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June J. Pilcher, Melissa A. Vander Wood & Kristina L. O'Connell. *The effects of extended work under sleep deprivation conditions on team-based performance.* Pages 587-596.

Teamwork is becoming increasingly common in today's workplaces; however, little research has examined how well teams perform under sleep deprivation conditions. The purpose of the current study was to examine the effect of extended work under sleep deprivation conditions on team performance. A total of 24 participants were sleep deprived for 30 h and completed 16 h of sustained operations during the last portion of the sleep deprivation period. The participants completed the Wombat, a complex task including vigilance and cognitive components, with a partner in four 24-min testing sessions during the sustained operations period. The results indicated that team performance increased during the work period while, within each testing session, team performance on vigilance tasks remained stable and overall performance decreased. The current results suggest that performance on two-person teams results in improved performance but does not fully counteract the decreases in performance within each work period. Performance in two-person teams increased across an extended work shift under sleep deprivation conditions. However, vigilance performance remained stable while overall performance decreased when examining performance in 8-min segments. These results suggest that averaging team-based performance over a longer testing period may mask the negative effects of sleep deprivation. **Statement of Relevance:** Performance in two-person teams increased across an extended work shift under sleep deprivation conditions. However, vigilance performance remained stable while overall performance decreased when examining performance in 8-min segments. These results suggest that averaging team-based performance over a longer testing period may mask the negative effects of sleep deprivation.

- **Keywords:** performance, sleep deprivation, sustained operations, teamwork

Robert S. Bridger, Kate Brasher, Angela Dew & Kathy Sparshott. *Cumulative psychological strain and future strain in Naval personnel: is executive function the elephant in the room?* Pages 597-608.

Psychological strain was measured in 592 Naval personnel at four phases using the General Health Questionnaire (GHQ-12). The GHQ-12 Likert score was summed to generate a measure of cumulative strain, which was best predicted by the Cognitive

Failures Questionnaire (CFQ) score, effort–reward imbalance and a measure of organisational commitment. Point strain at phase IV was best predicted by CFQ score, whereas need for recovery was best predicted by over-commitment to work role. Susceptibility to strain, both cumulatively over 2 years and 12 months in the future appears to depend on a cognitive factor measured by the CFQ. This factor was more strongly associated with strain than with fatigue. Psychosocial stress exposure at work played a lesser role in predicting cumulative and future strain, possibly because these stressors were of an acute nature. The findings are discussed with reference to recent research on attention and anxiety and some of the practical implications are considered. **Statement of Relevance:** There is renewed interest in intrinsic variables that predict adverse reactions to occupational stress. The paper presents evidence that self-reported cognitive failure is a vulnerability factor for future episodes of psychological strain. The paper strengthens the conclusions of a previous article and adds empirical support to recent research on the links between anxiety and attention.

- **Keywords:** cognitive failure, Navy, occupational stress, psychological strain

Catherine Harvey, Neville A. Stanton, Carl A. Pickering, Mike McDonald & Pengjun Zheng. *To twist or poke? : a method for identifying usability issues with the rotary controller and touch screen for control of in-vehicle information systems.* Pages 609-625.

In-vehicle information systems (IVIS) can be controlled by the user via direct or indirect input devices. In order to develop the next generation of usable IVIS, designers need to be able to evaluate and understand the usability issues associated with these two input types. The aim of this study was to investigate the effectiveness of a set of empirical usability evaluation methods for identifying important usability issues and distinguishing between the IVIS input devices. A number of usability issues were identified and their causal factors have been explored. These were related to the input type, the structure of the menu/tasks and hardware issues. In particular, the translation between inputs and on-screen actions and a lack of visual feedback for menu navigation resulted in lower levels of usability for the indirect device. This information will be useful in informing the design of new IVIS, with improved usability. **Statement of Relevance:** This paper examines the use of empirical methods for distinguishing between direct and indirect IVIS input devices and identifying usability issues. Results have shown that the characteristics of indirect input devices produce more serious usability issues, compared with direct devices and can have a negative effect on the driver–vehicle interaction.

- **Keywords:** evaluation, interaction, in-vehicle information systems, usability

Jung-Hyun Kim, Aitor Coca, W. Jon Williams & Raymond J. Roberge. *Subjective perceptions and ergonomics evaluation of a liquid cooled garment worn under protective ensemble during an intermittent treadmill exercise.* Pages 626-635.

While a personal protective equipment (PPE) ensemble effectively provides workers with protection from occupational hazards, working in a vapour-resistant ensemble increases the risk of heat illness/injuries and physiological burdens. The purpose of this study was to investigate the effect of body cooling via a liquid-cooled garment (LCG) underneath a PPE ensemble on perceived thermal strain, physiological responses and ergonomics during an intermittent treadmill exercise in warm environmental conditions. The results of the present study indicated that the concomitant wearing of LCG underneath the PPE ensemble significantly reduced subjective perception of heat and alleviated overall increase in body temperature and heart rate while no impact of wearing LCG on ergonomic features was found. The extension of the present findings to practical applications in occupational settings requires further research on a LCG system design

and performance evaluations while the LCG is incorporated within the PPE ensemble. **Statement of Relevance:** Implementation of a LCG underneath PPE for body cooling was investigated, focusing on its impact on individuals' perceived thermal strain, physiological responses and ergonomics. The findings of the present study indicated that body cooling via a wearable LCG underneath PPE significantly alleviated both perceived thermal and physiological strain in uncompensable heat stress condition.

- **Keywords:** ergonomics, liquid-cooled garment, protective ensemble, subjective perceptions

Jemma L. Coleman, Leon M. Straker, Amity Campbell, Hiroyuki Izumi & Anne Smith. *Biering-Sorensen test performance of Japanese young males : comparison with other ethnicities and relationship to electromyography, near-infrared spectroscopy and exertion ratings. Pages 636-655.*

Back muscle endurance is a predictor of future low back pain and is commonly assessed using the Biering-Sorensen Test (BST). Differences exist between ethnic groups that may affect the performance and interpretation of the BST and should be investigated. This study's aim was to explore objective and subjective measures of the BST in a Japanese group in comparison with previous studies in other ethnic groups. A total of 27 young male Japanese students performed the BST while measures of muscle fatigue were collected. The mean BST time (152.7 (32.5) s) was greater than the median of the reported mean times in other ethnic groups over the previous decade (128.6 s). Objective measures indicated that the Japanese subjects' lumbar muscles were as fatigued as those of previous studies, while subjective measures appear to indicate that subjects under-reported exertion. The better performance of the Japanese subjects in the BST may reflect physical, psychosocial and lifestyle differences related to ethnicity. **Statement of Relevance:** Ergonomics research and practice needs to be applicable to different ethnic groups. Despite the substantial body of evidence on back muscle endurance and indications of potential ethnicity related differences, this had not been previously investigated. These results help ergonomists to interpret physical ergonomics evidence in a multi-ethnic world.

- **Keywords:** Biering-Sorensen, electromyography, ethnic differences, fatigue, near-infrared spectroscopy

Vibhor Agrawal, Robert Gailey, Ignacio Gaunaud, Robert Gailey III & Christopher O'Toole. *Weight distribution symmetry during the sit-to-stand movement of unilateral transtibial amputees. Pages 656-664.*

This study characterises weight distribution symmetry between the intact and amputated limbs of unilateral transtibial amputees during a sit-to-stand movement. A total of 12 amputees and 12 age-matched, non-amputees performed the activity for two conditions – rising with and without chair arm-rest assistance. The sit-to-stand movement was divided into five events: Pre-Ascent; Ascent Initiation; Seat-Off; Deceleration; Standing. Symmetry in ground reaction forces between limbs was calculated at each event together with the rise time. Results indicate that during the course of the movement, amputees increased loading of the intact limb by approximately 27%, resulting in a significant asymmetry at seat-off and deceleration events. Non-amputees loaded the dominant limb more than the non-dominant limb throughout the activity but did not exhibit substantial weight shifts. Weight distribution symmetry was not significantly different between the two rising conditions in either population. Amputees had significantly longer rise times than non-amputees only while rising without arm-rest assistance. **Statement of Relevance:** Sit-to-stand movements are performed frequently every day. Incorrect movement biomechanics caused by musculoskeletal impairments can lead to reduced

functional independence and secondary co-morbidities. This study defines five events of a sit-to-stand cycle and is the first to address asymmetries of transtibial amputees, providing ergonomic insights for clinical assessment and intervention.

- **Keywords:** amputee biomechanics, assisted rising, clinical movement analysis, sit-to-stand events, standing

Mark W. Creaby, Kirsty May & Kim L. Bennell. *Insole effects on impact loading during walking.* Pages 665-671.

Impact loading during walking has been associated with overuse related musculoskeletal disorders, such as osteoarthritis. This study was designed to determine the effect of two shoe insole designs on impact-related loading during walking. In total, 22 healthy adults walked along a 10-m walkway in three different insole conditions: (i) no insole; (ii) flat material insole; (iii) heel-cup insole. Impact forces at the ground were determined and estimated at the knee in a subset of participants ($n = 14$). Repeated measures ANOVA revealed a significant reduction in peak vertical ground reaction force (vGRF) with the flat material insole compared with the no insole and heel-cup conditions ($p = 0.001$). No differences between conditions were observed in vGRF loading rate ($p > 0.05$). Peak impact force at the knee was reduced with flat material insoles and heel-cup insoles ($p < 0.05$). These data indicate that reductions in impact forces during walking are dependent upon insole design. **Statement of Relevance:** This study provides new evidence that impact loads are reduced with shoe insoles during walking. High impact loads are implicated in the development and progression of knee pathologies, including osteoarthritis. Thus, these findings indicate that insole use may be beneficial for various musculoskeletal disorders, including key public health problems such as osteoarthritis.

- **Keywords:** biomechanics, gait, ground reaction force, orthotics, overuse Indry

D.C. Ribeiro, G. Sole, J.H. Abbott & S. Milosavljevic. *The reliability and accuracy of an electromagnetic motion analysis system when used conjointly with an accelerometer.* Pages 672-677.

The effect of an accelerometer driven electronic postural monitor (Spineangel®) placed within the electromagnetic measurement field of the Polhemus Fastrak™ is unknown. This study assessed the reliability and accuracy of Fastrak™ linear and angular measurements, when the Spineangel® was placed close to the sensor(s) and transmitter. Bland Altman plots and intraclass correlation coefficient (2,1) were used to determine protocol reproducibility and measurement consistency. Excellent reliability was found for linear and angular measurements (0.96, 95% CI: 0.90–0.99; and 1.00, 95% CI: 1.00–1.00, respectively) with the inclusion of Spineangel®; similar results were found, without the inclusion of Spineangel®, for linear and angular measurements, (0.96, 95% CI: 0.89–0.99; and 1.00, 95% CI: 1.00–1.00, respectively). The greatest linear discrepancies between the two test conditions were found to be less than 3.5 mm, while the greatest angular discrepancies were below 3.5°. As the effect on accuracy was minimal, these findings support the conjoint use of the Fastrak™ during validation studies of the Spineangel® device. **Statement of Relevance:** Although previous studies have used the Fastrak™ as the gold standard measurement system, the influence of an accelerometer driven postural monitor on accuracy has not been reported. The strength of the present study has been to determine the effect of accelerometer placement within the electromagnetic field on the reliability and accuracy of the Fastrak™.

- **Keywords:** accelerometer, accuracy, electromagnetic device, reliability, validity