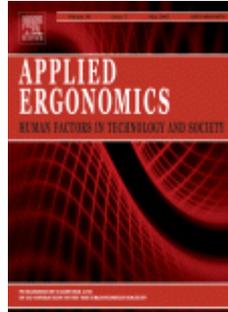


## **Applied Ergonomics - rok 2008, ročník 39**

### **Číslo 3 (May 2008)**



**Jennifer L. Martin, Beverley J. Norris, Elizabeth Murphy and John A. Crowe. *Medical device development : the challenge for ergonomics.* Pages 271-283.**

High quality, well-designed medical devices are necessary to provide safe and effective clinical care for patients as well as to ensure the health and safety of professional and lay device users. Capturing the user requirements of users and incorporating these into design is an essential component of this. The field of ergonomics has an opportunity to assist, not only with this area, but also to encourage a more general consideration of the user during medical device development. A review of the literature on methods for assessing user requirements in engineering and ergonomics found that little published work exists on the ergonomic aspects of medical device development. In particular there is little advice available to developers on which issues to consider during design and development or recommendations for good practice in terms of the methods and approaches needed to capture the full range of user requirements. The Multidisciplinary Assessment of Technology Centre for Health care (MATCH) is a research collaboration that is working in conjunction with industrial collaborators to apply ergonomics methods to real case study projects with the ultimate aim of producing an industry-focused guide to applying ergonomics principles in medical device development.

- **Keywords:** Medical device; Patient safety; User requirements

**Magne Helland, Gunnar Horgen, Tor Martin Kvikstad, Tore Garthus, Jan Richard Bruenech and Arne Aarås. *Musculoskeletal, visual and psychosocial stress in VDU operators after moving to an ergonomically designed office landscape.* Pages 284-295.**

This study investigated the effect of moving from single occupancy offices to a landscape environment. Thirty-four Visual Display Unit (VDU) operators reported significantly worsened condition of lighting and glare in addition to increased visual discomfort. For visual discomfort, the difference with 95% confidence interval was 10.7 (1.9–19.5) Visual Analog Scale (VAS) as group mean value. The most reasonable explanation for these results may be that the operators were glared from high luminance from the windows, when the Venetian blinds were not properly used. Glare was significantly correlated with visual discomfort,  $r_s=0.35$ . Both illuminance and luminance in the work area, and contrast reduction on the VDU screen were in line with recommendations from CIE for VDU work. In a regression analysis, the visual discomfort explained 53% of the variance in the neck and shoulder pain. In the office landscape, the eye blink rate during habitual

VDU work was recorded for 12 randomly selected operators from the 34 participants. A marked drop in eye blink rate during VDU work was found when this was compared to "easy conversation" (VDU work, mean=9.7 blinks per minute; "easy conversation," mean=21.4 blinks per minute). Participants reported many of the organizational and psychosocial conditions and work factors worse when landscape office was compared to single occupancy office. These factors may have influenced the musculoskeletal pain. However, the pain level was still low at 6 years and not significantly different when compared with the start of the study period, except for a small but significant increase in shoulder pain. In this study, visual discomfort is clearly associated with pain in the neck and shoulder area.

- **Keywords:** VDU workplaces; Lighting conditions; Visual conditions; Visual discomfort; Musculoskeletal illness; Eye blinking

**Eric E. Wickel and Raoul F. Reiser II. *The effect of floor slope on sub-maximal lifting capacity and technique.* Pages 296-304.**

Inclined surfaces, where both the lifter and load are on the slope, may be encountered in a jobsite situation. The purpose of this study was to determine if facing up or down a sloped surface (10° and 20°) would affect maximal acceptable weights of lift (MAWL) using a 10 min psychophysical approach with symmetric freestyle technique at 4 lifts/min. Seventeen healthy men and 18 women determined floor to knuckle height MAWL while facing uphill, downhill, and on a level surface. Motion capture was also performed to examine sagittal plane joint angles and foot placement relative to a milk crate. Slope did not alter MAWL ( $p > 0.05$ ) with the men lifting more than the women in every condition ( $p < 0.001$ ) (25 kg vs. 15 kg, respectively). Foot placement relative to the box was altered by slope such that both horizontal position behind and vertical position below the box increased as slope changed from the downhill to uphill conditions (both  $p < 0.001$ ). Forward torso lean as well as hip, knee, and ankle (plantar) flexion generally decreased as slope changed from the downhill to uphill conditions (all  $p < 0.001$ ). Torso and knee motion appeared to be protected compared to the other joints, changing the least. Though trends were the same in both sexes, interactions did exist in vertical foot position and hip angle (both  $p \leq 0.001$ ). In conclusion, the body is highly adaptive to floor slope, maintaining MAWL at least in the short term. However, while slight technique differences exist between men and women, care should be taken by all when facing uphill due to the tendency to stand further from the load horizontally and when facing downhill due to increased torso lean.

- **Keywords:** Incline; Psychophysical method; Low-back pain and injury; Sex

**Micky P. Kerr, David S. Knott, Michael A. Moss, Chris W. Clegg and Robin P. Horton. *Assessing the value of human factors initiatives.* Pages 305-315.**

This paper examines the effectiveness of human factors initiatives and addresses some difficulties reported in calculating the value of such interventions. Company representatives and researchers applied a novel probabilistic assessment tool to estimate the financial impact of two macro-ergonomic projects. Key benefits of the company intranet project include reduced administrative and operational costs compared to a paper-based system; time savings for users asking for, providing and receiving information; and improved system usability and higher levels of usage. The communities of practice project demonstrates value through more efficient distribution and retrieval of information; reduced duplication by re-using technical knowledge to solve similar problems and improved sharing of good working practices, lessons and resources. The strengths of the tool include transparency, being quick and easy to learn and the collaborative workshop format, involving researchers and key representatives from the organization. It makes a useful contribution to the challenge of assessing the financial

value of ergonomic interventions, and, by exploiting its diagnostic and planning capabilities, could be extended to other domains.

- **Keywords:** Human factors interventions; Value; Probabilistic assessment

**T. Murphy and M.L. Oliver. *Development and design of a dynamic armrest for hydraulic-actuation joystick controlled mobile machines.* Pages 316-324.**

Standard armrests used in conjunction with joysticks of heavy mobile machinery have been proven to inadequately meet operator needs, resulting in excessive static loading of shoulder musculature. During joystick operation, the trajectory of the user's forearm is governed by the motion of the controller, which creates horizontal and vertical movement of the forearm. The vertical motion of the forearm in the forward and backward motion create postures that stationary armrests cannot support thereby generating increased muscle activation and risk of repetitive strain injuries. The current paper describes the design process used in creating a dynamic armrest that replicates the operator's natural motion trajectories. By incorporating the natural motion paths into a dynamic armrest, the postural requirements and muscular activation of the operator's shoulder may be reduced.

- **Keywords:** Armrest; Joystick; Ergonomics

**Juhani Smolander, Tanja Juuti, Marja-Liisa Kinnunen, Kari Laine, Veikko Louhevaara, Kaisa Männikkö and Heikki Rusko. *A new heart rate variability-based method for the estimation of oxygen consumption without individual laboratory calibration : application example on postal workers.* Pages 325-331.**

Traditionally, the estimation of oxygen consumption ( $VO_2$ ) at work using heart rate (HR) has required the determination of individual HR/ $VO_2$  calibration curves in a separate exercise test in a laboratory ( $VO_2$ -TRAD). Recently, a new neural network-, and heart rate variability-based method has been developed (Firstbeat PRO heartbeat analysis software) for the estimation of  $VO_2$  without individual calibration ( $VO_2$ -HRV). In the present study, the  $VO_2$ -values by the  $VO_2$ -HRV were compared with the values by  $VO_2$ -TRAD in 22 postal workers. Within individuals the correlation between the two methods was high (range 0.80–0.99). The  $VO_2$ -TRAD gave higher values of  $VO_2$  compared to  $VO_2$ -HRV (19%) especially during low physical activity work when non-metabolic factors may increase HR. When assessed in different HR categories, the smallest difference (11%), and highest correlations (range 0.83–0.99) in  $VO_2$  between the methods were observed at higher HR levels. The results indicate that the  $VO_2$ -HRV is a potentially useful method to estimate  $VO_2$  in the field without laboratory calibration.

- **Keywords:** Oxygen consumption; Heart rate; Heart rate variability

**A. Van Brecht, D. Nuytens, J.M. Aerts, S. Quanten, G. De Bruyne and D. Berckmans. *Quantification of ventilation characteristics of a helmet.* Pages 332-341.**

Despite the augmented safety offered by wearing a cyclist crash helmet, many cyclists still refuse to wear one because of the thermal discomfort that comes along with wearing it. In this paper, a method is described that quantifies the ventilation characteristics of a helmet using tracer gas experiments. A Data-Based Mechanistic model was applied to provide a physically meaningful description of the dominant internal dynamics of mass transfer in the imperfectly mixed fluid under the helmet. By using a physical mass balance, the local ventilation efficiency could be described by using a single input–single

output system. Using this approach, ventilation efficiency ranging from 0.06 volume refreshments per second ( $s^{-1}$ ) at the side of the helmet to  $0.22 s^{-1}$  at the rear ventilation opening were found on the investigated helmet. The zones at the side were poorly ventilated. The influence of the angle of inclination on ventilation efficiency was dependent on the position between head and helmet. General comfort of the helmet can be improved by increasing the ventilation efficiency of fresh air at the problem zones.

- **Keywords:** Tracer gas; Grey box model; Ventilation efficiency

**Irina Rivilis, Dwayne Van Eerd, Kimberley Cullen, Donald C. Cole, Emma Irvin, Jonathan Tyson and Quenby Mahood. *Effectiveness of participatory ergonomic interventions on health outcomes : a systematic review.* Pages 342-358.**

The objective of this study was to conduct a systematic review of the literature on the effectiveness of participatory ergonomic (PE) interventions for improving workers' health. The search strategy targeted six electronic databases and identified 442 potential articles. Each article was examined by pairs of reviewers for relevance (assessed a participative ergonomic workplace intervention, with at least one health outcome, published in English in peer reviewed literature). Twenty-three articles met relevance criteria and were then appraised for methodological strength. Using a best evidence synthesis approach, 12 studies that were rated as 'medium' or higher provided partial to moderate evidence that PE interventions have a positive impact on: musculoskeletal symptoms, reducing injuries and workers' compensation claims, and a reduction in lost days from work or sickness absence. However, the magnitude of the effect requires more precise definition.

- **Keywords:** Participatory ergonomics; Health outcomes; Systematic review

**Wen-Ruey Chang, Yueng-Hsiang Huang, Kai Way Li, Alfred Filiaggi and Theodore K. Courtney. *Assessing slipperiness in fast-food restaurants in the USA using friction variation, friction level and perception rating.* Pages 359-367.**

Although friction variation is speculated to be a significant contributor to slip and fall incidents, it has not been related to a measurement of slipperiness in the literature. This field study investigated the relationship among multiple friction variations, friction levels and the perception ratings of slipperiness in six major working areas of 10 fast-food restaurants in the USA. The mean perception rating score for each working area was correlated with various friction reduction variables across all the restaurants in comparison with its correlation with the mean friction coefficient of each working area. The results indicated that the absolute and relative reductions in friction over the whole working area, among 12 friction reduction variables evaluated, could have a slightly better correlation with the perception rating score ( $r=0.34$  and  $0.37$ , respectively) than the mean friction coefficient of each working area ( $0.33$ ). However, in friction measurements, more effort and time are needed to quantify friction variations than to obtain the mean friction coefficient. The results of the multiple regression model on the perception rating indicated that adding friction reduction variables into the regression model, in addition to the mean friction coefficient, did not make a significant impact on the outcomes. The results further indicated a statistically significant correlation between the mean friction coefficient and the maximum relative friction reduction over the whole area in each working area across all the restaurants evaluated ( $r=0.80$ ). Despite a slightly lower correlation with perception rating than the friction variation, the mean friction coefficient of an area is still a reasonably good indicator of slipperiness.

- **Keywords:** Slip and fall incidents; Perception rating of slipperiness; Friction variation; Fast-food restaurants

**I. Aluclu, A. Dalgic and Z.F. Toprak. *A fuzzy logic-based model for noise control at industrial workplaces. Pages 368-378.***

Ergonomics is a broad science encompassing the wide variety of working conditions that can affect worker comfort and health, including factors such as lighting, noise, temperature, vibration, workstation design, tool design, machine design, etc. This paper describes noise-human response and a fuzzy logic model developed by comprehensive field studies on noise measurements (including atmospheric parameters) and control measures. The model has two subsystems constructed on noise reduction quantity in dB. The first subsystem of the fuzzy model depending on 549 linguistic rules comprises acoustical features of all materials used in any workplace. Totally 984 patterns were used, 503 patterns for model development and the rest 481 patterns for testing the model. The second subsystem deals with atmospheric parameter interactions with noise and has 52 linguistic rules. Similarly, 94 field patterns were obtained; 68 patterns were used for training stage of the model and the rest 26 patterns for testing the model. These rules were determined by taking into consideration formal standards, experiences of specialists and the measurements patterns. The results of the model were compared with various statistics (correlation coefficients, max-min, standard deviation, average and coefficient of skewness) and error modes (root mean square error and relative error). The correlation coefficients were significantly high, error modes were quite low and the other statistics were very close to the data. This statement indicates the validity of the model. Therefore, the model can be used for noise control in any workplace and helpful to the designer in planning stage of a workplace.

- **Keywords:** Ergonomics; Noise control; Fuzzy logic

**Ping-Huang Ting, Jiun-Ren Hwang, Chin-Ping Fung, Ji-Liang Doong and Ming-Chang Jeng. *Rectification of legibility distance in a driving simulator. Pages 379-384.***

Visual differences lead to differences in the legibility distances of traffic signs between driving simulators and real road environments. To ensure that the legibility distance in a simulator is similar to that in the real world, this study proposes a theoretical equation for predicting legibility distance and a simple algorithm for determining the magnifying power of a traffic sign for a display system in a simulator. Experiments of traffic sign recognition using a simulator were conducted under quasi-static and dynamic driving conditions. On-road tests were also carried out under quasi-static and dynamic driving conditions. Thirty healthy and non-disabled volunteers were recruited. The experimental results showed that the proposed theoretical equation for predicting legibility distance and the simple algorithm for determining the magnifying power of traffic signs reduced the difference in legibility distances between the simulator and real road environment under quasi-static and dynamic driving conditions.

- **Keywords:** Driving simulator; Legibility distance; Traffic sign

**Chuansi Gao, Ingvar Holmér and John Abeysekera. *Slips and falls in a cold climate : underfoot surface, footwear design and worker preferences for preventive measures. Pages 385-391.***

Slips and falls and associated outdoor injuries are prevalent in cold climates. The objectives of this field investigation were to describe the consequences of slips and falls on ice and snow and the associated injuries, to assess the risks of various icy and snowy surfaces, to identify design needs of footwear, and to ascertain preventive measure

preferences of outdoor workers. The organizations investigated were a newspaper delivery service, a military regiment, mining and construction industries. The results showed that fall events occur most frequently on ice covered with snow. This is due to the difficulty of perceiving hidden risks in order to adjust gait strategies. The professional footwear provided does not provide enough protection against slips and falls. Slip resistant properties are ranked as one of the top requirements by the users. Their most preferred preventive measures are footwear with anti-slip properties and the application of anti-slip materials, such as sand or salt.

- **Keywords:** Slip; Ice; Footwear; Prevention

**Daijiro Abe, Satoshi Muraki and Akira Yasukouchi. *Ergonomic effects of load carriage on the upper and lower back on metabolic energy cost of walking.* Pages 392-398.**

We examined the effects of load carriage position on the energy cost of walking defined as the ratio of the 2-min steady-state oxygen consumption to the speed and economical speed. Fourteen healthy men walked on a treadmill at various speeds without and with load on the lower and upper back, which corresponded to 15% of their body mass. The energy cost of walking significantly decreased during walking with load than without load at slower speeds. A significant decrease in the energy cost of walking was also observed while carrying the load on the upper back than on the lower back at 60–80 m/min. The economical speed significantly decreased when carrying the load on the upper and lower back, and it was significantly correlated with body height. These findings suggest that an optimal carrying method is evident to reduce physical stress during walking with loads.

- **Keywords:** Locomotion; Optimal speed; Free-ride

**Yung-Hui Lee and Mu-Chuan Su. *Design and validation of a desk-free and posture-independent input device.* Pages 399-406.**

This study investigates variations in performance, postures and strains on the hand–arm–shoulder musculature during the operation of a wireless mouse, trackpad and a new input device. The device is held between the flexed index and middle fingers with the palm facing sideways. The buttons and wheels are activated by flexion and/or rolling of the thumb. Eleven males and nine females participated in the study. All subjects performed an aiming task to test the pointing and dragging functions. The results of this study reveal that the new pointing device allowed users to adopt more ergonomic postures and has the advantage of reduced muscular loadings of the upper extremities. Mean (SD) muscular activities (%RVC) using the wireless mouse, the trackpad and the new input device were as follows: trapezius: 3.0 (1.7), 4.4 (2.9) and 1.4 (1.0), and extensor carpi ulnaris: 7.3 (4.4), 14.5 (8.4) and 5.6 (3.1), respectively. The device was used in a variety of hand positions, alternatively. The size of the working area was far greater when the new input device was used than when the two conventional analogues were used. Although reasonable performance was not achieved, the results support recommendations concerning the redesign of the device. The ergonomic efforts in the design of the input device are of heuristic value, providing a basis for future development.

- **Keywords:** Input device; Ergonomic design; Desk free; Posture independent

**F.F. Al-ajmi, D.L. Loveday, K.H. Bedwell and G. Havenith. *Thermal insulation and clothing area factors of typical Arabian Gulf clothing ensembles for males and females : measurements using thermal manikins.* Pages 407-414.**

The thermal insulation of clothing is one of the most important parameters used in the thermal comfort model adopted by the International Standards Organisation (ISO) [BS EN ISO 7730, 2005. Ergonomics of the thermal environment. Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria. International Standardisation Organisation, Geneva.] and by ASHRAE [ASHRAE Handbook, 2005. Fundamentals. Chapter 8. American Society of Heating Refrigeration and Air-conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA.]. To date, thermal insulation values of mainly Western clothing have been published with only minimal data being available for non-Western clothing. Thus, the objective of the present study is to measure and present the thermal insulation (clo) values of a number of Arabian Gulf garments as worn by males and females. The clothing ensembles and garments of Arabian Gulf males and females presented in this study are representative of those typically worn in the region during both summer and winter seasons. Measurements of total thermal insulation values (clo) were obtained using a male and a female shape thermal manikin in accordance with the definition of insulation as given in ISO 9920. In addition, the clothing area factors ( $f_{cl}$ ) determined in two different ways were compared. The first method used a photographic technique and the second a regression equation as proposed in ISO 9920, based on the insulation values of Arabian Gulf male and female garments and ensembles as they were determined in this study. In addition, fibre content, descriptions and weights of Arabian Gulf clothing have been recorded and tabulated in this study.

- **Keywords:** Clothing thermal insulation; Thermal comfort; Islamic dress; Clothing area factor