel design. An interview with helicopter pilots formed the first step of our research. In that interview, pilots were asked to provide a quantitative evaluation of basic interface arrangement principles. In the second phase of the research, a paper prototyping study was conducted with same pilots. The final phase of the study entailed synthesizing the findings from interviews and observational studies to formulate an optimal flight instrument arrangement methodology. The primary results that we present in our paper are the methodology that we developed and three new interface arrangement concepts, namely relationship of inseparability, integrated value and locational value. An optimum instrument panel arrangement is also proposed by the researchers.

- Keywords: User-centered design; Helicopter flight instrument panel; User-interface arrangement


This paper briefly explores the expected impact of the ‘Global Drivers’ (such as population demographics, food security; energy security; community security and safety), and the role of sustainability engineering in mitigating the potential effects of these Global Drivers. The message of the paper is that sustainability requires a significant input from Ergonomics/Human Factors, but the profession needs some expansion in its thinking in order to make this contribution. Creating a future sustainable world in which people experience an acceptable way of life will not happen without a large input from manufacturing industry into all the Global Drivers, both in delivering products that meet sustainability criteria (such as durability, reliability, minimised material requirement and low energy consumption), and in developing sustainable processes to deliver products for sustainability (such as minimum waste, minimum emissions and low energy consumption). Appropriate changes are already being
implemented in manufacturing industry, including new business models, new jobs and new skills. Considerable high-level planning around the world is in progress and is bringing about these changes; for example, there is the US ‘Advanced Manufacturing National Program’ (AMNP), the German ‘Industrie 4.0’ plan, the French plan ‘la nouvelle France industrielle’ and the UK Foresight publications on the ‘Future of Manufacturing’. All of these activities recognise the central part that humans will continue to play in the new manufacturing paradigms; however, they do not discuss many of the issues that systems ergonomics professionals acknowledge. This paper discusses a number of these issues, highlighting the need for some new thinking and knowledge capture by systems ergonomics professionals. Among these are ethical issues, job content and skills issues. Towards the end, there is a summary of knowledge extensions considered necessary in order that systems ergonomists can be fully effective in this new environment, together with suggestions for the means to acquire and disseminate the knowledge extensions.

- **Keywords:** Sustainability; Manufacturing; Systems ergonomics

**Nikolaos Kaklanis, Georgios Stavropoulos, Dimitrios Tzovaras. Modeling people with motor disabilities to empower the automatic accessibility and ergonomic assessment of new products. Pages 120-136.**

Virtual User Models (VUMs) can be a valuable tool for accessibility and ergonomic evaluation of designs in simulation environments. As increasing the accessibility of a design is usually translated into additional costs and increased development time, the need for specifying the percentage of population for which the design will be accessible is crucial. This paper addresses the development of VUMs representing specific groups of people with disabilities. In order to create such VUMs, we need to know the functional limitations, i.e. disability parameters, caused by each disability and their variability over the population. Measurements were obtained from 90 subjects with motor disabilities and were analyzed using both parametric and nonparametric regression methods as well as a proposed hybrid regression method able to handle small sample sizes. Validation results showed that in most cases the proposed regression analysis can produce valid estimations on the variability of each disability parameter.

- **Keywords:** User modeling; Virtual User Model; Regression analysis

**Hongwei Hsiao, Jennifer Whitestone, Michael Wilbur, J. Roger Lackore, J. Gordon Routley. Seat and seatbelt accommodation in fire apparatus: anthropometric aspects. Pages 137-151.**

This study developed anthropometric information on U.S. firefighters to guide fire-apparatus seat and seatbelt designs and future standards development. A stratified sample of 863 male and 88 female firefighters across the U.S. participated in the study. The study results suggested 498 mm in width, 404 mm in depth, and 365–476 mm in height for seat pans; 429–522 mm in width and 542 mm in height for seat back; 871 mm in height for head support; a seat space of 733 mm at shoulder and 678 mm at hip; and a knee/leg clearance of 909 mm in fire truck cab. Also, 1520 mm of lap belt web effective length and 2828 mm of lap-and-shoulder belt web effective length were suggested. These data for fire-truck seats and seatbelts provide a foundation for fire apparatus manufacturers and standards committees to improve firefighter seat designs and seatbelt usage compliance.

- **Keywords:** Firefighter; Seatbelt; Anthropometry

**Nikki S. Olsen, Ann M. Williamson. Development of safety incident coding systems through improving coding reliability. Pages 152-162.**
This paper reviews classification theory sources to develop five research questions concerning factors associated with incident coding system development and use and how these factors affect coding reliability. Firstly, a method was developed to enable the comparison of reliability results obtained using different methods. Second, a statistical and qualitative review of reliability studies was conducted to investigate the influence of the identified factors on the reliability of incident coding systems. As a result several factors were found to have a statistically significant effect on reliability. Four recommendations for system development and use are provided to assist researchers in improving the reliability of incident coding systems in high hazard industries.

- **Keywords:** Incident classification; Reliability; Safety management system

**Zhenyu Yuan, Yongjuan Li, Lois E. Tetrick. Job hindrances, job resources, and safety performance: the mediating role of job engagement. Pages 163-171.**

Job engagement has received widespread attention in organizational research but has rarely been empirically investigated in the context of safety. In the present study, we examined the mediating role of job engagement in the relationships between job characteristics and safety performance using self-reported data collected at a coal mining company in China. Most of our study hypotheses were supported. Job engagement partially mediated the relationships between job resources and safety performance dimensions. Theoretical and practical implications and directions for future research are also discussed.

- **Keywords:** Job characteristics; Safety performance; Job engagement

**Gunn Robstad Andersen, Synne Bendal, Rolf H. Westgaard. Work demands and health consequences of organizational and technological measures introduced to enhance the quality of home care services: a subgroup analysis. Pages 172-179.**

This study of home care workers in a Norwegian municipality aimed to examine the effect of two measures involving organizational (job checklists) and technological (personal digital assistants) job aids on perceived work demands and musculoskeletal health. Questionnaire data was collected in 2009 (n = 138, response rate 76.2%) and 2011 (n = 80, response rate 54%). Forty-six home care workers responded at both waves. Respondents were assigned into ‘high’, ‘moderate’ and ‘low’ strain groups based on their responses to open and closed survey questions regarding impact of the two measures. One-way ANOVA with post-hoc t-tests and regression analyses investigated group differences and examined development in variables. Perceived work demands and health effects over the two-year study period were unchanged overall, yet significant differences between subgroups were highlighted. Work demands and shoulder-neck pain remained high for high-strain workers, but were reduced for low and moderate strain workers. Management should be aware of diversity in worker responses to rationalizations and give priority to supplementary, targeted measures to counteract adverse effects.

- **Keywords:** Rationalization; Musculoskeletal health; Work environment

**Iman Dianat, Madeh Kord, Parvin Yahyazade, Mohammad Ali Karimi, Alex W. Stedmon. Association of individual and work-related risk factors with musculoskeletal symptoms among Iranian sewing machine operators. Pages 180-188.**

This cross-sectional study evaluated working conditions and the occurrence of self-reported musculoskeletal symptoms among 251 Iranian sewing machine operators. A
questionnaire and direct observations of working postures using the rapid upper limb assessment (RULA) method were used. A high prevalence of musculoskeletal symptoms, particularly in the neck/shoulders, back and hands/wrists were found. The mean RULA grand score of 5.7 highlighted a poor sewing workstation design and indicated that most operators (with posture assessed at action level 3) needed an investigation and changes in their working habits soon. Work-related factors (including number of years worked as an operator, prolonged working hours per shift, long duration of sitting work without a break, feeling pressure due to work and working postures) and individual factors (including age, gender, BMI and regular sport/physical activities) were associated with musculoskeletal symptoms in multiple logistic regression models. The findings add to the understanding of working conditions of those jobs involving sewing activities and emphasise the need for ergonomic interventions to reduce musculoskeletal symptoms in the future.

- **Keywords:** Sewing operation; MSDs; RULA


Maintaining the musculoskeletal health of children using mobile information and communication technologies (ICT) at home presents a challenge. The physical environment influences postures during ICT use and can contribute to musculoskeletal complaints. Few studies have assessed postures of children using ICT in home environments. The present study investigated the Rapid Upper Limb Assessment (RULA) scores determined by 16 novice and 16 experienced raters. Each rater viewed 11 videotaped scenarios of a child using two types of mobile ICT at home. The Grand Scores and Action Levels determined by study participants were compared to those of an ergonomist experienced in postural assessment. All postures assessed were rated with an Action Level of 2 or above; representing a postural risk that required further investigation and/or intervention. The sensitivity of RULA to assess some of the unconventional postures adopted by children in the home is questioned.

- **Keywords:** Minimising risk; Mobile technologies; Rapid Upper Limb Assessment (RULA)


The purpose of this study was to characterize the inter-rater reliability of two physical exposure assessment methods of the upper extremity, the Strain Index (SI) and Occupational Repetitive Actions (OCRA) Checklist. These methods are commonly used in occupational health studies and by occupational health practitioners. Seven raters used the SI and OCRA Checklist to assess task-level physical exposures to the upper extremity of workers performing 21 cheese manufacturing tasks. Inter-rater reliability was characterized using a single-measure, agreement-based intraclass correlation coefficient (ICC). Inter-rater reliability of SI assessments was moderate to good (ICC = 0.59, 95% CI: 0.45–0.73), a similar finding to prior studies. Inter-rater reliability of OCRA Checklist assessments was excellent (ICC = 0.80, 95% CI: 0.70–0.89). Task complexity had a small, but non-significant, effect on inter-rater reliability SI and OCRA Checklist scores. Both the SI and OCRA Checklist assessments possess adequate inter-rater reliability for the purposes of occupational health research and practice. The OCRA Checklist inter-rater reliability scores were among the highest reported in the literature for semi-quantitative physical exposure assessment tools of the upper extremity. The OCRA Checklist however, required more training time and time to conduct the risk assessments compared to the SI.
Keywords: Exposure assessment; Inter-rater reliability; Upper extremity musculoskeletal disorders


Job rotation is often recommended to optimize physical work demands and prevent work-related musculoskeletal complaints, but little is known about possible facilitators and barriers to its usefulness and ease of use. Following a qualitative research design, semi-structured interviews with employers (n = 12) and workers (n = 11) from the construction industry were conducted. Organizational climate, job autonomy, job characteristics and work processes were mentioned as either facilitators or barriers on an organizational level. Worker characteristics, work behavior and attitude were mentioned as either facilitators or barriers on an individual level. Following a structured approach to assess usefulness of job rotation to optimize physical work exposures and identifying barriers to usefulness and ease of use in relevant stakeholder groups is necessary in order to select or develop strategies to overcome these barriers, or to reject job rotation as a useful or easy to use intervention in the given context.

Keywords: Job rotation; Musculoskeletal complaints; Qualitative research


Data from 15 jewellery students, in their 1st and 3rd years of training, were analysed to show how data collected from work settings can be used to objectively evaluate performance in the use of tools. Participants were asked to use a piercing saw to cut 5 lines in a piece of metal. Performance was categorised in terms of functional dynamics. Data from strain gauges and a tri-axial accelerometer (built into the handle of the saw) were recorded and thirteen metrics derived from these data. The key question for this paper is which metrics could be used to distinguish levels of ability. Principal Components Analysis identified five components: sawing action; grasp of handle; task completion time; lateral deviation of strokes; and quality of lines cut. Using representative metrics for these components, participants could be ranked in terms of performance (low, medium, high) and statistical analysis showed significant differences between participants on key metrics.

Keywords: Tool use; Jewellery making; Functional dynamics

M. Faiz Syuaib. Anthropometric study of farm workers on Java Island, Indonesia, and its implications for the design of farm tools and equipment. Pages 222-235.

Anthropometric data are a prerequisite for designing agricultural tools and equipment that enable workers to achieve better performance and productivity while providing better safety and comfort. A set of thirty anthropometric dimensions was collected from a total sample of 371 male and female farm-workers from three different regions (west, central and east) of Java Island, Indonesia. The mean stature is 162.0 cm and 152.5 cm, the sitting height is 82.9 cm and 77.4 cm, and the body weight is 57.1 kg and 52.3 kg for male and female subjects, respectively. The index of relative sitting height (RSH) was 0.51 on average for both male and female subjects. Significant differences are found in most of the anthropometric dimensions between gender and regional data groups as well. Compared with groups of people from several other countries, the anthropometric
dimensions of Indonesian people are quite similar to Indian people, but are relatively smaller than Filipino, Chinese, Japanese, British, and American people. An attempt was conducted to illustrate the use of this anthropometric database and ergonomic considerations in refining the design of traditional tools and equipment commonly in use for rice farming operations.

- **Keywords:** Anthropometry; Farm worker; Tool design


The clip fitting task is a frequently encountered assembly operation in the car industry. It can cause upper limb pain. During task laboratory simulations, upper limb muscular activity and external force were compared for 4 clip fitting methods: with the bare hand, with an unpowered tool commonly used at a company and with unpowered and powered prototype tools. None of the 4 fitting methods studied induced a lower overall workload than the other three. Muscle activity was lower at the dominant limb when using the unpowered tools and at the non-dominant limb with the bare hand or with the powered tool. Fitting clips with the bare hand required a higher external force than fitting with the three tools. Evaluation of physical workload was different depending on whether external force or muscle activity results were considered. Measuring external force only, as recommended in several standards, is insufficient for evaluating physical workload.

- **Keywords:** Engineering; Physical workload; Surface electromyography


A smaller screen of smartwatches compare to conventional mobile devices such as PDAs and smartphones is one of the main factors that makes users to input texts difficult. However, several studies have only proposed a concept for entering texts for smartwatches without usability tests while other studies showed low text input performance. In this study, we proposed a new text entry method called Virtual Sliding QWERTY (VSQ) which utilizes a virtual qwerty-layout keyboard and a ‘Tap-N-Drag’ method to move the keyboard to the desired position. In addition, to verify VSQ we conducted a usability test with 20 participants for a combination of 5 key sizes and 4 CD-gains. As a result, VSQ achieved an average of 11.9 Words per Minute which was higher than previous studies. In particular, VSQ at 5 × 5 key size and 2×, or 3× CD-gain had the highest performance in terms of the quantitative and qualitative usability test.

- **Keywords:** Smartwatch; Ultra small display; Text entry; Qwerty keyboard; Tap-N-Drag


The increasing number of handheld mobile devices used today and the increasing dependency on them in the workplace makes understanding how users interact with these devices critical. This study seeks to understand how user error changes based on user age as well as input content type on ruggedized handheld devices. Participants completed data entry tasks of word and character input on two different devices, a physical keypad and touchscreen device. The number of errors and types of error, corrected and permanent were collected for each participant. Based on results on the
study, touchscreen devices proved to be the optimal ruggedized handheld device to minimize user error.

- **Keywords:** User error; Handheld devices; Generation

**Sara Dockrell, Ciaran Simms, Catherine Blake. Schoolbag carriage and schoolbag-related musculoskeletal discomfort among primary school children. Pages 281-290.**

Schoolbag carriage is a common occurrence and has been associated with musculoskeletal discomfort in children. The current study investigated the relationship between schoolbag-related musculoskeletal discomfort and individual, physical and psychosocial risk factors in primary school children in Ireland. A cross-sectional survey and pretest–posttest quasi-experimental design was used. The site and intensity of musculoskeletal discomfort was assessed before and after schoolbag carriage to provide a dose-response assessment of schoolbag-related discomfort for the first time. Objective measurements of the children, schoolbags and other additional items were made, and a researcher assisted questionnaire was completed on arrival at school. A total of 529 children (male 55.8%; female 44.2%) with a mean age of 10.6 years ± 7.14 months were included. The majority had backpacks (93.8%) and 89.7% (n = 445) carried the backpack over 2 shoulders. The mean schoolbag weight (4.8 ± 1.47 kgs) represented a mean % body weight (%BW) of 12.6 ± 4.29%. Only 29.9% carried schoolbags that were ≤10%BW. A significantly greater proportion of normal weight children carried schoolbags that were ≥10%BW compared to overweight/obese children (p < 0.001). The mean %BW carried was 18.3 ± 5.03 for those who had an additional item. The majority (77.5%) carried schoolbags to school for ≤10 min. The prevalence of baseline musculoskeletal discomfort was high (63.4%). Schoolbag-related discomfort was reported more frequently in the shoulders (27.3%) than in the back (15%). The dose-response assessment indicated that both statistically and meaningfully significant increases in discomfort were observed following schoolbag carriage. Multiple logistic regression models indicated that psychosocial factors and a history of discomfort were predictors of schoolbag-related back discomfort, while gender (being female) and a history of discomfort were predictors of schoolbag-related shoulder discomfort. None of the physical factors (absolute/relative schoolbag weight, carrying an additional item, duration of carriage, method of travel to school) were associated with schoolbag-related discomfort. This study highlights the need to consider the multi-factorial nature of schoolbag-related discomfort in children, and also the need to identify background pain as its presence can inadvertently influence the reporting of 'schoolbag-related' discomfort if it is not accounted for.

- **Keywords:** Schoolbag; Children; Schoolbag weight; Schoolbag-related musculoskeletal discomfort


The trade-off between feasibility and accuracy of measurements of physical exposure at the workplace has often been discussed, but is insufficiently understood. We therefore explored the effect of two low-back loading measurement tools with different accuracies on exposure estimates and their associations with low-back pain (LBP). Low-back moments of 93 workers were obtained using two methods: a moderately accurate observation-based method and a relatively more accurate video-analysis method. Group-based exposure metrics were assigned to a total of 1131 workers who reported on their LBP status during three follow-up years. The two methods were compared regarding
individual and group-based moments and their predictive value for LBP. Differences between the two methods for peak moments were high at the individual level and remained substantial at group level. For cumulative moments, differences between the two methods were attenuated as random inaccuracies cancelled out. Peak moments were not predictive for LBP in any method while cumulative moments were, suggesting comparable predictive values of the two methods. While assessment of low-back load improves from investing in collecting relatively more accurate individual-based data, this does not necessarily lead to better predictive values on a group level, especially not for cumulative loads.

- **Keywords:** Low-back load; Exposure assessment; Low-back pain; Accuracy

**Simone Nyholm Andersen, Ole Broberg. Participatory ergonomics simulation of hospital work systems: the influence of simulation media on simulation outcome. Pages 331-342.**

Current application of work system simulation in participatory ergonomics (PE) design includes a variety of different simulation media. However, the actual influence of the media attributes on the simulation outcome has received less attention. This study investigates two simulation media: full-scale mock-ups and table-top models. The aim is to compare, how the media attributes of fidelity and affordance influence the ergonomics identification and evaluation in PE design of hospital work systems. The results illustrate, how the full-scale mock-ups’ high fidelity of room layout and affordance of tool operation support ergonomics identification and evaluation related to the work system entities space and technologies & tools. The table-top models’ high fidelity of function relations and affordance of a helicopter view support ergonomics identification and evaluation related to the entity organization. Furthermore, the study addresses the form of the identified and evaluated conditions, being either identified challenges or tangible design criteria.

- **Keywords:** Participatory simulation; Hospital work systems; Participatory ergonomics

**Julie Paxion, Edith Galy, Catherine Berthelon. Overload depending on driving experience and situation complexity: which strategies faced with a pedestrian crossing? Pages 343-349.**

The purpose of this study was to identify the influence of situation complexity and driving experience on subjective workload and driving performance, and the less costly and the most effective strategies faced with a hazard pedestrian crossing. Four groups of young drivers (15 traditionally trained novices, 12 early-trained novices, 15 with three years of experience and 15 with a minimum of five years of experience) were randomly assigned to three situations (simple, moderately complex and very complex) including unexpected pedestrian crossings, in a driving simulator. The subjective workload was collected by the NASA-TLX questionnaire after each situation. The main results confirmed that the situation complexity and the lack of experience increased the subjective workload. Moreover, the subjective workload, the avoidance strategies and the reaction times influenced the number of collisions depending on situation complexity and driving experience. These results must be taken into account to target the prevention actions.

- **Keywords:** Subjective workload; Driving experience; Situation complexity

This study compared the ability of forty anaesthetists to judge absolute levels of oxygen saturation, direction of change, and size of change in saturation using auditory pitch and pitch difference in two laboratory-based studies that compared a linear pitch scale with a logarithmic scale. In the former the differences in saturation become perceptually closer as the oxygenation level becomes higher whereas in the latter the pitch differences are perceptually equivalent across the whole range of values. The results show that anaesthetist participants produce significantly more accurate judgements of both absolute oxygenation values and size of oxygenation level difference when a logarithmic, rather than a linear, scale is used. The line of best fit for the logarithmic function was also closer to $x = y$ than for the linear function. The results of these studies can inform the development and standardisation of pulse oximetry tones in order to improve patient safety.

**Keywords:** Pulse oximetry; Patient monitoring; Patient safety; Auditory perception

**Arthur Stewart, Robert Ledingham, Graham Furnace, Alan Nevill. Body size and ability to pass through a restricted space: Observations from 3D scanning of 210 male UK offshore workers. Pages 358-362.**

Offshore workers are subjected to a unique physical and cultural environment which has the ability to affect their size and shape. Because they are heavier than the UK adult population we hypothesized they would have larger torso dimensions which would adversely affect their ability to pass one another in a restricted space. A sample of 210 male offshore workers was selected across the full weight range, and measured using 3D body scanning for shape. Bideltoid breadth and maximum chest depth were extracted from the scans and compared with reference population data. In addition a size algorithm previously calculated on 44 individuals was applied to adjust for wearing a survival suit and re-breather device. Mean bideltoid breadth and chest depth was 51.4 cm and 27.9 cm in the offshore workers, compared with 49.7 cm and 25.4 cm respectively in the UK population as a whole. Considering the probability of two randomly selected people passing within a restricted space of 100 cm and 80 cm, offshore workers are 28% and 34% less likely to pass face to face and face to side respectively, as compared with UK adults, an effect which is exacerbated when wearing personal protective equipment.

**Keywords:** Body size; 3D scanning; Bideltoid breadth; Chest depth; Restricted space

**Jie Yang, Wenguo Weng, Ming Fu. A coupling system to predict the core and skin temperatures of human wearing protective clothing in hot environments. Pages 363-369.**

The aim of this study is to predict the core and skin temperatures of human wearing protective clothing in hot environments using the coupling system. The coupling system consisted of a sweating manikin Newton controlled by a multi-node human thermal model, and responded dynamically to the thermal environment as human body. Validation of the coupling system results was conducted by comparison with the subject tests. Five healthy men wearing protective clothing were exposed to the thermal neutral and high temperature environments. The skin temperatures of seven body segments and the rectal temperatures were recorded continuously. The predictions of core temperatures made by the coupling system showed good agreement with the experimental data, with maximum difference of 0.19 °C and RMSD of 0.12 °C. The predicted mean skin temperatures fell outside of the 95% CI for most points, whereas the difference between the simulated results and measured data was no more than 1 °C which is acceptable. The coupling system predicted the local skin temperatures reasonably with the maximum local skin temperature of 1.30 °C. The coupling system
has been validated and exhibited reasonable accuracy compared with the experimental results.

- **Keywords:** Core temperature; Skin temperature; Subject tests; Coupling system; Hot environment

**Paul Rothmore, Paul Aylward, Jonathan Karnon. The implementation of ergonomics advice and the stage of change approach. Pages 370-376.**

This paper investigates the implementation of injury prevention advice tailored according to the Stage of Change (SOC) approach. The managers of 25 workgroups, drawn from medium to large companies across a wide range of occupational sectors were allocated to receive either standard ergonomics advice or ergonomics advice tailored according to the workgroup SOC. Twelve months after the advice was provided, semi-structured interviews were conducted with each manager. In a multivariate model, managers who had received tailored advice were found to have implemented significantly more of the recommended changes (IRR = 1.68, 95% CI 1.07–2.63) and more “additional” changes (IRR = 1.90, 95% CI 1.12–3.20). Qualitative analysis identified that the key barriers and facilitators to the implementation of changes were largely related to worker resistance to change and the attitudes of senior managers towards health and safety. The findings from this study suggest that the implementation of ergonomics recommendations may be improved by the tailoring of advice according to SOC principles.

- **Keywords:** Stage of Change; Implementation; Ergonomics interventions

**Morteza Tehrani, Brett R.C. Molesworth. Pre-flight safety briefings, mood and information retention. Pages 377-382.**

Mood is a moderating factor that is known to affect performance. For airlines, the delivery of the pre-flight safety briefing prior to a commercial flight is not only an opportunity to inform passengers about the safety features on-board the aircraft they are flying, but an opportunity to positively influence their mood, and hence performance in the unlikely event of an emergency. The present research examined whether indeed the pre-flight safety briefing could be used to positively impact passengers' mood. In addition, the present research examined whether the recall of key safety messages contained within the pre-flight safety briefing was influenced by the style of briefing. Eighty-two participants were recruited for the research and divided into three groups; each group exposed to a different pre-flight cabin safety briefing video (standard, humorous, movie theme). Mood was measured prior and post safety briefing. The results revealed that pre-flight safety briefing videos can be used to manipulate passengers' mood. Safety briefings that are humorous or use movie themes to model their briefing were found to positively affect mood. However, there was a trade-off between entertainment and education, the greater the entertainment value, the poorer the retention of key safety messages. The results of the research are discussed from both an applied and theoretical perspective.

- **Keywords:** Mood; Memory; Aviation; Cabin safety; Pre-flight safety briefing

**H.S. Loo, Paul H.P. Yeow. Effects of two ergonomic improvements in brazing coils of air-handler units. Pages 383-391.**

The research aims to address the physically loading task and quality and productivity problems in the brazing of coils of air-handler units. Eight operators participated in two intervention studies conducted in a factory in Malaysia to compare the status quo brazing with (1) the use of a new twin-brazing torch that replaced the single-brazing gun and (2) brazing in a sitting position. The outcome measures are related to quality, productivity, monetary costs, body postures and symptoms. After baseline, Interventions I and II
were applied for 3 months respectively. The results show a 58.9% quality improvement, 140% productivity increase and 113 times ROI. There was also a reduction in poor work postures e.g. in the raising of the arms and shoulders; bending, twisting and extending of the neck; and bending of left and right wrists, and the back. This research can be replicated in other factories that share similar processes.

- **Keywords:** Work postures; Twin-brazing torch; Musculoskeletal symptoms; Productivity; Quality; Cost savings

Nicole E. Werner, Richard J. Holden. *Interruptions in the wild: development of a sociotechnical systems model of interruptions in the emergency department through a systematic review.* Pages 244-254.

Interruptions are unavoidable in the “interrupt driven” Emergency Department (ED). A critical review and synthesis of the literature on interruptions in the ED can offer insight into the nature of interruptions in complex real-world environments. Fifteen empirical articles on interruptions in the ED were identified through database searches. Articles were reviewed, critiqued, and synthesized. There was little agreement and several gaps in conceptualizing sociotechnical system factors, process characteristics, and interruption outcomes. While multiple outcomes of interruptions were mentioned, few were measured, and the relationship between multiple outcomes was rarely assessed. Synthesizing the literature and drawing on ergonomic concepts, we present a sociotechnical model of interruptions in complex settings that motivates new directions in research and design. The model conceptualizes interruptions as a process, not a single event, that occurs within and is shaped by an interacting socio-technical system and that results in a variety of interrelated outcomes.

- **Keywords:** Interruptions; Emergency medicine; Sociotechnical systems


The purpose of this study was to identify and summarize the current research evidence on approaches to preventing musculoskeletal disorders (MSD) within Occupational Health and Safety Management Systems (OHSMS). Databases in business, engineering, and health and safety were searched and 718 potentially relevant publications were identified and examined for their relevance. Twenty-one papers met the selection criteria and were subjected to thematic analysis. There was very little literature describing the integration of MSD risk assessment and prevention into management systems. This lack of information may isolate MSD prevention, leading to difficulties in preventing these disorders at an organizational level. The findings of this review argue for further research to integrate MSD prevention into management systems and to evaluate the effectiveness of the approach.

- **Keywords:** Occupational Health and Safety Management Systems; Integrated management systems; Risk assessment; Ergonomics; Participative ergonomics


This systematic literature review provides information on the use of mixed methods research in human factors and ergonomics (HFE) research in health care. Using the PRISMA methodology, we searched four databases (PubMed, PsycInfo, Web of Science,
and Engineering Village) for studies that met the following inclusion criteria: (1) field study in health care, (2) mixing of qualitative and quantitative data, (3) HFE issues, and (4) empirical evidence. Using an iterative and collaborative process supported by a structured data collection form, the six authors identified a total of 58 studies that primarily address HFE issues in health information technology (e.g., usability) and in the work of healthcare workers. About two-thirds of the mixed methods studies used the convergent parallel study design where quantitative and qualitative data were collected simultaneously. A variety of methods were used for collecting data, including interview, survey and observation. The most frequent combination involved interview for qualitative data and survey for quantitative data. The use of mixed methods in healthcare HFE research has increased over time. However, increasing attention should be paid to the formal literature on mixed methods research to enhance the depth and breadth of this research.

- **Keywords:** Mixed methods research; Health care; Systematic review; Qualitative and quantitative data