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Robert S. Bridger, Andrea J. Day & Kate Morton. *Occupational stress and employee turnover.* Pages 1629-1639.

Questionnaire data captured in January–March 2007 were examined in relation to turnover in males and females during the next five years. In general, most of the workplace stressors (such as role conflict or peer support) were not antecedents of turnover in any group. Junior personnel with psychological strain in 2007 had an increased risk of turnover in the next five years. Low commitment to the service in 2007 increased the odds of turnover in male and female juniors and in female officers. Female juniors with less effective skills for coping with stress and who exercised less frequently on a weekly basis were more likely to leave. An incidental finding was that the odds of turnover were three times greater in female officers with children than in female officers with no children. Stress management interventions focusing on effective coping and sports and exercise participation which are targeted appropriately may improve retention.

Practitioner Summary: Much is known about the adverse effects of occupational stress on health and well-being. This study demonstrates a link between stress and employee turnover implying that stress management interventions may benefit employers, by reducing turnover.

- **Keywords:** occupational stress, psychological strain, turnover

Kati Karhula, Mikko Härmä, Mikael Sallinen, Christer Hublin, Jussi Virkkala, Mika Kivimäki, Jussi Vahtera & Sampsa Puttonen. *Association of job strain with working hours, shift-dependent perceived workload, sleepiness and recovery.* Pages 1640-1651.

We explored the relationship of job strain with working hours, shift-dependent perceived workload, sleepiness and recovery. Nurses/nursing assistants (n = 95) were recruited from wards that belonged to either the top (high-strain group, HJS) or the bottom (low-strain group, LJS) job strain quartiles of a Job Content Questionnaire survey of employees in five health care districts and four cities in Finland. Three-week field measurements during naturally occurring shift schedules and a subset of pre-selected shift arrangements consisted of the Karolinska Sleepiness Scale, perceived workload and recovery. The HJS group (n = 42) had more single days off and quick returns than the

LJS group (n = 53, p < 0.01), and both mental workload and physical workload were rated as higher (p < 0.01). During naturally occurring shift arrangements, severe sleepiness was more common in the HJS group only in quick returns (p = 0.04) and the HJS group recovered on average more poorly from work after all shifts (p = 0.01) and morning shifts (p = 0.02). During pre-selected shift arrangements, the differences between the groups were only minor. In conclusion, job strain-related differences in sleepiness and recovery were mostly attributable to differences in shift arrangements.

Practitioner Summary: High job strain among shift workers is associated with higher perceived work load, poorer ergonomics in work schedules and low control over shift scheduling. Ergonomics in shift planning and better opportunities to influence working hours and workload should be implemented to reduce work strain.

- **Keywords:** work stress, shift work, shift planning, nursing, need for recovery from work

Dong-Joo Yang, Dongmug Kang, Young-Ki Kim, Yeun-Hee Kim, Yeong-Ae Yang, Su-Min Cha, Il Kyu Eom & Jong-Eun Kim. *Reliability of self-administered Work Ability Index questionnaire among Korean workers.* Pages 1652-1657.

Although the Work Ability Index (WAI) has been used in many countries, its reliability is yet to be validated in Korea. In our study, test–retest results of WAI total score, WAI category and seven subscales were compared. The correlation coefficients of WAI total score and subscales 1 and 2 between test and retest were 0.70, 0.80 and 0.63, respectively. The κ values on WAI category, subscales 4, 5, 6 and 7 were 0.52, 0.32, 0.31, 0.48 and 0.85, respectively. The results of our reliability test show that WAI scores of female, younger and private company workers were found to be higher than those of male, older and public company workers, respectively. We conclude that overall test–retest reliability of WAI in Korea is acceptable. Another notable observation from our study is that work ability dimension (subscales 1, 2 and 7) had a higher reliability, whereas health dimension (subscales 3–6) had a lower reliability.

Practitioner Summary: The reliability of WAI was acceptable. Reliabilities of female, younger and private company workers were higher than those of workers male, older and public company worker. Reliability of work ability dimension was also higher than that of health dimension.

- **Keywords:** Work Ability Index, reliability, subscale, dimension, Korea

Marina Meinert, Mirjam König & Wolfgang Jaschinski. *Web-based office ergonomics intervention on work-related complaints: a field study.* Pages 1658-1668.

The aim of this study was a proof of concept to examine the effects of a web-based office ergonomics intervention on subjects' individual workplace adjustments. An intervention study was conducted with 24 office workers lasting 6 weeks with three consecutive phases (before, 1 and 5 weeks after the intervention). Employees used a purpose-made website for adjusting their computer workplaces without any personal support of ergonomics experts. Workplace measurements were taken directly on site and by analysing photos taken of the employee. Self-reported complaints were assessed by filling in a questionnaire. It was found that 96% of the employees changed their workplaces on their own and retained them mostly unchanged after the intervention. Furthermore, self-reported musculoskeletal complaints and headache symptoms decreased significantly after the intervention. These findings suggest an improvement of

workplace conditions so that cost-effective ergonomic web-based interventions appear promising in further research and application.

Practitioner Summary: A field study was conducted using for the first time a website as an intervention tool in offices. Employees used it independently without personal expert training. Results indicated that employees could improve their computer workplace situation after using the website.

- **Keywords:** computer workplace, eyestrain, musculoskeletal complaints, training, e-learning

Richard J. Holden, Pascale Carayon, Ayse P. Gurses, Peter Hoonakker, Ann Schoofs Hundt, A. Ant Ozok & A. Joy Rivera-Rodriguez. *SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients.* Pages 1669-1686.

Healthcare practitioners, patient safety leaders, educators and researchers increasingly recognise the value of human factors/ergonomics and make use of the discipline's person-centred models of sociotechnical systems. This paper first reviews one of the most widely used healthcare human factors systems models, the Systems Engineering Initiative for Patient Safety (SEIPS) model, and then introduces an extended model, 'SEIPS 2.0'. SEIPS 2.0 incorporates three novel concepts into the original model: configuration, engagement and adaptation. The concept of *configuration*highlights the dynamic, hierarchical and interactive properties of sociotechnical systems, making it possible to depict how health-related performance is shaped at 'a moment in time'. *Engagement*conveys that various individuals and teams can perform health-related activities separately and collaboratively. Engaged individuals often include patients, family caregivers and other non-professionals. *Adaptation* is introduced as a feedback mechanism that explains how dynamic systems evolve in planned and unplanned ways. Key implications and future directions for human factors research in healthcare are discussed.

Practitioner Summary: SEIPS 2.0 is a new human factors/ergonomics framework for studying and improving health and healthcare. It describes how sociotechnical systems shape health-related work done by professionals and non-professionals, independently and collaboratively. Work processes, in turn, shape patient, professional and organisational outcomes. Work systems and processes undergo planned and unplanned adaptations.

- **Keywords:** healthcare, work system, patient-centred care, patient and family engagement, SEIPS model

J.B. Mackrill, P.A. Jennings & R. Cain. *Improving the hospital 'soundscape': a framework to measure individual perceptual response to hospital sounds.* Pages 1687-1697.

Work on the perception of urban soundscapes has generated a number of perceptual models which are proposed as tools to test and evaluate soundscape interventions. However, despite the excessive sound levels and noise within hospital environments, perceptual models have not been developed for these spaces. To address this, a two-stage approach was developed by the authors to create such a model. First, semantics were obtained from listening evaluations which captured the feelings of individuals from hearing hospital sounds. Then, 30 participants rated a range of sound clips representative of a ward soundscape based on these semantics. Principal component analysis extracted a two-dimensional space representing an emotional–cognitive

response. The framework enables soundscape interventions to be tested which may improve the perception of these hospital environments.

Practitioner Summary: Hospital sound is commonly measured in terms of objective sound level. This does not consider the positive or negative subjective reactions to these sounds. This paper understands these reactions and produces a perceptual framework which can be used to measure the subjective response to a hospital soundscape.

- **Keywords:** perception, hospital, sound, environment

Monica R. Weiler, Steven A. Lavender, J. Mac Crawford, Paul A. Reichelt, Karen M. Conrad & Michael W. Browne. *A structural equation modelling approach to predicting adoption of a patient-handling intervention developed for EMS providers.* Pages 1698-1707.

Patient-handling tasks are integral to Emergency Medical Service (EMS) work as are the musculoskeletal injuries associated with these tasks. The aim of this study was to develop and test a structural equation model that describes the interactions between previously identified factors that contribute to the adoption of a specific ergonomics intervention designed for EMS work. EMS responders (n = 187), from six different organisations, participated in a 2-month longitudinal study following the introduction of a foldable patient transfer-board (slide-board) designed to assist with lateral patient transfers. Surveys administered at baseline, after 1 month and after 2 months sampled factors potentially influencing EMS responders' adoption decisions. Perceived ergonomics advantage, which was influenced by access and storage concerns and prior tool experience, contributed most strongly to intention to use at the end of the first month and to the emergence of champions, which contributed to the intention to use at the end of the second month.

Practitioner Summary: Emergency Medical Service (EMS) responders' intention to use and actual use of a foldable transfer-board was strongly influenced by perceived 'ergonomics advantage'. Perceived ergonomics advantage was influenced by access/storage issues and previous tool experience. Perceived 'ergonomics advantage' also affects the emergence of champions which, in turn, impacts the EMS responders' intention to use.

- **Keywords:** intervention adoption, ergonomics intervention, injury prevention, Emergency Medical Service, firefighter

Christopher J. Palmer, Carol Bigelow & Richard E.A. Van Emmerik. *Defining soldier equipment trade space: load effects on combat marksmanship and perception–action coupling.* Pages 1708-1721.

Soldier equipment compromises task performance as temporal constraints during critical situations and load increase inertial and interactive forces during movement. Methods are necessary to optimise equipment that relate task performance to underlying coordination and perception–action coupling. Employing ecological task analysis and methods from dynamical systems theory, equipment load and coordination was examined during two sub-tasks embedded in combat performance, threat discrimination and dynamic marksmanship. Perception–action coupling was degraded with load during threat discrimination, leading to delays in functional reaction time. Reduced speed and accuracy during dynamic marksmanship under load was related to disrupted segmental coordination and adaptability during postural transitions between targets. These results show how reduced performance under load relates to coordination changes and perception–action coupling. These changes in functional capability are directly related to soldier survivability in combat. The methods employed may aid equipment design

towards more optimised performance by modifying equipment or its distribution on humans.

Practitioner Summary: The combat equipment necessary for soldier survival and mission accomplishment significantly impedes task performance. Understanding relations among equipment, task performance, situational awareness and segmental coordination is necessary to define the trade space for design optimisation. This article begins to define this trade space in terms of perception–action coupling and survivability in combat.

- **Keywords:** military ergonomics, marksmanship, perception–action coupling, coordination dynamics, survivability

J.D. Rose, E. Mendel & W.S. Marras. *Carrying and spine loading.* Pages 1722-1732.

The advantages and disadvantages of different methods of carrying objects on spine loading are still not fully understood. Previous studies have either examined the effects of carrying using physiological measures or examined isolated spine segments using biomechanical models. Additionally, most studies have been restricted to only a small number of carrying conditions. Very few studies have attempted to examine the various factors influencing spine loading together. To improve understanding of interacting factors on carrying, this study assessed the lumbar spine loads of 16 subjects as they assumed six styles of carrying at two weight levels and two activity levels (walking vs. standing). Concurrent with each trial, a subject-specific biomechanical model was used to assess spine forces over the full lumbar spine. Most carrying methods in the trials resulted in relatively low levels of spine loading. Anterior/posterior (A/P) shear loading was the only spine-loading dimension that reached biomechanically meaningful levels. Two carrying conditions, with bins carried in front of the body, significantly increased A/P shear compared with other carrying styles. This increase appeared to be due to the greater moment arms occurring in these conditions. Many of the other carrying styles produced A/P shears that were similar to those observed when carrying nothing at all. Of all the tasks, the backpack carry characteristically produced especially low spine loads. The findings of the study suggest that to achieve optimal carrying in terms of spine loading, loads should be positioned close to the body, even when carrying relatively light loads.

Practitioner Summary: The risks carrying poses to the spine are still not fully understood. This study analysed forces on the lumbar spine for various realistic carrying styles. The findings indicate methods of carrying that increase the relative risk to the lumbar spine and others that have a minimal effect at the weights tested.

- **Keywords:** carry, low back disorders, spine biomechanics, manual materials handling

Xueliang Huo, Ashley N. Johnson-Long, Maysam Ghovanloo & Minoru Shinohara. *Motor performance of tongue with a computer-integrated system under different levels of background physical exertion.* Pages 1733-1744.

The purpose of this study was to compare the motor performance of tongue, using Tongue Drive System, to hand operation for relatively complex tasks under different levels of background physical exertion. Thirteen young able-bodied adults performed tasks that tested the accuracy and variability in tracking a sinusoidal waveform, and the performance in playing two video games that require accurate and rapid movements with cognitive processing using tongue and hand under two levels of background physical

exertion. Results show additional background physical activity did not influence rapid and accurate displacement motor performance, but compromised the slow waveform tracking and shooting performances in both hand and tongue. Slow waveform tracking performance by the tongue was compromised with an additional motor or cognitive task, but with an additional motor task only for the hand.

Practitioner Summary: We investigated the influence of task complexity and background physical exertion on the motor performance of tongue and hand. Results indicate the task performance degrades with an additional concurrent task or physical exertion due to the limited attentional resources available for handling both the motor task and background exertion.

- **Keywords:** assistive device, dual task, finger, motor control, tongue

Tad T. Brunyé, Jessica L. Howe, Brian R. Kimball, Marianna D. Eddy & Caroline R. Mahoney. *Variable transmission lens influences on the dynamics of pupillary light reflexes.* Pages 1745-1753.

This study examined the influence of liquid crystal variable transmission lenses on pupillary light reflexes in response to sudden bright light onset. Participants were exposed to bright light while pupil size was monitored using an eye tracker; eyewear was configured across four transition conditions: constant low-light filtering, constant high-light filtering, variable-light filtering in response to light detection and a control condition without eyewear. Before light onset, pupil diameter was largest in the high-filter condition, medium in the variable- and low-light filtering conditions and smallest in the control condition. Following light onset, the low-light filtering and control conditions, and the high-light filtering and variable-light filtering conditions converged over time. Critically, automatically transitioning between low- and high-light filtering reduced the magnitude (approximately 0.2 mm) and duration (approximately 360 ms) of the pupillary response relative to constant low-light filtering.

Practitioner Summary: Emerging civilian and specialised industrial and military eyewear technologies incorporating variable transmission lenses quickly and automatically adapt lens tints to environmental lighting conditions. We demonstrate that this technology alters the dynamics of pupillary light reflexes, optimising the efficiency with which humans can adapt to sudden changes in environmental lighting.

- **Keywords:** adaptive eyewear, light transmission, pupillary light reflex, vision

Byungjoo Lee & Hyunwoo Bang. *A kinematic analysis of directional effects on mouse control.* Pages 1754-1765.

The directional effects associated with cursor movement controlled by a computer mouse have long been studied to improve mouse performance during precise tasks. However, those studies have rarely considered the kinematic variables associated with directional effects and have only analysed the projection of trajectories along the main axes of movement, eventually reducing the original dimensions of the data. In addition, as the angle of approach has a limited number of levels, it has been difficult to observe singular behaviour in the horizontal directions. In this study, we investigated the directional effects on kinematic variables when using a mouse to select circular targets. In this experiment, the measured trajectory of 16 different angles of approach was measured after separating the *x* and *y* components. The results revealed interesting biomechanical and cognitive features of mouse control and led to the suggestion of two improvements to be made upon the typical mouse design.

Practitioner Summary: The angle of approach was varied to determine its effect on the kinematic variables of a cursor trajectory. We analysed both the *x* and *y* coordinates

separately without reducing the original dimensions of the data. Therefore, we succeeded in identifying previously unknown characteristics of mouse control.

- **Keywords:** mouse, kinematic analysis, directional effect, ISO 9241-9

Errol R. Hoffmann, Alan H.S. Chan & Coskun Dizmen. *Capture of shrinking targets with realistic shrink patterns.* Pages 1766-1776.

Previous research [Hoffmann, E. R. 2011. "Capture of Shrinking Targets." *Ergonomics* 54 (6): 519–530] reported experiments for capture of shrinking targets where the target decreased in size at a uniform rate. This work extended this research for targets having a shrink-size versus time pattern that of an aircraft receding from an observer. In Experiment 1, the time to capture the target in this case was well correlated in terms of Fitts' index of difficulty, measured at the time of capture of the target, a result that is in agreement with the 'balanced' model of Johnson and Hart [Johnson, W. W., and Hart, S. G. 1987. "Step Tracking Shrinking Targets." Proceedings of the human factors society 31st annual meeting, New York City, October 1987, 248–252]. Experiment 2 measured the probability of target capture for varying initial target sizes and target shrink rates constant, defined as the time for the target to shrink to half its initial size. Data of shrink time constant for 50% probability of capture were related to initial target size but did not greatly affect target capture as the rate of target shrinking decreased rapidly with time.

Practitioner Summary: Shrinking targets occur in applications such as gunnery, computer games and game shooting, where the object to be shot or captured moves away from an observer. Times for capture of shrinking targets are developed in terms of a modified form of Fitts' law.

- **Keywords:** Fitts' law, shrinking targets, movement time

Christopher J. Garneau & Matthew B. Parkinson. *Considering just noticeable difference in assessments of physical accommodation for product design.* Pages 1777-1788.

Configuring products or environments for the size of their human users requires the consideration of several characteristics of the target user population, including body dimensions (anthropometry) and preferred interaction. Users are both adaptable and imperfect observers, which often makes it difficult for them to distinguish between candidate designs. This insensitivity is described by a concept called 'just noticeable difference', or JND. This paper presents an implementation of JND modelling and demonstrates how its use in the sizing of products or environments for target user populations can improve expected performance. Two facets of this problem are explored: (1) how experimental measures of JND for dimensional optimisation tasks may be obtained, and (2) how measures of JND may be included in models of user–device interaction for both adjustable and discretely sized products and the assumptions required. A case study demonstrating the collection and modelling of JND for a simple univariate problem is also presented.

Practitioner Summary: Since people are adaptable and imperfect observers, there exists a 'just noticeable difference' that can be considered when designing products and environments. When JND is modelled for a target population, less variability in design dimensions due to physical user requirements may be necessary. This paper considers JND in quantitative simulations of population accommodation.

- **Keywords:** just noticeable difference (JND), designing for human variability (DfHV), user sensitivity, anthropometry, physical accommodation