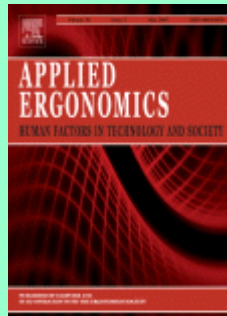


Applied Ergonomics - rok 2014, ročník 44

Číslo 1, část B (January 2014)



Bob Muffett, John R. Wilson, Theresa Clarke, Anthony Coplestone, Emma Lowe, John Robinson, Stuart Smith. *Management of personal safety risk for lever operation in mechanical railway signal boxes.* Pages 221-233.

Despite increased implementation of computer control systems in managing and regulating rail networks, mechanical signal boxes using lever operation will be in place for years to come. A rolling risk assessment programme identified a number of levers in mechanical signal boxes within the UK rail network which potentially presented unacceptable personal safety risk to signallers. These levers operate both points and signals and the risk is primarily the weights which have to be moved when pulling and pushing the levers. Operating difficulties are often compounded by the design and condition of lever frames, the linkages to the points/signals, maintenance regimes, the workspace and the postures and strategies adopted by signallers. Lever weights were measured as from 15 kg to 180 kg at over 160 boxes, using a specially designed and constructed device. Taken together with examination of injury and sickness absence data, interviews and field observations, and biomechanical computer modelling, the measurement programme confirmed the potential risks. A risk management programme has been implemented, comprising lever weight measurement, training of operations staff, a structured maintenance regime and renewal or redesign for boxes/levers where, after maintenance, a criterion weight level is still exceeded. For a feasible management programme, the first alert (or 1st action) value for further assessment is 55 kg, a second action level requiring specified maintenance is 80–99 kg, and a third action level requiring the lever to be signed out of use is 100 kg.

- **Keywords:** Rail; Signal boxes; Levers; Manual handling; Pulling force

Ryan T. Lewinson, Gholamreza Rouhi, D. Gordon E. Robertson. *Influence of snow shovel shaft configuration on lumbosacral biomechanics during a load-lifting task.* Pages 234-238.

Lower-back injury from snow shovelling may be related to excessive joint loading. Bent-shaft snow shovels are commonly available for purchase; however, their influence on lower back-joint loading is currently not known. Therefore, the purpose of this study was to compare L5/S1 extension angular impulses between a bent-shaft and a standard straight-shaft snow shovel. Eight healthy subjects participated in this study. Each completed a simulated snow-lifting task in a biomechanics laboratory with each shovel design. A standard motion analysis procedure was used to determine L5/S1 angular impulses during each trial, as well as peak L5/S1

extension moments and peak upper body flexion angle. Paired-samples t-tests ($\alpha = 0.05$) were used to compare variables between shovel designs. Correlation was used to determine the relationship between peak flexion and peak moments. Results of this study show that the bent-shaft snow shovel reduced L5/S1 extension angular impulses by 16.5% ($p = 0.022$), decreased peak moments by 11.8% ($p = 0.044$), and peak flexion by 13.0% ($p = 0.002$) compared to the straight-shaft shovel. Peak L5/S1 extension moment magnitude was correlated with peak upper body flexion angle ($r = 0.70$). Based on these results, it is concluded that the bent-shaft snow shovel can likely reduce lower-back joint loading during snow shovelling, and thus may have a role in snow shovelling injury prevention.

- **Keywords:** Ergonomics; Joint loading; Low back pain; L5/S1; Spine

Jagvir Singh, Abid Ali Khan. *Effect of coating over the handle of a drill machine on vibration transmissibility.* Pages 239-246.

This study was to see the effect of different coatings on the handle of hand-held drilling machines. Out of five different handles chosen for this study, including one handle uncoated. Root mean square (rms) values of the vibration levels (acceleration) were recorded at the surface of handle and wrist of the operators. Results showed that maximum vibrations were reduced by coating of handle coated with rubber sheet and Rexene (H4) followed by handle coated with cotton sandwiched between jeans cloth (H5). Equivalent vibrations transmitted through coating of handles coated with sponge and velvet (H2) and jute and cotton (H3) were of almost same magnitude and these two coated handles were able to reduce least vibration transmitted. Transmissibility of vibrations along dominant (Z) direction was analyzed using ANOVA. Results showed that coating on handles significantly affected vibration transmitted in Z direction. Vibration transmissibility ratios were found to be 0.354, 0.571, 0.408, 0.4326, and 0.3555 for handles H1, H2, H3, H4 and H5 respectively.

- **Keywords:** Coating; Vibration transmissibility; Work related musculoskeletal disorders

Susanne Schmidt, Maximilian Amereller, Matthias Franz, Ralf Kaiser, Ansgar Schwirtz. *A literature review on optimum and preferred joint angles in automotive sitting posture.* Pages 247-260.

In this study, a survey of the scientific literature in the field of optimum and preferred human joint angles in automotive sitting posture was conducted by referring to thirty different sources published between 1940 and today. The strategy was to use only sources with numerical angle data in combination with keywords. The aim of the research was to detect commonly used joint angles in interior car design. The main analysis was on data measurement, usability and comparability of the different studies. In addition, the focus was on the reasons for the differently described results.

It was found that there is still a lack of information in methodology and description of background. Due to these reasons published data is not always usable to design a modern ergonomic car environment. As a main result of our literature analysis we suggest undertaking further research in the field of biomechanics and ergonomics to work out scientific based and objectively determined "optimum" joint angles in automotive sitting position.

- **Keywords:** Coating; Vibration transmissibility; Work related musculoskeletal disorders

Takanori Chihara, Akihiko Seo. *Evaluation of multiple muscle loads through multi-objective optimization with prediction of subjective satisfaction level: Illustration by an application to handrail position for standing.* Pages 261-269.

Proposed here is an evaluation of multiple muscle loads and a procedure for determining optimum solutions to ergonomic design problems. The simultaneous muscle load evaluation is formulated as a multi-objective optimization problem, and optimum solutions are obtained for each participant. In addition, one optimum solution for all participants, which is defined as the compromise solution, is also obtained. Moreover, the proposed method provides both objective and subjective information to support the decision making of designers. The proposed method was applied to the problem of designing the handrail position for the sit-to-stand movement. The height and distance of the handrails were the design variables, and surface electromyograms of four muscles were measured. The optimization results suggest that the proposed evaluation represents the impressions of participants more completely than an independent use of muscle loads. In addition, the compromise solution is determined, and the benefits of the proposed method are examined.

- **Keywords:** Coating; Vibration transmissibility; Work related musculoskeletal disorders

Kathleen D. Klinich, Miriam A. Manary, Carol A.C. Flannagan, Sheila M. Ebert, Laura A. Malik, Paul A. Green, Matthew P. Reed. *Effects of child restraint system features on installation errors.* Pages 270-277.

This study examined how child restraint system (CRS) features contribute to CRS installation errors. Sixteen convertible CRS, selected to include a wide range of features, were used in volunteer testing with 32 subjects. Subjects were recruited based on their education level (high or low) and experience with installing CRS (none or experienced). Each subject was asked to perform four child restraint installations in the right-rear passenger seat of a 2006 Pontiac G6 sedan using a crash dummy as a child surrogate. Each subject installed two CRS forward-facing (FF), one with LATCH and one with the vehicle seatbelt, and two CRS rear-facing (RF), one with LATCH and one with the seatbelt. After each installation, the experimenter evaluated 42 factors for each installation, such as choice of belt routing path, tightness of installation, and harness snugness.

Analyses used linear mixed models to identify CRS installation outcomes associated with CRS features. LATCH connector type, LATCH strap adjuster type, and the presence of belt lockoffs were associated with the tightness of the CRS installation. The type of harness shoulder height adjuster was associated with the rate of achieving a snug harness. Correct tether use was associated with the tether storage method. In general, subject assessments of the ease-of-use of CRS features were not highly correlated with the quality of their installation, suggesting a need for feedback with incorrect installations.

The data from this study provide quantitative assessments of some CRS features that were associated with reductions in CRS installation errors. These results provide child restraint designers with design guidelines for developing easier-to-use products. Research on providing effective feedback during the child restraint installation process is recommended.

Davood Afshari, Majid Motamedzade, Reza Salehi, Ali Reza Soltanian. Continuous assessment of back and upper arm postures by long-term inclinometry in carpet weavers. Pages 278-284.

Awkward back and shoulder postures have been suggested to be a cause of back and shoulder discomfort in carpet weavers. This study aimed at continuous assessment of the upper arm and back postures and estimation of biomechanical load subtasks using inclinometers during 4 h.

Median of trunk flexion angle in weavers was 18° and 13° during knotting and compacting subtasks, respectively. The weavers worked with arms elevated greater than 45° for 4.5% of the work time. The average cumulative compression load for males and females were estimated at 22 MN-S and 13 MN-S, respectively.

In addition to poor workstation design, constrained posture of the trunk and low elevation and velocity for both arms may be the main risk factors for developing fatigue and disorders in the back and shoulder regions among carpet weavers. Therefore, any ergonomic interventions should be focused on reducing trunk flexion and the constrained postures of weavers.

- **Keywords:** Posture; Kinematics; Ergonomic

Kermit G. Davis, Lida Orta Anés. Potential of adjustable height carts in reducing the risk of low back injury in grocery stockers. Pages 285-292.

While the workers of the Wholesale and Retail Trade industrial sector suffer from musculoskeletal disorders at an alarming rate, there have been few investigative studies into potential effective interventions to reduce the ergonomic stress. The objective of the study was to determine whether a cart with an adjustable shelf could reduce awkward postures and motions while stocking products in a grocery store. Fifteen workers at a small grocery store in Puerto Rico completed stocking tasks with two types of carts: traditional and adjustable height cart or Ergo Cart. Trunk kinematics, LBD risk index, NIOSH lifting index, subjective ratings, and productivity indicators were collected during four typical stocking tasks. The Adjustable Ergo Cart reduced the sagittal trunk flexion by 7° and velocity by about 5°/s but increased twisting by about 2° and twist velocity by 4°/s as compared to the traditional cart. The LBD risk index was reduced by a small 2.4% in probability although greater reductions were found for larger items (e.g. bags of dog food and 2-L of Soda). The consensus among workers was that the adjustable cart would be easier to use. Overall, the study provides objective evidence that an ergonomically designed cart (e.g. adjustable height) has some potential to reduce sagittal trunk flexion, LBD risk index, and the NIOSH lift index. Overall, the results indicate that any intervention such as an adjustable cart can only have marginal effectiveness unless the entire systems perspective is considered.

- **Keywords:** Posture; Kinematics; Ergonomic

Hatice Mujde Sari, Michael J. Griffin. Postural stability when walking: Effect of the frequency and magnitude of lateral oscillatory motion. Pages 293-299.

While walking on an instrumented treadmill, 20 subjects were perturbed by lateral sinusoidal oscillations representative of those encountered in transport: frequencies in the range 0.5–2 Hz and accelerations in the range 0.1–2.0 ms⁻² r.m.s., corresponding to velocities in the range 0.032–0.16 ms⁻¹ r.m.s. Postural stability was assessed from the self-reported probability of losing balance (i.e., perceived risk of falling) and the movements of the centre of pressure beneath the feet. With the same acceleration at all frequencies, the velocities and displacements of the

oscillatory perturbations were greater with the lower frequency oscillations, and these caused greater postural instability. With the same velocity at all frequencies, postural instability was almost independent of the frequency of oscillation. Movements of the centre of pressure show that subjects attempted to compensate for the perturbations by increasing their step width and increasing their step rate.

- **Keywords:** Posture; Kinematics; Ergonomic

Toh Yen Pang, Aleksandar Subic, Monir Takla. *Evaluation of thermal and evaporative resistances in cricket helmets using a sweating manikin.* Pages 300-307.

The main objective of this study is to establish an approach for measuring the dry and evaporative heat dissipation cricket helmets. A range of cricket helmets has been tested using a sweating manikin within a controlled climatic chamber. The thermal manikin experiments were conducted in two stages, namely the (i) dry test and (ii) wet test. The ambient air temperature for the dry tests was controlled to

~23 °C, and the mean skin temperatures averaged ~35 °C. The thermal insulation

value measured for the manikin with helmet ensemble ranged from 1.0 to 1.2 clo. The results showed that among the five cricket helmets, the Masuri helmet offered slightly more thermal insulation while the Elite helmet offered the least. However, under the dry laboratory conditions and with minimal air movement (air velocity = $0.08 \pm 0.01 \text{ ms}^{-1}$), small differences exist between the thermal resistance values for the tested helmets. The wet tests were conducted in an isothermal condition, with an ambient and skin mean temperatures averaged

~35 °C, the evaporative resistance, R_{et} , varied between 36 and 60 $\text{m}^2 \text{ Pa W}^{-1}$.

These large variations in evaporative heat dissipation values are due to the presence of a thick layer of comfort lining in certain helmet designs. This finding suggests that the type and design of padding may influence the rate of evaporative heat dissipation from the head and face; hence the type of material and thickness of the padding is critical for the effectiveness of evaporative heat loss and comfort of the wearer. Issues for further investigations in field trials are discussed.

- **Keywords:** Posture; Kinematics; Ergonomic

Takanori Chihara, Taiki Izumi, Akihiko Seo. *Perceived discomfort functions based on joint moment for various joint motion directions of the upper limb.* Pages 308-317.

The aim of the present study was to formulate the relationship between the perceived discomfort and the joint moment ratio for twelve joint motion directions of the upper limb by considering the between-subject variability, and to investigate the effect of joint motion direction. Three approximation models (i.e., linear, exponential, and logistic function models) were compared in terms of the accuracy of predicting the perceived discomfort, and the logistic function was selected because its average error was lowest. The concept of L-R fuzzy number was used to consider the individual variability of perceived discomfort, and a simplified distribution of perceived discomfort was represented. Cluster analysis showed that the twelve discomfort functions formed two clusters: one for elbow flexion and a

second for the remaining joint motions. The data show that elbow flexion is more sensitive than other joint motions to increases in the joint moment ratio.

- **Keywords:** Biomechanics; Function approximation; Human diversity; Perceived discomfort; Fuzzy numbers

Yuri Gerasimov, Anton Sokolov. *Ergonomic evaluation and comparison of wood harvesting systems in Northwest Russia. Pages 318-338.*

A comparison of 14 currently applicable wood harvesting systems was assessed with respect to ergonomic point of view. For this purpose, the research method, based on the Hodges–Lehmann rule and the integrated work-severity rate of single machinery, was developed for ergonomic evaluation of cut-to-length, tree-length and full-tree harvesting systems. Altogether, about 130 different parameters of 36 units of equipment that impact on the ergonomics and work conditions were measured and estimated in interviews undertaken directly at forestry harvesting workplaces in 15 logging companies in the Republic of Karelia, Northwest Russia. Then the results were compared to the effective norms, and the degree of compliance with the stipulated values was determined. The estimates obtained for the degree of compliance were combined. This permits a direct comparison of the workload on forestry harvesting workers such as operators, lumberjacks and choker setters. In many respects, the current ergonomic standard is standard, except for the operators of cable skidders, chainsaws and choker settings. Visibility and work postures were considered to be the most critical features influencing the operator's performance. Problems still exist, despite the extensive development of cabs. The best working conditions in terms of harvesting systems were provided by "harvester + forwarder" in cut-to-length harvesting, and "feller–buncher + grapple skidder" in full-tree harvesting. The motor-manual tree-length harvesting performed with cable skidders showed the worst results in terms of ergonomics.

- **Keywords:** Ergonomics; Harvester; Forwarder; Skidder; Feller buncher; Chainsaw; Choker settings

V. Balasubramanian, M. Jagannath, K. Adalarasu. *Muscle fatigue based evaluation of bicycle design. Pages 339-345.*

Bicycling posture leads to considerable discomfort and a variety of chronic injuries. This necessitates a proper bicycle design to avoid injuries and thereby enhance rider comfort. The objective of this study was to investigate the muscle activity during cycling on three different bicycle designs, i.e., rigid frame (RF), suspension (SU) and sports (SP) using surface electromyography (sEMG). Twelve male volunteers participated in this study. sEMG signals were acquired bilaterally from extensor carpi radialis (ECR), trapezius medial (TM), latissimus dorsi medial (LDM) and erector spinae (ES), during 30 min of cycling on each bicycle and after cycling. Time domain (RMS) and frequency domain (MPF) parameters were extracted from acquired sEMG signals. From the sEMG study, it was found that the fatigue in right LDM and ES were significantly ($p < 0.05$) higher in SP bicycle. This was corroborated by a psychophysical assessment based on RBG pain scale. The study also showed that there was a significantly lesser fatigue with the SU bicycle than the RF and SP bicycles.

- **Keywords:** Bicycle design; Surface electromyography (sEMG); Posture; RGB pain scale; Muscle fatigue

Dina Burkolter, Benjamin Weyers, Annette Kluge, Wolfram Luther. Customization of user interfaces to reduce errors and enhance user acceptance. Pages 346-353.

Customization is assumed to reduce error and increase user acceptance in the human-machine relation. Reconfiguration gives the operator the option to customize a user interface according to his or her own preferences. An experimental study with 72 computer science students using a simulated process control task was conducted. The reconfiguration group (RG) interactively reconfigured their user interfaces and used the reconfigured user interface in the subsequent test whereas the control group (CG) used a default user interface. Results showed significantly lower error rates and higher acceptance of the RG compared to the CG while there were no significant differences between the groups regarding situation awareness and mental workload. Reconfiguration seems to be promising and therefore warrants further exploration.

- **Keywords:** Reconfiguration; Customization; Process control; User acceptance

Lindsey K. McIntire, R. Andy McKinley, Chuck Goodyear, John P. McIntire. Detection of vigilance performance using eye blinks. Pages 354-362.

Research has shown that sustained attention or vigilance declines over time on task. Sustained attention is necessary in many environments such as air traffic controllers, cyber operators, and imagery analysts. A lapse of attention in any one of these environments can have harmful consequences. The purpose of this study was to determine if eye blink metrics from an eye-tracker are related to changes in vigilance performance and cerebral blood flow velocities. Nineteen participants performed a vigilance task while wearing an eye-tracker on four separate days. Blink frequency and duration changed significantly over time during the task. Both blink frequency and duration increased as performance declined and right cerebral blood flow velocity declined. These results suggest that eye blink information may be an indicator of arousal levels. Using an eye-tracker to detect changes in eye blinks in an operational environment would allow preventative measures to be implemented, perhaps by providing perceptual warning signals or augmenting human cognition through non-invasive brain stimulation techniques.

- **Keywords:** Blink frequency; Blink duration; Vigilance