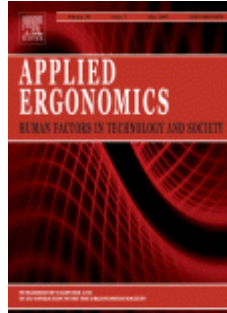


## **Applied Ergonomics - rok 2007, ročník 38**

### **Číslo 5 (September 2007)**



**Danielle R. Bouchard and François Trudeau. *Reliability of the assessment of the oxygen/heart rate relationship during a workday.* Pages 491-497.**

The purpose of the present study was to evaluate the reliability of the oxygen consumption/heart rate ( $VO_2/HR$ ) relationship used to estimate energy expenditure during a workday. Before and after a 6–10 h work shift, the  $VO_2/HR$  relationship was measured in 57 workers (28 female, 29 male) in our laboratory.  $VO_2$  was similar before and after the shift at HR of 100 and 125 beats per minute (bpm). However, the  $VO_2/HR$  relation and perceived exertion (RPE) became less accurate after a work shift as  $VO_2$  and RPE were, respectively, increased at HR above 150 and 125 bpm. Increase of RPE for a same exercise intensity was higher in female subjects. Our results suggest good reliability of the  $VO_2/HR$  relationship at HR usually found in workplaces.

- **Keywords:**  $VO_2/HR$  relationship; Cardiovascular drift; Perceived exertion

**P. Adams and G.C. David. *Light vehicle fuelling errors in the UK : The nature of the problem, its consequences and prevention.* Pages 499-511.**

Errors arising during the fuelling of light vehicles are increasing. It is estimated that around 300,000 misfuellings occurred in the UK in 2001 alone, with direct costs of approximately £35 million and considerable inconvenience caused to all those involved.

This study has investigated the causes of fuelling errors. A hierarchical task analysis of the fuelling of light vehicles was developed and data gathered from 23 individuals who had misfuelled. Errors were found to have occurred because the physical and psychological conditions on the filling station forecourt presented sufficient opportunity for an error producing sequence of events to be triggered. These occurred when specific factors were present either singly or in combination in the fuelling environment, creating an error 'pathway'. The probability of an error occurring is dependent upon the strength and type of influence these factors have on the performance of the fuelling task.

It is proposed that errors are best prevented by applying ergonomic principles to the design, and/or modification of filling station layout and equipment. In this way, the error pathways may be broken and successful fuelling encouraged.

- **Keywords:** Error; Vehicles; Fuelling

**Maaria Nuutinen, Paula Savioja and Sanna Sonninen. *Challenges of developing the complex socio-technical system : realising the present, acknowledging the past, and envisaging the future of vessel traffic services.* Pages 513-524.**

This paper raises the question of how to guide the development of an emerging complex socio-technical system. The empirical basis for the discussion is a study of Vessel Traffic Services (VTS). We analysed the current state and the history of the service in Finland in four studies and identified several development needs. The results showed that there are differences between the outcome, practices and conceptions of the core task across different experts in the VTS centres, which can be explained by the current state of the constituents and the history of the activity system. Qualitatively different development phases characterised either by a top-down standardisation or bottom-up construction process were recognised. A combination of these processes was suggested for the future development strategy of the VTS. This could allow both continuous development within VTS and recognition of the need for a new system. A promising way to achieve continuous development is by creating reflective practices supported for instance with annual simulator exercises aimed at procedure development. We conclude that solving the current problems and promoting the development of the complex system call for a dynamic, open vision of the target future of the system, in which the pressures from the social, political and technological environments are taken into account. The results of ergonomics studies can help in self-reflecting, envisaging and developing supportive methods for the system but the persons within the system create the will to develop and find their way towards the development horizon.

- **Keywords:** Vessel traffic services; Core-task analysis; Maritime traffic safety and security authorities; Work practices; Methods

**Hui Dong, Peter Loomer, Alan Barr, Charles LaRoche, Ed Young and David Rempel. *The effect of tool handle shape on hand muscle load and pinch force in a simulated dental scaling task.* Pages 525-531.**

Work-related upper extremity musculoskeletal disorders, including carpal tunnel syndrome, are prevalent among dentists and dental hygienists. An important risk factor for developing these disorders is forceful pinching which occurs during periodontal work such as dental scaling. Ergonomically designed dental scaling instruments may help reduce the prevalence of carpal tunnel syndrome among dental practitioners. In this study, eight custom-designed dental scaling instruments with different handle shapes were used by 24 dentists and dental hygienists to perform a simulated tooth scaling task. The muscle activity of two extensors and two flexors in the forearm was recorded with electromyography while thumb pinch force was measured by pressure sensors. The results demonstrated that the instrument handle with a tapered, round shape and a 10 mm diameter required the least muscle load and pinch force when performing simulated periodontal work. The results from this study can guide dentists and dental hygienists in selection of dental scaling instruments.

- **Keywords:** Dentistry; Hand tool; Electromyography

**Angela DiDomenico, Raymond W. McGorry and Chien-Chi Chang. *Association of subjective ratings of slipperiness to heel displacement following contact with the floor.* Pages 533-539.**

Falls precipitated by slipping are listed among the leading causes of occupational injuries. Several factors may influence the risk of slips and falls, including perception of surface conditions. The current research examined the relationship between perceptions of slipperiness and slip distance at heel strike. The investigation compared objective and

subjective measures for 31 participants ranging in age from 19 to 67 years old. Subjective slipperiness ratings for several floor surface and walking velocity conditions were obtained. Small slips were not generally perceived, but a uniform slip distance threshold could not be identified due to the large variability in ratings. The Pearson correlation coefficient between slip distance and subjective ratings for slides (30–100 mm) was  $r=-0.17$ . Results indicate that subjective ratings should be used cautiously as a measure of slipperiness, partially due to possible underestimation of slipperiness and the variability in perceptions.

- **Keywords:** Slips and falls; Slip distance; Subjective ratings of floor slipperiness

**Stephanie A. Southard and Gary A. Mirka. *An evaluation of backpack harness systems in non-neutral torso postures.* Pages 541-547.**

Much of the research on backpack design has been focused on spinal loading/biomechanics while the wearer is in a neutral/upright trunk posture, such as those employed by outdoor enthusiasts and schoolchildren. This research has led to some important harness design improvements that reduce trunk muscle exertions, fatigue and improve overall comfort. There are number of occupations, however, wherein workers wear back-mounted packs/devices (e.g. air tanks) while working in non-neutral trunk postures. The objective of the current study was to evaluate the effects of these non-neutral postures on biomechanical loading and then reconsider the backpack system design recommendations. Fifteen participants were asked to support a 18.2 kg load on their back while assuming static forward flexed postures of the torso (15°, 30°, 45°, and 60° of sagittal bend). The mass on the back was attached to the participant through two different harness mechanisms: a basic harness design (as seen on college student backpacks) and a more advanced design containing lateral stiffness rods and a weight-bearing hip belt (as seen on backpacks for hikers). While performing these static, posture maintenance tasks, the activation levels of the bilateral trapezius, erector spinae, and rectus abdominis were collected. Participants also provided subjective ratings of comfort. The results showed that there was a significant interaction between harness type and forward flexion angle for the trapezius and the erector spinae muscles. The normalized EMG for the trapezius muscles showed a 14% and 11% reduction in muscle activity at 15° and 30°, respectively, with the advanced design but these positive effects of the advanced design were not found at the greater flexion angles. Likewise the erector spinae muscles showed a 24% and 14% reduction in muscle activity at 15° and 30°, respectively, with the advanced design harness but these effects of the advanced design were not found at the greater forward flexion angles. The level of forward flexion angle affected the rectus abdominis muscle activity, but neither the harness type main effect nor the interaction of harness type and forward flexion angle was significant. The subjective survey results agreed with the EMG results and showed the advanced design harness was generally more comfortable with respect to the shoulder and low back areas. Collectively, the subjective and objective results show a significant improvement with the advanced harness system but also note an interesting interaction with degree of sagittal flexion, indicating a diminished effectiveness of the design improvements at forward flexed postures. Design criteria for harness systems in these forward flexed postures are discussed.

- **Keywords:** Backpack; Electromyography; Awkward postures

**Robert H. Meyer and Robert G. Radwin. *Comparison of stoop versus prone postures for a simulated agricultural harvesting task.* Pages 549-555.**

Physical and psychophysical differences between working in the stooped and prone postures were compared while performing a simulated agricultural harvesting task for 30 min. Fifteen male subjects participated. The measures used to compare the two

postures included perceived discomfort, electromyography (EMG), and heart rate (HR). Average hamstrings localized discomfort (0–10 scale) was 6.17 (SD=2.9) for the stoop posture and 0.67 (SD=1.29) for the prone posture. Erector spinae and hamstring EMG RMS increased 68% and 18%, respectively, while mean power frequency for the hamstrings decreased 13% for the stoop task. Mean power frequency for the middle trapezius muscle decreased in both postures (stoop 4.13%, prone 3.79%). Average heart rate during the last work cycle was 35% greater than the resting heart rate for the stoop posture while average heart rate was 17% greater for the prone posture. Subjects worked on the prone workstation without rest during the 15 min work simulations with less discomfort, no localized fatigue in the back or leg muscles tested, and lower working heart rates than subjects working in the stoop posture.

- **Keywords:** Agriculture; Posture; Fatigue

**Pamela Entzel, Jim Albers and Laura Welch. Best practices for preventing musculoskeletal disorders in masonry: Stakeholder perspectives. Pages 557-566.**

Brick masons and mason tenders report a high prevalence of work-related musculoskeletal disorders (WMSDs), many of which can be prevented with changes in materials, work equipment or work practices. To explore the use of “best practices” in the masonry industry, NIOSH organized a 2-day meeting of masonry stakeholders. Attendees included 30 industry representatives, 5 health and safety researchers, 4 health/safety specialists, 2 ergonomic consultants, and 2 representatives of state workers’ compensation programs. Small groups discussed ergonomic interventions currently utilized in the masonry industry, including factors affecting intervention implementation and ways to promote diffusion of interventions. Meeting participants also identified various barriers to intervention implementation, including business considerations, quality concerns, design issues, supply problems, jobsite conditions and management practices that can slow or limit intervention diffusion. To be successful, future diffusion efforts must not only raise awareness of available solutions but also address these practical concerns.

- **Keywords:** Masonry; Ergonomics; Intervention

**James T. Mathis and J. Keith Clutter. Evaluation of orientation and environmental factors on the blast hazards to bomb suit wearers. Pages 567-579.**

This paper discusses the use of 3-D computational fluid dynamics (CFD) software for simulation of explosive detonations against the wearer of a typical bomb suit. The focus is to demonstrate the utility of the model to assess the differential overpressure loads on the various bomb suit components protecting critical body parts. Since overpressures can vary significantly depending on the position and orientation of the wearer, simulations are performed for a range of orientations including kneeling and standing at common standoff distances. Overpressure loads on the head, neck, and torso regions are predicted for each orientation, capturing ground and other surface reflections that can enhance effects of the blast. This is not normally observed during tests of individual bomb suit components. Direct correlations between the suit orientation and environmental factors to load enhancements are documented, and an effort to address probable injury is made.

**Steven A. Lavender, Karen M. Conrad, Paul A. Reichelt, Aniruddha K. Kohok and Jessica Gacki-Smith. Designing ergonomic interventions for emergency medical services workers : part III : Bed to stairchair transfers. Pages 581-589.**

The objective of the current work was to test interventions aimed at reducing the low-back musculoskeletal loads experienced by firefighters/paramedics (FFPs) providing emergency medical services (EMS) that involve transferring a patient between a bed and a stairchair. The interventions, developed or selected using focus groups, were a prototype Drew People Mover™, and a Transfer Sling. These interventions changed the coupling between the EMS worker and the patient. They were compared with an under-axilla lift. Eleven FFP teams transferred a 75 kg dummy between a bed and a stairchair. Both interventions were tested using two-person transfers. In addition, the Transfer Sling was tested using a one-person transfer. Surface electromyographic (EMG) data were collected from 8 trunk muscles from each participant along with spine kinematic data. Additionally, ground reaction force data obtained from two forceplates were acquired for one member of each FFP team that was used to estimate directional spine moments using a 3D linked-segment model. In the two-person transfers, there was 19° less trunk flexion ( $p=0.002$ ) for the FFP on the patient's left side and a trend towards less motion for the FFP on the patient's *right* side ( $p=0.079$ ) when using the interventions. Both FFPs showed reductions in the ipsilateral Erector Spinae activity using the Drew People Mover and the Transfer Sling that averaged approximately 9% MVC, which corresponds to a 21% decrease in the muscle activation levels. While the overall EMG was greater when performing a single-FFP transfer, the Transfer Sling reduced the bilateral Erector Spinae activity by approximately 20%. During the two-person transfers, the FFP on the forceplate to the right side of the patient showed a reduction in the forward bending moment using the Drew People Mover relative to the Sling and under-axilla conditions. During the single-person transfers, only the twisting moment was significantly reduced through use of the Transfer Sling. These objective measures, when combined with the subjective ratings of perceived exertion and the verbal feedback lead us to recommend the use of these interventions for bed to stairchair transfers.

- **Keywords:** Low-back disorders; Emergency medical services; Intervention; Firefighter; Back pain

**Nancy L. Grugle and Brian M. Kleiner. *Effects of chemical protective equipment on team process performance in small unit rescue operations.* Pages 591-600.**

In the event of a nuclear, biological, or chemical terrorist attack against civilians, both military and civilian emergency response teams must be able to respond and operate efficiently while wearing protective equipment. Chemical protective equipment protects the user by providing a barrier between the individual and hazardous environment. Unfortunately, the same equipment that is designed to support the user can potentially cause heat stress, reduced task efficiency, and reduced range-of-motion. Targeted Acceptable Responses to Generated Events of Tasks (TARGETS), an event-based team performance measurement methodology was used to investigate the effects of Mission Oriented Protective Posture (MOPP) on the behavioral processes underlying team performance during simulated rescue tasks. In addition, this study determined which team processes were related to team performance outcomes. Results of six primary analyses indicated that team process performance was not degraded by MOPP 4 on any rescue task and that the team processes critical for successful task performance are task-dependent. This article discusses the implications of these results with respect to the study design and the limitations of using an event-based team performance measurement methodology.

- **Keywords:** Team performance; MOPP; Personal protective equipment; TARGETS

**Kong-King Shieh and Der-Song Lee. *Preferred viewing distance and screen angle of electronic paper displays.* Pages 601-608.**

This study explored the viewing distance and screen angle for electronic paper (E-Paper) displays under various light sources, ambient illuminations, and character sizes. Data analysis showed that the mean viewing distance and screen angle were 495 mm and 123.7°. The mean viewing distances for Kolin Chlorestic Liquid Crystal display was 500 mm, significantly longer than Sony electronic ink display, 491 mm. Screen angle for Kolin was 127.4°, significantly greater than that of Sony, 120.0°. Various light sources revealed no significant effect on viewing distances; nevertheless, they showed significant effect on screen angles. The screen angle for sunlight lamp (D65) was similar to that of fluorescent lamp (TL84), but greater than that of tungsten lamp (F). Ambient illumination and E-paper type had significant effects on viewing distance and screen angle. The higher the ambient illumination was, the longer the viewing distance and the lesser the screen angle. Character size had significant effect on viewing distances: the larger the character size, the longer the viewing distance. The results of this study indicated that the viewing distance for E-Paper was similar to that of visual display terminal (VDT) at around 500 mm, but greater than normal paper at about 360 mm. The mean screen angle was around 123.7°, which in terms of viewing angle is 29.5° below horizontal eye level. This result is similar to the general suggested viewing angle between 20° and 50° below the horizontal line of sight.

- **Keywords:** Electronic paper; Viewing distance; Screen angle

**Reuben Escorpizo and Anne Moore. *The effects of cycle time on the physical demands of a repetitive pick-and-place task.* Pages 609-615.**

This study seeks to elucidate the effects of the cycle time of a pick-and-place task on muscle activity, grip force, posture, and perception-based measures (discomfort and difficulty). Six healthy adults (3 males, 3 females) participated. A 4×2 repeated measures design was used with cycle time (1, 2, 5, and 10 s) and grip (power and chuck) as independent variables. The task consists of repetitively picking a 0.7 kg part and placing it into a bin. A reduction in cycle time (CT) resulted in both a decrease of task time and physical rest time ( $p < 0.001$ ). The physiological muscle rest was much lower than the physical rest time ( $p < 0.05$ ). An increase in static muscle loading ( $p < 0.01$ ), grip force ( $p < 0.001$ ), and discomfort ( $p < 0.001$ ) were also observed. These results suggest that a pace threshold (between 2 and 5 s for this task) is reached at a higher CT than that defined by the ability to perform the task.

- **Keywords:** Pick-and-place; Cycle time; Work-related musculoskeletal disorders

**Alireza Choobineh, Mostafa Hosseini, Mohammadali Lahmi, Reza Khani Jazani and Houshang Shahnava. *Musculoskeletal problems in Iranian hand-woven carpet industry : guidelines for workstation design.* Pages 617-624.**

Long hours of static work with awkward posture at traditionally designed looms can cause high prevalence of musculoskeletal disorders (MSDs) among carpet weavers. A comprehensive study was conducted in this industry with the objectives of determination of MSDs symptoms prevalence; identification of major factors associated with MSDs symptoms in carpet weaving occupation; and development of guidelines for weaving workstation design. In the present paper, this ergonomics study is presented.

The study consisted of two phases. In the first phase, MSDs symptoms in nine Iranian provinces were surveyed by questionnaire among 1439 randomly selected weavers. Working posture and weaving workstations were ergonomically assessed as well. The results of this phase revealed that symptoms from the musculoskeletal system occurred in high rate among weavers with the prevalence significantly higher than that of the general Iranian population ( $P < 0.001$ ). It was found that the majority of ergonomics shortcomings originated from ill-designed weaving workstation. Based on the findings, some general

guidelines for workstation design were presented. In the second phase, considering the general guidelines, an adjustable workstation was designed and constructed. To develop quantitative guidelines for optimizing workstation set-up, in the laboratory, nine sets of experimental conditions were tested, and working posture and weavers' perceptions were measured. The results of this lab work showed that working posture was acceptable for both the researchers and the weavers when the weaving height was adjusted 20 cm above the elbow height and a high seat with forward slope was used.

By combining the results of the two phases, guidelines for weaving workstation design were presented. In this ergonomics-oriented workstation, loom is vertical. Seat, loom and weaving heights are adjustable. There is enough leg room under the loom. The seat with 10° forward slope is adjusted 15 cm above the popliteal height of the weaver. Weaving height is set at 20 cm above the elbow height. It is believed that the recommended workstation improves working posture and results in reduced postural stress on weavers' bodies and, consequently, reduced prevalence of MSDs symptoms.

- **Keywords:** Hand-woven carpet industry; Musculoskeletal problems; Weaving workstation design

**Jean Lemoyne, Louis Laurencelle, Michel Lirette and François Trudeau. *Occupational health problems and injuries among Quebec's physical educators.* Pages 625-634.**

The purpose of this study was to describe the traumatology of teaching physical education (PE) and to document the causes and mechanisms of injuries in this occupation. Our sample was composed of 314 physical educators (PEs) teaching at three school levels (primary school, secondary school and college) who responded to a questionnaire survey. The results showed a 0.55 rate of recent lesion per teacher per year (0.65 for women and 0.51 for men). A total of 37.6% of subjects were affected by a lesion during the last year at work. Subjects with a higher weekly frequency of leisure physical activities or endurance activities (five times and more) were less affected by chronic lesions as well as those who frequently practiced aerobic physical activities. Prevalence of chronic injuries was higher in older teachers. Our results confirm that the rate of lesions in this group of workers is high, and that school level and respondent age may influence the rate of lesion and the characteristics of risk factors. In particular, the effect of ageing and teaching specialization on the incidence of occupational problems in PEs warrants further research. Given the relatively high rate of injuries among PE teachers, we suggest that it is necessary to further explore preventive strategies to reduce occupational risk in these workers. In particular, prophylactic physical activity outside of work may represent such a strategy since PEs more active outside their work have lower chronic injury prevalence. PEs gave long periods of standing the highest rating for movements or positions most likely to cause them occupational injuries. It can thus be suggested to find ways to reduce standing position sustained for long periods.

- **Keywords:** Lesions; Teachers; Physical demand

**Rie Tamagawa, Brenda Lobb and Roger Booth. *Tolerance of shift work.* Pages 635-642.**

This study aimed to explore criteria for shift work tolerance and to investigate the relationships between personality traits and states and shift work tolerance. Eighty-nine policemen and policewomen completed a questionnaire, once during consecutive night shifts and again during rotating shifts, and their responses were used to assess anxiety, emotional control, positive and negative affect, health complaints, sleep quality, difficulties in social and domestic life, and perceptions about shift work. Both the criteria for tolerance and the relationship between tolerance and personality varied according to shift type. Night shift tolerance involved four factors—*somatic health, flexibility, sleep*

and *sleep need*—while rotating shift tolerance involved three factors—*somatic health*, *flexibility* and *fatigue*. Tolerance of shift work was associated with anxiety, repressive emotional style and mood. During night shifts, anxiety was the most influential personality factor for the somatic health and sleep dimensions of shift tolerance. During rotating shifts, positive and negative moods, rather than trait personality factors, were important predictors of the somatic health and fatigue shift tolerance dimensions. These results suggest a mechanism for more effective matching of workers to suitable shift schedules.

- **Keywords:** Shift schedule; Physical symptoms; Trait anxiety; Emotional control; Behavioral traits; Mood

**L.F.M. Kuijt-Evers, T. Bosch, M.A. Huysmans, M.P. de Looze and P. Vink. *Association between objective and subjective measurements of comfort and discomfort in hand tools.* Pages 643-654.**

In the current study, the relationship between objective measurements and subjective experienced comfort and discomfort in using handsaws was examined. Twelve carpenters evaluated five different handsaws. Objective measures of contact pressure (average pressure, pressure area and pressure-time ( $P-t$ ) integral) in static and dynamic conditions, muscle activity (electromyography) of five muscles of the upper extremity, and productivity were obtained during a sawing task. Subjective comfort and discomfort were assessed using the comfort questionnaire for hand tools and a scale for local perceived discomfort (LPD). We did not find any relationship between muscle activity and comfort or discomfort. The  $P-t$  integral during the static measurement ( $\beta = -0.24$ ,  $p < 0.01$ ) was the best predictor of comfort and the pressure area during static measurement was the best predictor of LPD ( $\beta = 0.45$ ,  $p < 0.01$ ). Additionally, productivity was highly correlated to comfort ( $\beta = 0.31$ ,  $p < 0.01$ ) and discomfort ( $\beta = -0.49$ ,  $p < 0.01$ ).

- **Keywords:** Comfort/discomfort; Hand tools; Objective measurements

**Lilli Kirkeskov Jensen and Claus Friche. *Effects of training to implement new tools and working methods to reduce knee load in floor layers.* Pages 655-665.**

The purpose was to measure the effect of a participatory ergonomics implementation strategy consisting of information, education, and facilitation on the use of new tools and working methods in the floor laying trade. Floor layers ( $n = 292$ ) were trained in using new working methods. The effects were evaluated by using questionnaires, interviews, and assessments of quality and productivity. Following the training, 43% had used the new working methods weekly/daily compared to 11% before. There was a reduction in the degree of self-reported pain in the knees among the floor layers using the new working methods weekly or daily compared to those using them never or occasionally. The musculoskeletal complaints did not increase from any other region and the quality and the productivity of the work were not decreased. This indicates that within a 3-months perspective the implementation strategy succeeded.

- **Keywords:** Implementation; New working methods; Construction industry

**Chang-Franw Lee and Wang-Chin Tsai. *Mapping of user interfaces on electronic appliances.* Pages 667-674.**

The purpose of this study was to investigate mapping of user interfaces on consumer electronic appliances. A digital clock with five different interface modes was chosen for the experiment. Forty elderly subjects (above 65 years) and 40 middle-aged subjects



(45–64 years) participated in the study. Every subject had to complete three different tasks, namely time setting, alarm time setting and date setting. The researchers investigated what problems were encountered when performing these tasks and collected data such as operational time, the number of total inputs, subjective estimation and interview information. The findings of this study indicated that the interface modes had significant effects on operational time, the number of total inputs and subjective estimation. Finally, the study confirms that when the spatial relationship between buttons and display contents are clearly indicated, the operation is easier to complete.

- **Keywords:** The elderly; User interface; Mapping; Electronic appliance; Digital clock