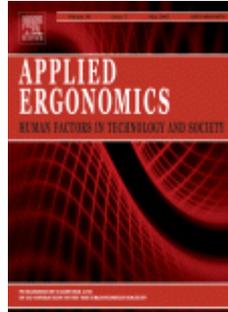


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Thomas R. Waters, Arun Garg. *Two-dimensional biomechanical model for estimating strength of youth and adolescents for manual material handling tasks.* Pages 1-7.

Youth and adolescents are routinely engaged in manual material handling (MMH) tasks that may exceed their strength capability to perform the task and may place them at excessive risk for musculoskeletal disorders. This paper reports on a two-dimensional biomechanical model that was developed to assess MMH tasks performed by youth 3–21 years of age. The model uses age, gender, posture of the youth performing the MMH activity, and weight of the load handled as input, and provides an estimate of the strength demands of the task and spinal disc compression and shear force resulting from the activity as output. The model can be used to assess whether a specific MMH task exceeds the strength demands for youth of certain ages or genders, which of the internal muscle strengths are most affected, and provides information about the estimated spinal disc compression and shear forces on the spine as a result of the specified MMH task. These results would be helpful in deciding whether a task is appropriate for a youth to perform or whether a certain task modification may be sufficient in reducing the physical demands to a level acceptable for a youth of certain age and gender.

- **Keywords:** Youth; Strength; Prediction; Manual material handling

Tom Wellings, Mark Williams, Charles Tennant. *Understanding customers' holistic perception of switches in automotive human-machine interfaces.* Pages 8-17.

For successful new product development, it is necessary to understand the customers' holistic experience of the product beyond traditional task completion, and acceptance measures. This paper describes research in which ninety-eight UK owners of luxury saloons assessed the feel of push-switches in five luxury saloon cars both in context (in-car) and out of context (on a bench). A combination of hedonic data (i.e. a measure of 'liking'), qualitative data and semantic differential data was collected. It was found that customers are clearly able to differentiate between switches based on the degree of liking for the samples' perceived haptic qualities, and that the assessment environment had a statistically significant effect, but that it was not universal. A factor analysis has shown that perceived characteristics of switch haptics can be explained by three independent factors defined as 'Image', 'Build Quality', and 'Clickiness'. Preliminary steps have also been taken towards identifying whether existing theoretical frameworks for user experience may be applicable to automotive human-machine interfaces.

- **Keywords:** User-centred design; Haptics; Affective design; Automotive HMI

Larry J. Chapman, Astrid C. Newenhouse, Ben-Tzion Karsh. *Evaluation of a 3 year intervention to increase adoption of safer nursery crop production practices. Pages 18-26.*

Background: We conducted a 3 year intervention to increase awareness and adoption of eight more profitable nursery crop production practices that reduced certain traumatic and musculoskeletal injury hazards. **Methods:** We disseminated information to nursery managers across seven states using information channels they were known to rely on (e.g. trade publications, public events, university Extension, other managers). We evaluated rolling, independent, probability samples ($n = 1200$) with mail questionnaires before the intervention and after each of 3 intervention years. We also evaluated samples ($n = 250$) from a comparison group of New Zealand nursery managers. **Results:** The intervention was associated with increased awareness of four of the eight practices among US managers after year 3 compared to their baseline: zippers (20 vs. 32%, $p \leq 0.000$), stools (11 vs. 22%, $p \leq 0.001$), pruners (29 vs. 40%, $p \leq 0.014$), and tarps (24 vs. 33%, $p \leq 0.009$). There were no changes in adoption. New Zealand manager awareness was increased for hoes after year 2 compared to their baseline (35 vs. 52%, $p \leq 0.010$). **Conclusions:** A modest, regionwide information dissemination intervention was associated with increased awareness, but not adoption.

- **Keywords:** Agriculture; Ergonomics; Evaluation studies; Horticulture; Occupational health; Safety

Wen-Ruey Chang, Simon Matz, Raoul Grönqvist, Mikko Hirvonen. *Linear regression models of floor surface parameters on friction between Neolite and quarry tiles. Pages 27-33.*

For slips and falls, friction is widely used as an indicator of surface slipperiness. Surface parameters, including surface roughness and waviness, were shown to influence friction by correlating individual surface parameters with the measured friction. A collective input from multiple surface parameters as a predictor of friction, however, could provide a broader perspective on the contributions from all the surface parameters evaluated. The objective of this study was to develop regression models between the surface parameters and measured friction. The dynamic friction was measured using three different mixtures of glycerol and water as contaminants. Various surface roughness and waviness parameters were measured using three different cut-off lengths. The regression models indicate that the selected surface parameters can predict the measured friction coefficient reliably in most of the glycerol concentrations and cut-off lengths evaluated. The results of the regression models were, in general, consistent with those obtained from the correlation between individual surface parameters and the measured friction in eight out of nine conditions evaluated in this experiment. A hierarchical regression model was further developed to evaluate the cumulative contributions of the surface parameters in the final iteration by adding these parameters to the regression model one at a time from the easiest to measure to the most difficult to measure and evaluating their impacts on the adjusted R^2 values. For practical purposes, the surface parameter R_a alone would account for the majority of the measured friction even if it did not reach a statistically significant level in some of the regression models.

- **Keywords:** Surface waviness; Surface roughness; Dynamic friction; Regression model

Anna Fenko, Hendrik N.J. Schifferstein, Paul Hekkert. *Shifts in sensory dominance between various stages of user-product interactions. Pages 34-40.*

In the area of product design, sensory dominance can be defined as the relative importance of different sensory modalities for product experience. It is often assumed that vision dominates the other senses. In the present study, we asked 243 participants to describe their experiences with consumer products in various situations: while buying a product, after the first week, the first month, and the first year of usage. The data suggest that the dominant sensory modality depends on the period of product usage. At the moment of buying, vision is the most important modality, but during the usage the other sensory modalities gain importance. The roles of the different modalities during usage are product-dependent. Averaged over 93 products analyzed in this study, after one month of usage touch becomes more important than vision, and after one year vision, touch and audition appear to be equally important. We conclude that to create a long-lasting positive product experience, designers need to consider user-product interaction at different stages of product usage and to determine which sensory modality dominates product experience at each stage.

- **Keywords:** Sensory dominance; User-product interaction; Product design

Raymond W. McGorry, Angela DiDomenico, Chien-Chi Chány. *The anatomy of a slip: Kinetic and kinematic characteristics of slip and non-slip matched trials.* Pages 41-46.

To improve understanding of slip propagation mechanisms, one could compare features of early stance phase during slips and non-slips. This study investigated the similarities and differences in kinematics and utilized COF of paired trials, defined as a matched pair of slip and non-slip trials produced by the same participant walking on the same floor condition at the same walking speed condition. Twenty-two participants produced 47 matched trial pairs while walking at 1.5, 1.8 and 2.1 m/s, over a forceplate with an available COF ranging from 0.12 to 0.21. Heel displacement was captured with an infrared motion tracking system and utilized COF was derived from ground reaction forces. ANOVA revealed no significant differences between the slip and non-slip groups in horizontal heel velocity just prior to heel strike or for heel velocity or slip distance during the 20 ms period following heel strike. Significant differences were found between the groups in utilized COF and horizontal heel velocity at 25 and 30 ms following heel strike. Differences in heel kinematics and kinetics during early stance phase between the slip and non-slip trials are discussed. The results differ from several previous studies, likely due to methodological differences, as the present study was conducted on marginally slippery surfaces, as opposed to very low COF conditions with thick contaminant layers.

- **Keywords:** Micro-slip; Heel strike; Coefficient of friction

S.R. Herring, A.E. Trejo, M.S. Hallbeck. *Evaluation of four cursor control devices during a target acquisition task for laparoscopic tool control.* Pages 47-57.

Current laparoscopic surgery instruments create awkward postures which produce fatigue and pressure points in surgeons. In order to alleviate some of this discomfort a new laparoscopic tool had been developed with the inclusion of an articulating end-effector manipulated by a trackball. The current study was developed to assess the performance of four input devices which could replace the manual trackball in a powered laparoscopic tool. A simple Fitts' law task was conducted and the devices' performance was evaluated with both subjective and objective measures. This article makes three main contributions to the scientific community. First, it provides a comparison of four control devices (TouchPad, Mouse Button Module, MiniJoystick Module and MicroJoystick) for use in a powered laparoscopic tool. Second, it provides an understanding of how the non-traditional measure of target re-entry can be utilized to compare control devices and how this relates to the more traditional measures of throughput and error rate. Finally, it contributes to the understanding of how a user's familiarity with a control device could

affect the subjective and objective performance of the device. The main results indicate that the TouchPad and MicroJoystick are the best candidate-devices for use in a powered laparoscopic tool. The article also provides support for utilizing the new measure target re-entry when comparing control performance. Although studied in the application of laparoscopic surgery, the results can be generalized for the design of any hand-held device in which the speed and accuracy of the control device is critical.

- **Keywords:** Laparoscopic surgery; Ergonomic design; Human computer interaction; Control design; TouchPad; MicroJoystick; Minimal invasive surgery; Laparoscopic tool; Fitts' law

Philippa M. Dall, Andrew Kerr. *Frequency of the sit to stand task : an observational study of free-living adults. Pages 58-61.*

The sit to stand movement is a key determinant of functional independence. Knowledge of the frequency with which the sit to stand movement is performed throughout the day could inform workplace ergonomics, but has rarely been examined. Healthy adults ($n = 140$) were recruited from the general population. Free-living activity for each participant was reported using an activity monitor. On average, participants performed 60 (± 22) sit to stand movements each day. Participants in indoor sedentary occupations performed significantly more sit to stand movements per day than participants in outdoor active occupations (66 vs. 54; $n = 102$; $p = 0.003$). Participants ($n = 33$) performed significantly more sit to stand movements on working days than on non-working days (65 vs. 55; $p = 0.018$). This analysis provides contemporary data for sit to stand frequency in a predominantly working population, and demonstrates that work and employment have a significant effect on that frequency.

- **Keywords:** Sit to stand movement; Activity monitoring; Workplace act

Chia-Hua Ku, Michael J. Smith. *Organisational factors and scheduling in locomotive engineers and conductors : effects on fatigue, health and social well-being. Pages 62-71.*

This study examines critical organisational factors and work scheduling in railway freight operators to understand how job-related factors are related to fatigue, health and social well-being. A 148-item questionnaire was developed and distributed to a sample of 276 locomotive engineers and conductors working for the U.S. Operations of a North American Railway. One hundred and twenty-five questionnaires were returned, which was a response rate of 45.3%. Structural equation modeling was performed to identify the relationships between the examined factors. The analytical results of this study indicate that organisational factors and the scheduling system could not be distinguished as two separate factors. The scheduling system is not just the practice of assigning locomotive crewmen to trains, but it is a function tightly connected with other organisational factors. Social Well-Being is an important mediator between Scheduling and Fatigue. Finally, the study revealed a strong relationship between fatigue and health complaints.

- **Keywords:** Organisational factors; Scheduling; Locomotive engineers and conductors

Alethea Blackler, Vesna Popovic, Doug Mahar. *Investigating users' intuitive interaction with complex artefacts. Pages 72-92.*

This paper examines the role of intuition in the way that people operate unfamiliar devices. Intuition is a type of cognitive processing that is often non-conscious and utilises stored experiential knowledge. Intuitive interaction involves the use of knowledge gained from other products and/or experiences. Two initial experimental studies revealed that

prior exposure to products employing similar features helped participants to complete set tasks more quickly and intuitively, and that familiar features were intuitively used more often than unfamiliar ones. A third experiment confirmed that performance is affected by a person's level of familiarity with similar technologies, and also revealed that appearance (shape, size and labelling of features) seems to be the variable that most affects time spent on a task and intuitive uses during that time. Age also seems to have an effect. These results and their implications are discussed.

- **Keywords:** Intuitive interaction; Intuitive use; Interface design; Observational analysis; Prior experience; Product design

Alessandra Paiva de Castro, José Rubens Rebelatto, Thaís Rabiatti Aurichio. *The relationship between foot pain, anthropometric variables and footwear among older people.* Pages 93-97.

Objective: To verify the prevalence of pain among older people when wearing shoes, and the relationships between foot pain, high-heeled shoes and anthropometric variables. **Method:** Both feet of 227 older women and 172 older men were evaluated with respect to anthropometric variables, arch index and foot posture index. The participants were also asked about the presence of foot pain while wearing high-heeled shoes. The data were analyzed using the Chi-square test, Pearson's correlation, MANOVA, multiple regression analysis, *t* test, and analysis of probability. **Findings:** The prevalence of foot pain when wearing shoes was high and was associated with the female gender, however wearing high-heeled shoes was not associated with pain. The women with foot pain presented larger values for the circumferences of the metatarsal heads and the instep (after normalization with the foot length) than those without pain. The men with pain did not present different measurements from those without pain.

- **Keywords:** Pain; Feet; Aging

Hsieh-Ching Chen, Cha-Mei Chang, Yung-Ping Liu, Chih-Yong Chen. *Ergonomic risk factors for the wrists of hairdressers.* Pages 98-105.

This study utilized a portable data logger to measure the wrist angles and forearm flexor and extensor electromyography (EMG) of 21 hairstylists. The hairstylists were divided into two groups, one with 11 barbers (9 males and 2 females) specializing in men's hairdressing, and one with 10 hairdressers (2 males and 8 females) specializing in women's hairdressing. The standard haircut task was divided into three subtasks: hair cutting, washing and blow-drying. The mechanical exposures of the overall task and subtasks were quantified to compare how subtasks, occupational groups, and gender groups differ. Experimental results show that the average time to finish a woman's haircut (51.4 min) is significantly longer than that for a man's haircut (35.6 min) ($p < 0.005$). Female hairstylists had significantly greater EMG activity than male hairstylists did ($p < 0.001$). The non-dominant hands of hairdressers have significantly higher overall wrist velocity than those of barbers ($p < 0.005$). Analytical results suggest that the relatively higher force exertion and wrist velocity of female hairstylists combined with prolonged exposure may account for the higher rate of hand/wrist pain in female hairdressers than in male barbers.

- **Keywords:** Workload; Musculoskeletal disorder; Ergonomic risk factors

Balmatee Bidassie, James D. McGlothlin, Irene Mena, Vincent G. Duffy, James W. Barany. *Evaluation of lifestyle risk factors and job status associated with back injuries among employees at a mid-western university.* Pages 106-114.

For decades the literature has shown an association between work-related risk factors and back injuries among employees. However, only recently, there is a growing body of literature that suggests lifestyle risk factors may also be associated with back injuries. The purpose of this research was to determine if selected lifestyle risk factors are associated with a greater risk of back injuries. Further, there may be an association between job status and incident reporting, lost workdays cases and workers' compensation (WC) paid for back injuries among university employees. Aggregate data from a Health Risk Assessment (HRA) questionnaire were used to analyze 6053 university employees for lifestyle risk factors associated with back injuries. Of the total sample, 57% ($n = 3471$) were female; 46% ($n = 2778$) worked as clerical or service staff; and the mean age was 45 years. Pearson chi-square (χ^2) analyses indicate that job status ($\chi^2 = 307.07$, $df = 4$, $p < .001$) and gender ($\chi^2 = 40.14$, $df = 2$, $p < .001$) were associated with high risk back score. An ordinal regression analysis predicted that participants who exercised vigorously for at least 20 min, 3 or more days per week, or 3 or more days per week of combined vigorous exercise and moderate-intensity physical activity are almost 30 times less likely to have a high back risk score compared to participants who do not exercise vigorously or participate in less than 3 days per week of moderate-intensity physical activity (OR = 29.68, 95% CI = 25–35.25, $p < .001$). Participants who have a low risk score for BMI are three times less likely (OR = 3.20, 95% CI = 2.74–3.75, $p < .001$) to have a high back risk score when compared to participants who have a high risk score for BMI. A regression tree predicted high back risk scores were participants who: (1) receive an adequate amount of physical activity or vigorous exercise and is a male service or clerical staff; (2) do not receive an adequate amount of physical activity or vigorous exercise, and is not overweight; or (3) who do not receive an adequate amount of physical activity or vigorous exercise, and is overweight. Six years of Occupational Safety and Health Administration (OSHA) 300 logs and WC claims data paid for back injuries supported the finding that clerical or service staff had the greatest risk of back injuries. Based on the results of this study, there appears to be an association between lifestyle risk factors, job status and back injuries among university employees. We believe our evaluation approach may be used to study other work populations to verify the outcomes observed in this study.

- **Keywords:** Back injuries; Lifestyle risk factors; Job status; Health Risk Assessment (HRA); OSHA 300 logs; Workers' compensation (WC)

Hwa -S. Jung, Hyung-Shik Jung. A survey of the optimal handle position for boxes with different sizes and manual handling positions. Pages 115-122.

Handles on objects are very important for enhancing the safety and efficiency of manual handling for people who use them. In this study, four different prototype boxes with auxiliary handles were designed to determine the optimal handle position of a box based on the evaluated user preferences and body part discomfort (BPD). Twenty male students participated in the experiment. Likert-5 point summated rating was applied to evaluate user preferences for the provided boxes with handles in upper, middle, and lower positions, in four different sizes and manual handling positions. Ten additional subjects were asked to indicate their BPD on a body chart after performing a similar experiment. The results show that the subjects preferred the upper part of the handle on a small box regardless of handling position; while the mid to upper parts of the handle on a big box were preferred for handling above the waist height. BPD also indicated that an upper handle was less stressful for a relatively smaller box than a big one; and mid to upper handles were less comfortable for a big box. The optimal handle positions depending on box size and handling position were suggested based on the results of the evaluation. It is thus recommended that a box provides a handle according to its relevant position, depending on size and manual handling condition, to reduce the musculoskeletal stress and in turn to increase user satisfaction.

- **Keywords:** Handles; Box; Carton; Manual materials handling; Musculoskeletal disorders

Yu-Hern Chang, Chung-Hsing Yeh. *Human performance interfaces in air traffic control*. Pages 123-129.

This paper examines how human performance factors in air traffic control (ATC) affect each other through their mutual interactions. The paper extends the conceptual SHEL model of ergonomics to describe the ATC system as human performance interfaces in which the air traffic controllers interact with other human performance factors including other controllers, software, hardware, environment, and organisation. New research hypotheses about the relationships between human performance interfaces of the system are developed and tested on data collected from air traffic controllers, using structural equation modelling. The research result suggests that organisation influences play a more significant role than individual differences or peer influences on how the controllers interact with the software, hardware, and environment of the ATC system. There are mutual influences between the controller–software, controller–hardware, controller–environment, and controller–organisation interfaces of the ATC system, with the exception of the controller–controller interface. Research findings of this study provide practical insights in managing human performance interfaces of the ATC system in the face of internal or external change, particularly in understanding its possible consequences in relation to the interactions between human performance factors.

- **Keywords:** Air traffic control; Human performance factors; Human performance interfaces; SHEL model

Jürgen Sauer, Katrin Seibel, Bruno Rüttinger. *The influence of user expertise and prototype fidelity in usability tests*. Pages 130-140.

An empirical study examined the impact of user expertise and prototype fidelity on the outcomes of a usability test. User expertise (expert vs. novice) and prototype fidelity (paper prototype, 3D mock-up, and fully operational appliance) were manipulated as independent variables in a 2 × 3 between-subjects design. Employing a floor scrubber as a model product, 48 users carried out several cleaning tasks. Usability problems identified by participants were recorded. Furthermore, performance, system management strategies and perceived usability were measured. The results showed that experts reported more usability problems than novices but these were considered to be less severe than those reported by novices. Reduced fidelity prototypes were generally suitable to predict product usability of the real appliance. The implications for the running of usability tests are specific to the fidelity of the prototype.

- **Keywords:** Usability test; Prototype fidelity; User expertise

Vincent M. Ciriello, Rammohan V. Maikala, Patrick G. Dempsey, Niall V. O'Brien *Psychophysically determined forces of dynamic pushing for female industrial workers : comparison of two apparatuses*. Pages 141-145.

Using psychophysics, the maximum acceptable forces for pushing have been previously developed using a magnetic particle brake (MPB) treadmill at the Liberty Mutual Research Institute for Safety. The objective of this study was to investigate the reproducibility of maximum acceptable initial and sustained forces while performing a pushing task at a frequency of 1 min⁻¹ both on a MPB treadmill and on a high-inertia pushcart. This is important because our pushing guidelines are used extensively as a ergonomic redesign strategy and we would like the information to be as applicable as possible to cart pushing. On two separate days, nineteen female industrial workers performed a 40-min

MPB treadmill pushing task and a 2-hr pushcart task, in the context of a larger experiment. During pushing, the subjects were asked to select a workload they could sustain for 8 h without "straining themselves or without becoming unusually tired, weakened, overheated or out of breath." The results demonstrated that maximum acceptable initial and sustained forces of pushing determined on the high inertia pushcart were 0.8% and 2.5% lower than the MPB treadmill. The results also show that the maximum acceptable sustained force of the MPB treadmill task was 0.5% higher than the maximum acceptable sustained force of Snook and Ciriello (1991). Overall, the findings confirm that the existing pushing data developed by the Liberty Mutual Research Institute for Safety still provides an accurate estimate of maximal acceptable forces for the selected combination of distance and frequency of push for female industrial workers.

- **Keywords:** Psychophysics; Cart pushing; Manual materials handling

A.K. Dey, D.D. Mann. *A complete task analysis to measure the workload associated with operating an agricultural sprayer equipped with a navigation device.* Pages 146-149.

The objective of this study was to perform a complete task analysis to measure the workload associated with operating an agricultural sprayer equipped with a navigation device. The task analysis included a written questionnaire and subsequent observation of sprayer operators. The questionnaire revealed that the lightbar was the most important source of guidance information (as opposed to relying on guidance information from external field cues). Observation consisted of recording eye-glance behaviour and heart rate variability while operators were spraying in a field setting. The eye-glance data suggest that external cues are more important than the lightbar for providing the necessary navigation information. Thus, the questionnaire and observation data contradict each other. Based on heart rate variability, operators who used a lightbar navigation device experienced more mental workload than operators who used an auto-steer navigation device.

- **Keywords:** Workload; Agricultural spraying; Task analysis; Mental workload; Eye-glance behaviour

Maryline Rebsamen, Jean-Michel Boucheix, Michel Fayol. *Quality control in the optical industry : from a work analysis of lens inspection to a training programme, an experimental case study.* Pages 150-160.

A cognitive work analysis of quality inspection in the optical industry has been carried out in order to devise a training programme. The task concerned the inspection of high quality human eyeglass lenses. We conducted an experimental investigation of defect detection and acceptability decision-making tasks in 18 experts and novice inspectors. Detection and decision-making were investigated together and separately in two experimental sessions. We showed the effect of expertise on reaction times and errors, and we described the cognitive processes of novice inspectors. On the basis of the processing differences between the two groups, a training programme for new inspectors was devised and described. Finally, training effects were tested.

- **Keywords:** Control; Expertise; Training

David Barr, Warren Gregson, Thomas Reilly. *The thermal ergonomics of firefighting reviewed.* Pages 161-172.

The occupation of firefighting is one that has repeatedly attracted the research interests of ergonomics. Among the activities encountered are attention to live fires, performing search and rescue of victims, and dealing with emergencies. The scientific literature is

reviewed to highlight the investigative models used to contribute to the knowledge base about the ergonomics of firefighting, in particular to establish the multi-variate demands of the job and the attributes and capabilities of operators to cope with these demands. The job requires individuals to be competent in aerobic and anaerobic power and capacity, muscle strength, and have an appropriate body composition. It is still difficult to set down thresholds for values in all the areas in concert. Physiological demands are reflected in metabolic, circulatory, and thermoregulatory responses and hydration status, whilst psychological strain can be partially reflected in heart rate and endocrine measures. Research models have comprised of studying live fires, but more commonly in simulations in training facilities or treadmills and other ergometers. Wearing protective clothing adds to the physiological burden, raising oxygen consumption and body temperature, and reducing the time to fatigue. More sophisticated models of cognitive function compatible with decision-making in a fire-fighting context need to be developed. Recovery methods following a fire-fighting event have focused on accelerating the restoration towards homeostasis. The effectiveness of different recovery strategies is considered, ranging from passive cooling and wearing of cooling jackets to immersions in cold water and combinations of methods. Rehydration is also relevant in securing the safety of firefighters prior to returning for the next event in their work shift.

- **Keywords:** Firefighter; Physical demands; Physiological responses; Recovery strategies