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Øystein Vedaa, Anette Harris, Bjørn Bjorvatn, Siri Waage, Børge Sivertsen, Philip Tucker & Ståle Pallesen. *Systematic review of the relationship between quick returns in rotating shift work and health-related outcomes.* Pages 1-14.

A systematic literature search was carried out to investigate the relationship between quick returns (i.e. 11.0 hours or less between two consecutive shifts) and outcome measures of health, sleep, functional ability and work–life balance. A total of 22 studies published in 21 articles were included. Three types of quick returns were differentiated (from evening to morning/day, night to evening, morning/day to night shifts) where sleep duration and sleepiness appeared to be differently affected depending on which shifts the quick returns occurred between. There were some indications of detrimental effects of quick returns on proximate problems (e.g. sleep, sleepiness and fatigue), although the evidence of associations with more chronic outcome measures (physical and mental health and work–life balance) was inconclusive. **Practitioner Summary:** Modern societies are dependent on people working shifts. This study systematically reviews literature on the consequences of quick returns (11.0 hours or less between two shifts). Quick returns have detrimental effects on acute health problems. However, the evidence regarding effects on chronic health is inconclusive.

- **Keywords:** quick return, quick changeover, short changeover, short recovery

Rosemary H.M. Lim, Janet E. Anderson & Peter W. Buckle. *Work Domain Analysis for understanding medication safety in care homes in England: an exploratory study.* Pages 15-26.

Medication safety and errors are a major concern in care homes. In addition to the identification of incidents, there is a need for a comprehensive system description to avoid the danger of introducing interventions that have unintended consequences and are therefore unsustainable. The aim of this study was to explore the impact and uniqueness of Work Domain Analysis (WDA) to facilitate an in-depth understanding of medication safety problems within the care home system and identify the potential benefits of WDA to design safety interventions to improve medication safety. A comprehensive, systematic and contextual overview of the care home medication system

was developed for the first time. The novel use of the abstraction hierarchy (AH) to analyse medication errors revealed the value of the AH to guide a comprehensive analysis of errors and generate system improvement recommendations that took into account the contextual information of the wider system. **Practitioner Summary:** It is widely acknowledged that a systems approach is necessary to improve medication safety. This study used a cognitive engineering method, Work Domain Analysis, to map the care home medication system and analyse medication errors. A macro-level view of the system was developed and this has provided a knowledge base for future interventions.

- **Keywords:** care homes, nursing homes, human factors, medication safety, patient safety, Work Domain Analysis

Yutao Ba, Wei Zhang, QiJia Peng, Gavriel Salvendy & David Crundall. *Risk-taking on the road and in the mind: behavioural and neural patterns of decision making between risky and safe drivers. Pages 27-38.*

Drivers' risk-taking is a key issue of road safety. This study explored individual differences in drivers' decision-making, linking external behaviours to internal neural activity, to reveal the cognitive mechanisms of risky driving. Twenty-four male drivers were split into two groups (risky vs. safe drivers) via the Driver Behaviour Questionnaire-violation. The risky drivers demonstrated higher preference for the risky choices in the paradigms of Iowa Gambling Task and Balloon Analogue Risk Task. More importantly, the risky drivers showed lower amplitudes of feedback-related negativity (FRN) and loss-minus-gain FRN in both paradigms, which indicated their neural processing of error-detection. A significant difference of P300 amplitudes was also reported between groups, which indicated their neural processing of reward-evaluation and were modified by specific paradigm and feedback. These results suggested that the neural basis of risky driving was the decision patterns less revised by losses and more motivated by rewards. **Practitioner Summary:** Risk-taking on the road is largely determined by inherent cognitive mechanisms, which can be indicated by the behavioural and neural patterns of decision-making. In this regard, it is feasible to quantize drivers' riskiness in the cognitive stage before actual risky driving or accidents, and intervene accordingly

- **Keywords:** transportation safety, driving, event related potentials, decision making, individual differences

Christoph Hildebrandt, Martin Sedlmayr, Olivier Pion, Görkem Büyükyıldız, Roman Henze & Ferit Küçükay. *Driver perception of brake notifications under real driving conditions. Pges 39-47.*

The amount of information to be processed by drivers increases with the number of driver assistance systems (DAS). This implies that all relevant perception channels have to be used to convey information. The paper's contribution is to enable system designers to use differences in longitudinal acceleration as an information element in DAS. We conduct a study of the actual application context and examine the perceptible difference in longitudinal acceleration (kinaesthetic distortion). Thereby, we discuss dependencies of the perceptible difference on speed and acceleration immediately before the distortion. Furthermore, we investigate the spread of perceptual performance of different drivers. The results demonstrate smaller perceptible differences in acceleration at higher speed and weaker perception when the acceleration immediately before the warning is greater. This paper aims to provide a guideline for the implementation of brake warnings for informative DAS and for the adaption of the brake intensity according to current vehicle dynamics. **Practitioner Summary:** This paper aims to enable the kinaesthetic perception channel for informative driver assistance systems. A real world driving study reveals the perceptible difference in longitudinal acceleration (kinaesthetic distortion)

depending on vehicle speed and acceleration and serves as a guideline for applying brake warnings as an information element in vehicles.

- **Keywords:** psychophysics, driver assistance systems, perception, kinaesthetic distortion, brake notification

Nastaran Raffler, Rolf Ellegast, Thomas Kraus & Elke Ochsmann. *Factors affecting the perception of whole-body vibration of occupational drivers: an analysis of posture and manual materials handling and musculoskeletal disorders.* Pages 48-60.

Due to the high cost of conducting field measurements, questionnaires are usually preferred for the assessment of physical workloads and musculoskeletal disorders (MSDs). This study compares the physical workloads of whole-body vibration (WBV) and awkward postures by direct field measurements and self-reported data of 45 occupational drivers. Manual materials handling (MMH) and MSDs were also investigated to analyse their effect on drivers' perception. Although the measured values for WBV exposure were very similarly distributed among the drivers, the subjects' perception differed significantly. Concerning posture, subjects seemed to estimate much better when the difference in exposure was significantly large. The percentage of measured awkward trunk and head inclination were significantly higher for WBV-overestimating subjects than non-overestimators; 77 and 80% vs. 36 and 33%. Health complaints in terms of thoracic spine, cervical spine and shoulder–arm were also significantly more reported by WBV-overestimating subjects (42, 67, 50% vs. 0, 25, 13%, respectively). Although more MMH was reported by WBV-overestimating subjects, there was no statistical significance in this study. **Practitioner Summary:** Self-reported exposures of occupational drivers are affected by many other cofactors, and this can result in misinterpretations. A comparison between field measurement and questionnaire was used to highlight the factors affecting the perception of drivers for whole-body vibration (WBV) exposure. Posture and musculoskeletal disorders influenced the perception of the similarly WBV-exposed drivers significantly.

- **Keywords:** whole-body vibration, awkward posture, field measurements, questionnaires, musculoskeletal disorders

A Yanfei Xie, Grace P.Y. Szeto, Jie Dai & Pascal Madeleine. *Comparison of muscle activity in using touchscreen smartphone among young people with and without chronic neck–shoulder pain.* Pages 61-72."

This study aimed to examine differences in muscle activity between young people with and without neck–shoulder pain ($n = 20$ in each group), when they performed texting on a smartphone. Texting was compared between using both hands ('bilateral texting') and with only one hand ('unilateral texting'). Texting tasks were also compared with computer typing. Surface electromyography from three proximal postural muscles and four distal hand/thumb muscles on the right side was recorded. Compared with healthy controls, young people with neck–shoulder pain showed altered motor control consisting of higher muscle activity in the cervical erector spinae and upper trapezius when performing texting and typing tasks. Generally, unilateral texting was associated with higher muscle loading compared with bilateral texting especially in the forearm muscles. Compared with computer typing, smartphone texting was associated with higher activity in neck extensor and thumb muscles but lower activity in upper and lower trapezius as well as wrist extensors. **Practitioner Summary:** This study demonstrated that symptomatic individuals had increased muscle activity in the neck–shoulder region when texting on a smartphone. Contemporary ergonomic guidelines should include advice on how to interact with handheld electronic devices to achieve a relaxed posture and reduced muscle load in order to reduce the risk of musculoskeletal disorders.

- **Keywords:** neck–shoulder pain, touchscreen smartphone, texting, muscle activity

Chiuhsiang Joe Lin, Hung-Jen Chen & Jae-hoon Choi. *The postural and control-display gain effects of distal pointing on upper extremity fatigue.* Pages 73-84.

Pointing at displays from a distance is becoming common in both work and domestic environments. Ray-casting interaction is easy for novices to learn and understand, but this technique can cause physiological fatigue. To address this issue, the present study aims to investigate the issue of fatigue caused by joint-based pointing methods and Control-Display gains (CD gains) via Fitts' task. Ten healthy subjects participated in the experiment and performed multi-directional tapping tests with three joint-based pointing methods and three CD gains. The experimental results indicated that the joint-based pointing methods indeed affected the physiological and subjective fatigue of the upper limb muscles and measured body parts during distal pointing tasks. The wrist-based pointing method, which can induce substantially lower physiological and subjective fatigue, appears to be superior to the other two methods. There were no significant main effects of CD gains on either physiological fatigue or subjective Borg's CR-10 rating. **Practitioner Summary:** The present study investigates the issue of fatigue caused by joint-based pointing methods and CD gains via Fitts' task. The pointing methods affected the physiological and subjective fatigue of the upper-limb muscles. There were no significant main effects of CD gains on either physiological fatigue or subjective Borg's CR-10 rating.

- **Keywords:** ray-cast pointing, joint-based method, CD gain, fatigue, Fitts' law

A Michael W. Sonne & Jim R. Potvin. *Modified version of the three-compartment model to predict fatigue during submaximal tasks with complex force-time histories.* Pages 85-98.

The three-compartment model (3CM) was validated previously for prediction of endurance times by modifying its fatigue and recovery rates. However, endurance times do not typically represent work demands, and it is unknown if the current version of the 3CM is applicable for ergonomics analysis of all occupational tasks. The purpose of this study was to add biological fidelity to the 3CM, and validate the model against a series of submaximal force plateaus. The fatigue and recovery rates were modified to represent graded physiological motor unit characteristics (termed 3CM_{GMU}). In nine experiments of submaximal efforts, the 3CM_{GMU} produced a root-mean squared difference (RMSD) of $4.1 \pm 0.5\%$ MVC over experiments with an average strength loss (i.e. fatigue) of $31.0 \pm 1.1\%$ MVC. The 3CM_{GMU} model performed poorly for endurance tasks. The 3CM_{GMU} model is an improvement for evaluating submaximal force patterns consisting of intermittent muscle contractions of the hand and forearm. **Practitioner Summary:** We modified an existing fatigue model using known physiological properties in order to predict fatigue during nine different submaximal force profiles; consistent with efforts seen in industrial work. We expect this model to be included in digital human modelling software, for the assessment of repetitive work and muscle fatigue in repetitive tasks. **Social Media Summary:** The proposed model has applications for estimating task fatigue in proactive ergonomic analyses of complex force patterns using digital human models

- **Keywords:** muscle fatigue, modelling, ergonomics

Khoirul Muslim & Maury A. Nussbaum. *Traditional posterior load carriage: effects of load mass and size on torso kinematics, kinetics, muscle activity and movement stability.* Pages 99-111.

Traditional posterior load carriage (PLC), done without the use of an assistive device (e.g. backpack), has been associated with low back pain (LBP) development. This study evaluated the effects of important task demands, related to load mass and size, on potential mechanisms linking traditional PLC with LBP. Nine healthy participants completed PLC tasks with three load masses (20%, 35% and 50% of individual body mass) and three load sizes (small, medium and large). Torso kinematics, kinetics, muscle activity and slip risk were evaluated during PLC on a walkway, and torso movement stability was quantified during PLC on a treadmill. Increasing load mass caused increased torso flexion, L5/S1 flexion moment, abdominal muscle activity and torso movement stability in the frontal plane. Increasing load size also caused higher torso flexion, peak torso angular velocity and acceleration, and abdominal muscle activity. Complex interactive effects of load mass and size were found on paraspinal muscle activity and slip risk. Specific task demands, related to load mass and size, may thus influence the risk of LBP during PLC. **Practitioner Summary:** This study examined the effects of load mass and size on low back pain (LBP) risk using intermediary measures derived from torso kinematics, kinetics and muscle activity. Our current findings, along with earlier work, suggest that load mass and size can influence LBP risk, and that use of smaller and light loads may be beneficial during PLC.

- **Keywords:** load carriage, spine, stability, kinematics, kinetics, slip risk

C. Phimphasak, M. Swangnetr, R. Puntumetakul, U. Chatchawan & R. Boucaut. *Effects of seated lumbar extension postures on spinal height and lumbar range of motion during prolonged sitting. Pages 112-120.*

Prolonged sitting during sedentary work has been reported as a potential risk factor for low back pain. Furthermore, prolonged sitting can result in both reduced spinal height (SH) and lumbar range of motion (LROM). This study compared the effects of no intervention (control) with two recovery postures on SH and LROM (flexion and extension) during prolonged sitting. Twenty-four participants were randomly assigned to three interventions for three consecutive days. The interventions comprised two seated lumbar extension recovery postures (unsupported sustained and supported dynamic lumbar extension postures) and a control. Both interventions facilitated a relatively short recovery period for both SH and LROM. Supported dynamic lumbar extension conditions significantly helped SH recovery, as compared with control condition, after the first recovery posture intervention, and both postures have potential to maintain LROM. However, both postures failed to induce SH recovery over an extended time. **Practitioner Summary:** Unsupported sustained lumbar extension and supported dynamic lumbar extension postures may serve as effective and practical methods for reducing rate of SH loss and maintaining LROM. However, these postures should be further examined in various 'doses' to define optimal protocol for effectively minimising SH loss over time.

- **Keywords:** seated lumbar extension postures, spinal height recovery, prolonged sitting task, lumbar range of motion

Vibhor Agrawal, Christopher O'Toole, Ignacio A. Gaunard & Robert S. Gailey. *Analysis of weight distribution strategies in unilateral transtibial amputees during the stand-to-sit activity. Pages 121-129.*

Current methods of quantifying the stand-to-sit activity (StTS) are resource intensive and have not been applied to unilateral transtibial amputees (TTAs). The purpose of this study is to define five phases of arm-rest assisted and unassisted StTS using simple instrumentation and implement this method for assessing TTA movement patterns. Twelve TTAs and 12 age-matched non-amputees performed StTS with and without arm-rest support. Symmetry of weight distribution between lower limbs was calculated for five StTS phases: Descent Initiation; Descent Deceleration; Seat-Contact; Stabilisation

and Sitting. TTAs demonstrated an asymmetrical weight distribution pattern and a tendency to transfer weight to the intact limb during the course of the activity. Non-amputees had relatively higher symmetry and did not exhibit substantial weight shifts during the activity. Symmetry indices were similar for assisted and unassisted sitting in both subject groups. These results highlight a need for therapeutic interventions in TTAs for reducing loading asymmetries and associated co-morbidities. **Practitioner Summary:** This study defines a novel method for quantifying stand-to-sit movements using clinically friendly equipment and is the first to investigate the stand-to-sit activity of unilateral transtibial amputees. The observed differences in inter-limb weight distribution strategies between amputees and non-amputees could provide insights for clinical assessment and intervention.

- **Keywords:** weight distribution symmetry, arm-rest assistance, stand-to-sit phases, biomechanics, event standardization

Xiaona Chen, Sheridan A. Gho, Jianping Wang & Julie R. Steele. *Effect of sports bra type and gait speed on breast discomfort, bra discomfort and perceived breast movement in Chinese women.* Pages 130-142.

This study investigated the effect of sports bra type (encapsulation versus compression) and gait speed on perceptions of breast discomfort, bra discomfort and breast movement reported by Chinese women. Visual analogue scales were used to evaluate breast discomfort, bra component discomfort and perceived breast movement of 21 Chinese participants when they wore an encapsulation or a compression sports bra, while static and while exercising at three different gait speeds. Participants perceived less breast discomfort and breast movement when wearing a compression bra compared to an encapsulation bra at a high gait speed, suggesting that compression bras are likely to provide the most effective support for Chinese women. However, significantly higher bra discomfort was perceived in the compression bra compared to the encapsulation bra when static and at the lower gait speed, implying that ways to modify the design of sports bras, particularly the straps, should be investigated to provide adequate and comfortable breast support. **Practitioner Summary:** The compression sports bra provided more comfortable support than the encapsulation sports bra for these Chinese women when running on a treadmill. However, these women perceived higher bra discomfort when wearing the compression bra when stationary. Further research is needed to modify the design of sports bras, particularly the straps, to provide adequate and comfortable breast support.

- **Keywords:** sports bras, breast discomfort, bra discomfort, perceived breast movement, gait speed

Christopher J. Garneau & Matthew B. Parkinson. *A survey of anthropometry and physical accommodation in ergonomics curricula.* Pages 143-154.

The size and shape of users are an important consideration for many products and environments. Designers and engineers in many disciplines must often accommodate these attributes to meet objectives such as fit and safety. When practitioners have academic training in addressing these issues, it is typically through courses in Human Factors/Ergonomics (HF/E). This paper investigates education related to physical accommodation and offers suggestions for improvement. A survey was conducted wherein 21 instructors at 18 universities in the United States provided syllabi for 29 courses, which were analysed to determine topics related to anthropometry and resources used for the courses. The results show that within the US, anthropometry is covered in the majority of courses discussing physical ergonomics, but important related concepts were often omitted (e.g. digital human modelling, multivariate accommodation and variability across global populations). Curricula could be improved by incorporating

more accurate anthropometry, multivariate problems and interactive online tools. **Practitioner Summary:** This paper describes a study investigating collegiate ergonomics courses within the US in the area of physical accommodation. Course schedules and texts were studied for their treatment of several topics related to accommodating the spatial requirements (anthropometry) of users. Recommendations are made for improving course curricula.

- **Keywords:** Ergonomics tools and methods, anthropometry, physical ergonomics, ergonomics education

Alfredo Patrizi, Ettore Pennestrì & Pier Paolo Valentini. *Comparison between low-cost marker-less and high-end marker-based motion capture systems for the computer-aided assessment of working ergonomics. Pages 155-162.*"

The paper deals with the comparison between a high-end marker-based acquisition system and a low-cost marker-less methodology for the assessment of the human posture during working tasks. The low-cost methodology is based on the use of a single Microsoft Kinect V1 device. The high-end acquisition system is the BTS SMART that requires the use of reflective markers to be placed on the subject's body. Three practical working activities involving object lifting and displacement have been investigated. The operational risk has been evaluated according to the lifting equation proposed by the American National Institute for Occupational Safety and Health. The results of the study show that the risk multipliers computed from the two acquisition methodologies are very close for all the analysed activities. In agreement to this outcome, the marker-less methodology based on the Microsoft Kinect V1 device seems very promising to promote the dissemination of computer-aided assessment of ergonomics while maintaining good accuracy and affordable costs. **Practitioner's Summary:** The study is motivated by the increasing interest for on-site working ergonomics assessment. We compared a low-cost marker-less methodology with a high-end marker-based system. We tested them on three different working tasks, assessing the working risk of lifting loads. The two methodologies showed comparable precision in all the investigations.

- **Keywords:** motion capture, working posture, Microsoft Kinect, marker-less, ergonomics