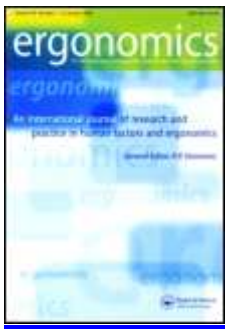
Ergonomics– rok 2009, ročník 52

Číslo 3



Ash M. Genaidy; Reynold Sequeira; Magda M. Rinder; Amal D. A-Rehim. *Determinants of business sustainability : an ergonomics perspective*. S. 273–301.

There is a need to integrate both macro- and micro-ergonomic approaches for the effective implementation of interventions designed to improve the root causes of problems such as work safety, quality and productivity in the enterprise system. The objective of this study was to explore from an ergonomics perspective the concept of business sustainability through optimising the worker-work environment interface. The specific aims were: (a) to assess the working conditions of a production department work process with the goal to jointly optimise work safety, quality and quantity; (b) to evaluate the enterprise-wide work process at the system level as a social entity in an attempt to trace the root causes of ergonomic issues impacting employees throughout the work process. The Work Compatibility Model was deployed to examine the experiences of workers (that is, effort, perceived risk/benefit, performance and satisfaction/dissatisfaction or psychological impact) and their associations with the complex domains of the work environment (task content, physical and non-physical work environment and conditions for learning/growth/development). This was followed by assessment of the enterprise system through detailed interviews with department managers and lead workers. A system diagnostic instrument was also constructed from information derived from the published literature to evaluate the enterprise system performance. The investigation of the production department indicated that the stress and musculoskeletal pain experienced by workers (particularly on the day shift) were derived from sources elsewhere in the work process. The enterprise system evaluation and detailed interviews allowed the research team to chart the feed-forward and feedback stress propagation loops in the work system. System improvement strategies were extracted on the basis of tacit/explicit knowledge obtained from department managers and lead workers. In certain situations concerning workplace human performance issues, a combined macro-micro ergonomic methodology is essential to solve the productivity, quality and safety issues impacting employees along the trajectory or path of the enterprise-wide work process. In this study, the symptoms associated with human performance issues in one production department work process had root causes originating in the customer service department work process. In fact, the issues found in the customer service department caused performance problems elsewhere in the enterprise-wide work process such as the traffic department. Sustainable enterprise solutions for workplace human performance require the integration of macro- and micro-ergonomic approaches.

- **Keywords:** business sustainability; work performance; improvement; human and enterprise performance; process health and safety

Dina Burkolter; Annette Kluge; Jürgen Sauer; Sandrina Ritzmann. *The predictive qualities of operator characteristics for process control performance : the influence of personality and cognitive variables*. S. 302–311.

This article examines the relationship between operator characteristics and process control performance. Thirty-nine trainee operators participated in a 4-h training session of a simulated process control task and a testing session in which various system faults had to be managed. Cognitive ability, cognitive flexibility, self-efficacy and personality traits were measured as operator characteristics. Cognitive ability related positively to system control performance but not to diagnostic performance. Participants with low cognitive flexibility performed best on system control, whereas participants with high cognitive flexibility performed best on diagnostic performance. A hierarchical regression analysis revealed that cognitive ability, cognitive flexibility and declarative knowledge accounted for about 30% of the variability of system control. The findings suggest that consideration of cognitive ability and cognitive flexibility be increased in personnel selection for complex work environments.

- **Keywords:** process control; individual characteristics; personnel selection; performance

R. W. G. Anderson; T. P. Hutchinson. *Optimising product advice based on age when design criteria are based on weight : child restraints in vehicles*. S. 312–324.

The motivation for this paper is the high rate of inappropriate child restraint selection in cars that is apparent in published surveys of child restraint use and how the public health messages promoting child restraints might respond. Advice has increasingly been given solely according to the child's weight, while many parents do not know the weight of their children. A common objection to promoting restraint use based on the age of the child is the imprecision of such advice, given the variation in the size of children, but the magnitude of the misclassification such advice would produce has never been estimated. This paper presents a method for estimating the misclassification of children by weight, when advice is posed in terms of age, and applies it to detailed child growth data published by the Centers for Disease Control and Prevention. In Australia, guidelines instructing all parents to promote their children from an infant restraint to a forward-facing child seat at 6 months, and then to a belt-positioning booster at 4 years, would mean that 5% of all children under the age of 6 years would be using a restraint not suited to their weight. Coordination of aged-based advice and the weight ranges chosen for the Australian Standard on child restraints could reduce this level of misclassification to less than 1%. The general method developed may also be applied to other aspects of restraint design that are more directly relevant to good restraint fit.

- **Keywords:** child restraint systems; standards; public information programmes; evaluation and assessment

Jason S. McCarley. *Effects of speed-accuracy instructions on oculomotor scanning and target recognition in a simulated baggage X-ray screening task*. S. 325–333.

Visual search tasks are often carried out under high levels of time stress. Transportation security screeners, for example, face demands to achieve high levels of accuracy while maintaining rapid passenger throughput. An experiment examined the strategies by

which operators regulate visual search performance under such conditions. Observers performed a simulated baggage-screening task under instructions to emphasise either response speed or accuracy. Behavioural measures and eye movements were recorded. Observers made fewer and briefer fixations under emphasise-speed than under emphasise-accuracy instructions. Losses in accuracy were produced by more frequent failures to fixate on targets and a decrease in the detection rate of non-fixated targets. The likelihood with which observers detected a fixated target was similar across speed-accuracy instructions. Results will inform efforts to model visual search in naturalistic tasks, allowing more accurate prediction of response times and error rate and may aid the design of training programmes and other interventions to improve search performance under stress.

- **Keywords:** visual search; attention; eye movements; time stress

Ivan A. Steenstra; Judith K. Sluiter; Monique H. W. Frings-Dresen. *The eye-complaint questionnaire in a visual display unit work environment : Internal consistency and test-retest reliability*. S. 334–344.

The internal consistency and test-retest reliability of a 10-item eye-complaint questionnaire (ECQ) were examined within a sample of office workers. Repeated within-subjects measures were performed within a single day and over intervals of 1 and 7 d. Questionnaires were completed by 96 workers (70% female, mean age 36.4 years) who perform more than 4 h of visual display unit work each day. The internal consistency of the ECQ was high (α = 0.801). Although test-retest reliability was low within a single day (morning and afternoon) (intra-class correlation coefficient (ICC) = 0.68, 95% CI 0.38, 0.82), it was good between two morning measurements over a 1-d interval (ICC = 0.91 95% CI 0.87, 0.94) and between morning measurements with a 7-d interval (ICC = 0.87, 95% CI 0.81, 0.92). The ICC between afternoon measurements over a 1-week interval was moderate (ICC = 0.78, 95% CI 0.66, 0.85). This questionnaire is a reliable and consistent instrument for easily assessing eye complaints in office work. The timing of the measurements must be kept in consideration since measurements are confounded by exposures over the day.

- **Keywords:** eye complaints; questionnaire; test-retest reliability; VDU work; clinimetrics

Abid Ali Khan; Leonard O'Sullivan; Timothy J. Gallwey. *Effects of combined wrist deviation and forearm rotation on discomfort score.* S. 345–361.

The aim of the study was to examine the pattern of the change in discomfort for combined wrist deviation and forearm rotation as joint angles increased away from neutral in a repetitive task. There were five levels of wrist deviation (neutral, 35% and 55% of the range of motion (ROM) in radial and ulnar deviation) and five levels of forearm rotation (neutral, 30% and 60% of the ROM in pronation and supination). Twenty-five participants performed a repetitive flexion task with a force of 10 N ± 1 N at a frequency of 15 exertions per min, with replication after 1 week for six of the participants. A visual analogue scale was used for recording the discomfort scores. Repeated measures analysis of covariance with the Greenhouse-Geisser correction, where necessary, was used on transformed values of the discomfort scores. Grip test endurance time at 50% of maximum voluntary contraction was included as a covariate. Wrist deviation (p = 0.007) and forearm rotation (p = 0.001) were found to have significant effects. Interactions of the main factors were not significant and nor was the covariate. Quadratic regression equations were derived and were used to generate iso-discomfort contours, which show a useful area of low discomfort around the central neutral zone of wrist postures, but with steep increases in discomfort at the extreme combinations of wrist ulnar/radial deviation with forearm pronation/supination.

Discomfort equations and contours, showing wrist and forearm postures, which are either acceptable or potentially injurious, are useful for the design of industrial tools, machine controls and workspaces. Reference to these can help to reduce the risk of musculoskeletal injury associated with the tasks or tools by avoiding poor postures with unacceptable deviations from neutral posture.

- **Keywords:** wrist radial/ulnar deviation; forearm prone/supine rotation; raw discomfort score; transformed discomfort score; endurance time; wrist flexion MVC

David W. Wagner; Rebecca L. Kirschweng; Matthew P. Reed. *Foot motions in manual material handling transfer tasks : a taxonomy and data from an automotive assembly plant*. S. 362–383.

Ergonomic job analysis commonly applies static postural and biomechanical analysis tools to particular postures observed during manual material handling (MMH) tasks, usually focusing on the most extreme postures or those involving the highest loads. When these analyses are conducted prospectively using digital human models, accurate prediction of the foot placements is critical to realistic postural analyses. In automotive assembly jobs, workers frequently take several steps between task elements, for example, picking up a part at one location and moving to another location to place it on the vehicle. A detailed understanding of the influence of task type and task sequence on the stepping pattern is necessary to accurately predict the foot placements associated with MMH tasks. The current study examined the patterns of foot motions observed during automotive assembly tasks. Video data for 529 pickup and delivery tasks from 32 automotive assembly jobs were analysed. A minimum of five cycles was analysed for each task. The approach angle, departure angle, hand(s) used, manipulation height and patterns of footsteps were coded from the video. Object mass was identified from the job information sheet provided by the assembly plant. Three independent raters coded each video and demonstrated an intraclass correlation coefficient of 0.54 for identification of the configuration of the lower extremities during terminal stance. Based on an analysis of the distribution of stepping behaviours during object transitions (pickups or deliveries), a transition classification system (TRACS) was developed. TRACS uses a compact notation to quantify the sequence of steps associated with a MMH transition. Five TRACS behaviour groups accounted for over 90% of the transition stepping behaviours observed in the assembly plant. Approximately two-thirds (68.4%) of the object transfers observed were performed with only one foot in contact with the ground during the terminal posture. The results from this paper suggest that a predictive model for choosing a transition stepping behaviour, coupled with a model to scale the selected foot behaviours, is needed to facilitate accurate prospective ergonomic analyses. This study proposes a method for categorising the stepping patterns associated with MMH tasks. The influence of task type and task sequence on the stepping patterns observed during several automotive assembly tasks is discussed. For prospective postural analyses conducted using digital human models, accurate prediction of the foot placements is critical to realistic postural analyses.

- **Keywords:** manual material handling; lifting; step; taxonomy; transfer

W. S. Marras; G. G. Knapik; S. Ferguson. *Lumbar spine forces during manoeuvring of ceiling-based and floor-based patient transfer devices*. S. 384–397.

Patient handling continues to represent a high risk task for low back pain (LBP) among health caregivers. Previous studies indicated that manual transfers of patients impose unacceptable loads on the spine even when two caregivers perform the transfer. Patient lift devices are considered a potential intervention; however, few biomechanical analyses have investigated the spine loads and LBP risk associated with these transfer devices.

This study analysed the 3-D spine forces imposed upon the lumbar spine when 10 subjects manipulated ceiling-based and floor-based patient lifts through various patient handling conditions and manoeuvres. The results indicated that ceiling-mounted patient lift systems imposed spine forces upon the lumbar spine that would be considered safe, whereas floor-based patient handling systems had the potential to increase anterior/posterior shear forces to unacceptable levels during patient handling manoeuvres. Given these findings, ceiling-based lifts are preferable to floor-based patient transfer systems.

- **Keywords:** low back pain; low back disorders; patient transfer; patient handling; patient lifting; safe patient handling; spine biomechanics

Sang Wook Lee; Xudong Zhang. *Development and validation of a biodynamic model for predicting multi-finger movements in cylinder-grasping tasks*. S. 398–406.

This article describes the development and validation of a model for predicting multi-finger movements in grasping activities. The model builds upon a newly proposed approach that incorporates forward dynamics and a system identification procedure, and is amenable to empirical tests. A database of multi-fingered grasping movements performed by 28 subjects was established and divided into four sets, one for model development and three for model validation. In the development phase, model parameter values were estimated by the iterative system identification procedure through a physics-based heuristic algorithm. The estimated parameter values were then statistically synthesised and integrated into the prediction model. In the validation phase, the model was applied to three novel datasets containing different grasping movements involving objects of varied sizes and different subjects. The results demonstrated the model's ability to predict hand prehensile movements with error magnitudes comparable to the inter-person variability in performing such movements. New insights into the control of multi-fingered hand prehensile movements at the systems and joint levels emerged from the model development and validation process. The current study contributes to building a foundation for long-term development of realistic biodynamic simulation of multi-finger hand movements. Such simulation capabilities will aid in design of hand-operated tools, devices or hand-intensive work for proactive ergonomics and in evaluation as well as treatment of functional impairment of the hand. This work was performed when both authors were at Department of Mechanical & Industrial Engineering, University of Illinois at Urbana-Champaign.

- **Keywords:** multi-finger movement; dynamic model; system identification; prediction