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T. Grundgeiger, P. M. Sanderson, C. Beltran Orihuela, A. Thompson, H. G. MacDougall, L. Nunnink & B. Venkatesh. *Prospective memory in the ICU: the effect of visual cues on task execution in a representative simulation.* Pages 579-589.

Despite the potential dangers of clinical tasks being forgotten, few researchers have investigated prospective memory (PM) – the ability to remember to execute future tasks – in health-care contexts. Visual cues help people remember to execute intentions at the appropriate moment. Using an intensive care unit simulator, we investigated whether nurses' memory for future tasks improves when visual cues are present, and how nurses manage PM demands. Twenty-four nurses participated in a 40-minute scenario simulating the start of a morning shift. The scenario included eight PM tasks. The presence or absence of a visually conspicuous cue for each task was manipulated. The presence of a visual cue improved recall compared to no cue (64% vs. 50%, $p = 0.03$ one-tailed, $\eta_p^2 = 0.15$). Nurses used deliberate reminders to manage their PM demands. PM in critical care might be supported by increasing the visibility of cues related to tasks.

Practitioner summary: Nurses must remember to execute multiple future tasks to ensure patient safety. We investigated the effect of visual cues on nurses' ability to remember future tasks. Experimental manipulation of cues in a representative intensive care unit simulation indicated that visual cues increase the likelihood that future tasks are executed.

- **Keywords:** interruptions, prospective memory, simulation, intensive care, nursing

Neville A. Stanton, Catherine Harvey, Katherine L. Plant & Luke Bolton. *To twist, roll, stroke or poke? A study of input devices for menu navigation in the cockpit.* Pages 590-611.

Modern interfaces within the aircraft cockpit integrate many flight management system (FMS) functions into a single system. The success of a user's interaction with an interface depends upon the optimisation between the input device, tasks and environment within which the system is used. In this study, four input devices were evaluated using a range of Human Factors methods, in order to assess aspects of usability including task interaction times, error rates, workload, subjective usability and physical discomfort. The performance of the four input devices was compared using a holistic approach and the findings showed that no single input device produced consistently high performance

scores across all of the variables evaluated. The touch screen produced the highest number of 'best' scores; however, discomfort ratings for this device were high, suggesting that it is not an ideal solution as both physical and cognitive aspects of performance must be accounted for in design.

Practitioner summary: This study evaluated four input devices for control of a screen-based flight management system. A holistic approach was used to evaluate both cognitive and physical performance. Performance varied across the dependent variables and between the devices; however, the touch screen produced the largest number of 'best' scores.

- **Keywords:** input devices, menu navigation, cockpit, aviation, transport

Divya Srinivasan, Bernard J. Martin & Matthew P. Reed. *Effects of task characteristics on unimanual and bimanual movement times. Pages 612-622.*

Fitts' law cannot be used to predict movement times (MTs) of bimanual tasks since no empirical relationships associating task difficulty and bimanual MT have been demonstrated yet. Development of a 'bimanual task difficulty index' has been challenged by the complex patterns of coordination involved in simultaneously performing two tasks, one with each hand, under a control system with limited visual and attentional resources. To address this fundamental issue in human motor performance, bimanual object transfers with the left and right hands to targets of various precision requirements and separated by different distances were studied in six healthy subjects. Visual resource allocation during task performance was used to identify 'primary' and 'secondary' hand movements in bimanual tasks. While the primary movement was similar to a unimanual movement, the secondary MT varied with its own, as well as the contralateral hand's task constraints. These results, which were stable and consistent across six subjects, provide preliminary evidence that visual behaviour, indicating closed-loop control, can be used to systematically derive bimanual MTs.

Practitioner summary: A simple extension of Fitts' law cannot be used to predict movement times (MTs) of bimanual tasks since there is no consensus on the definition of a 'bimanual task difficulty index' in the literature. In this paper, we have approached this problem by using visual resource allocation patterns to systematically derive bimanual MTs.

- **Keywords:** bimanual movements, movement time, motor performance, visual feedback

Ray F. Lin & Colin G. Drury. *Verification of models for ballistic movement time and endpoint variability. Pages 623-636.*

A hand control movement is composed of several ballistic movements. The time required in performing a ballistic movement and its endpoint variability are two important properties in developing movement models. The purpose of this study was to test potential models for predicting these two properties. Twelve participants conducted ballistic movements of specific amplitudes using a drawing tablet. The measured data of movement time and endpoint variability were then used to verify the models. This study was successful with Hoffmann and Gan's movement time model (Hoffmann, 1981; Gan and Hoffmann 1988) predicting more than 90.7% data variance for 84 individual measurements. A new theoretically developed ballistic movement variability model, proved to be better than Howarth, Beggs, and Bowden's (1971) model, predicting on average 84.8% of stopping-variable error and 88.3% of aiming-variable errors. These two validated models will help build solid theoretical movement models and evaluate input devices.

Practitioner summary: This article provides better models for predicting end accuracy and movement time of ballistic movements that are desirable in rapid aiming tasks, such as keying in numbers on a smart phone. The models allow better design of aiming tasks, for example button sizes on mobile phones for different user populations.

- **Keywords:** ballistic movements, motor control, human movements, input devices, Fitts' law

David Frost, Jordan Andersen, Thomas Lam, Tim Finlay, Kevin Darby & Stuart McGill. *The relationship between general measures of fitness, passive range of motion and whole-body movement quality. Pages 637-649.*

The goal of this study was to establish relationships between fitness (torso endurance, grip strength and pull-ups), hip range of motion (ROM) (extension, flexion, internal and external rotation) and movement quality in an occupational group with physical work demands. Fifty-three men from the emergency task force of a major city police force were investigated. The movement screen comprised standing and seated posture, gait, segmental spine motion and 14 tasks designed to challenge whole-body coordination. Relationships were established between each whole-body movement task, the measures of strength, endurance and ROM. In general, fitness and ROM were not strongly related to the movement quality of any task. This has implications for worker training, in that strategies developed to improve ROM or strength about a joint may not enhance movement quality.

Practitioner Summary: Worker-centered injury prevention can be described as *fitting workers to tasks* by improving fitness and modifying movement patterns; however, the current results show weak correlations between strength, endurance and ROM, and the way individuals move. Therefore, the development of occupation-specific injury prevention strategies may require both fitness and movement-oriented objectives.

- **Keywords:** movement screen, police force, injury, strength, torso endurance

Mary O'Keeffe, Wim Dankaerts, Peter O'Sullivan, Leonard O'Sullivan & Kieran O'Sullivan. *Specific flexion-related low back pain and sitting: comparison of seated discomfort on two different chairs. Pages 650-658.*

No study has examined the effectiveness of prescribing seating modifications according to the individual clinical presentation of people with low back pain (LBP). A dynamic, forward-inclined chair ('Back App') can reduce seated paraspinal muscle activation among pain-free participants. This study examined 21 participants whose LBP was specifically aggravated by prolonged sitting and was eased by standing. Low back discomfort (LBD) and overall body discomfort (OBD) were assessed every 15 min while participants sat for 1 h on both the dynamic, forward-inclined chair and a standard office chair. LBD increased significantly more ($p = 0.005$) on the standard office chair, with no significant difference ($p = 0.178$) in OBD between the chairs. The results demonstrate that, in a specific flexion-related subgroup of people with LBP, increased LBD during sitting can be minimised through modifying chair design. Mechanisms that minimise seated discomfort may be of relevance in LBP management, as part of a biopsychosocial management plan.

Practitioner summary: This study examined low back discomfort (LBD) during a typing task among people with low back pain (LBP). Sitting on a dynamic, forward-inclined chair resulted in less seated LBD than sitting on a standard office chair. Further research is required to examine the long-term effectiveness of ergonomics interventions in LBP.

- **Keywords:** back pain, office ergonomics, biomechanics, seating

Elias M. Delphinus & Mark Gregory Leigh Sayers. *The interrelationship of the thorax and pelvis under varying task constraints.* Pages 659-666.

The purpose of this study was to investigate the interrelationship between the thorax and pelvis during coupled movement patterns. Fifty-seven participants were assessed using an infrared motion analysis system to track trunk movement during maximal pelvis and thorax rotations over four trunk inclinations and two pelvic constraint conditions. A repeated-measures multivariate analysis of variance investigated the effects of forward trunk inclination and pelvic constraint on thorax and pelvic rotation. Forward trunk inclination from neutral to 45° resulted in a 46% ($p < 0.001$) decrease in axial pelvic rotation and a 15% ($p < 0.001$) decrease in axial thorax rotation with an unconstrained pelvis. A constrained pelvis resulted in a 15% ($p < 0.001$) decrease in axial thorax rotation. An externally constrained pelvis allowed the thorax to achieve an average of 18° ($SD = 2^\circ$) greater rotational range of motion across all angles. This study reinforced the importance of allowing the pelvis to rotate during whole body axial rotation tasks.

Practitioner Summary: Results indicated that maximum axial trunk rotation is best achieved in a neutral posture, when the pelvis is allowed to contribute and flexion at the hips should be minimised. For example, if a recumbent task requires rotation of the torso, then the chair seat should be allowed to swivel.

- **Keywords:** spine, axial rotation, kinematics, motion analysis

Monica L. H. Jones, Matthew P. Reed & Don B. Chaffin. *The effect of bracing availability on one-hand isometric force exertion capability.* Pages 667-681.

Environmental obstructions that workers encounter can kinematically limit the postures that they can achieve. However, such obstructions can also provide an opportunity for additional support by bracing with the hand, thigh or other body part. The reaction forces on bracing surfaces, which are in addition to those acting at the feet and task hand, are hypothesised to improve force exertion capability, and become required inputs to biomechanical analysis of tasks with bracing. The effects of kinematic constraints and associated bracing opportunities on isometric hand force were quantified in a laboratory study of 22 men and women. Analyses of one-hand maximal push, pull and lift tasks demonstrated that bracing surfaces available at the thighs and non-task hand enabled participants to exert an average of 43% more force at the task hand. Task hand force direction deviated significantly from the nominal direction for exertions performed with bracing at both medium and low task hand locations.

Practitioner summary: This study quantifies the effect of bracing on kinematically constrained force exertions. Knowledge that appropriate bracing surfaces can substantially increase hand force is critical to the evaluation of task-oriented strength capability. Force estimates may also involve large off-axis components, which have clear implications for ergonomic analyses of manual tasks.

- **Keywords:** bracing, constrained working postures, force exertion capability, hand force, push/pull

Justin G. Young, Jia-Hua Lin, Chien-Chi Chang & Raymond W. McGorry. *The natural angle between the hand and handle and the effect of handle orientation on wrist radial/ulnar deviation during maximal push exertions.* Pages 682-691.

The purpose of this experiment was to quantify the natural angle between the hand and a handle, and to investigate three design factors: handle rotation, handle tilt and

between-handle width on the natural angle as well as resultant wrist radial/ulnar deviation ('RUD') for pushing tasks. Photographs taken of the right upper limb of 31 participants (14 women and 17 men) performing maximal seated push exertions on different handles were analysed. Natural hand/handle angle and RUD were assessed. It was found that all of the three design factors significantly affected natural handle angle and wrist RUD, but participant gender did not. The natural angle between the hand and the cylindrical handle was $65 \pm 7^\circ$. Wrist deviation was reduced for handles that were rotated 0° (horizontal) and at the narrow width (31 cm). Handles that were tilted forward 15° reduced radial deviation consistently ($12\text{--}13^\circ$) across handle conditions.

Practitioner summary: Manual materials handling (MMH) tasks involving pushing have been related to increased risk of musculoskeletal injury. This study shows that handle orientation influences hand and wrist posture during pushing, and suggests that the design of push handles on carts and other MMH aids can be improved by adjusting their orientation to fit the natural interface between the hand and handle.

- **Keywords:** manual handling, hand tools and interfaces, pushing, posture, equipment design

Woojin Park & Sungjoon Park. *Body shape analyses of large persons in South Korea. Pages 692-706.*

Despite the prevalence of obesity and overweight, anthropometric characteristics of large individuals have not been extensively studied. This study investigated body shapes of large persons (Broca index ≥ 20 , BMI ≥ 25 or WHR > 1.0) using stature-normalised body dimensions data from the latest South Korean anthropometric survey. For each sex, a factor analysis was performed on the anthropometric data set to identify the key factors that explain the shape variability; and then, a cluster analysis was conducted on the factor scores data to determine a set of representative body types. The body types were labelled in terms of their distinct shape characteristics and their relative frequencies were computed for each of the four age groups considered: the 10s, 20s-30s, 40s-50s and 60s. The study findings may facilitate creating artefacts that anthropometrically accommodate large individuals, developing digital human models of large persons and designing future ergonomics studies on largeness.

Practitioner Summary: This study investigated body shapes of large persons using anthropometric data from South Korea. For each sex, multivariate statistical analyses were conducted to identify the key factors of the body shape variability and determine the representative body types. The study findings may facilitate designing artefacts that anthropometrically accommodate large persons.

- **Keywords:** obesity, overweight, anthropometry, body shape, body type

Francesca Romana d'Ambrosio Alfano, Boris Igor Palella & Giuseppe Riccio. *Notes on the implementation of the IREQ model for the assessment of extreme cold environments. Pages 707-724.*

This paper has been devoted to the difficulties that practitioners, skilled ergonomists or occupational health experts could find in the assessment of cold environments by means of (insulation required) *IREQ* model at the base of the (International Standardization Organization) ISO 11079 Standard. The in-depth analysis discussed here has underlined several difficulties about: (a) the graphical calculation of the predicted limit exposures; (b) some differences in both *IREQ* and (duration limit exposure) *DLE* values reported in ISO 11079; and (c) some errors and incongruities in the program available online for the assessment of *DLEs*. These occurrences lead to the systematic overestimation of the *DLE* that exceed up to 4 h, those obtained by means of the figures reported in the Standard with the consequent unreliable assessment. Such matters justify the need to promote, in

the whole scientific community involved in the ergonomics of the thermal environment, an in-depth discussion on the best practice to be followed for the assessment of extreme cold environments by means of *IREQ* model.

Practitioner summary: Incongruities in *IREQ* model and errors in the code suggested by ISO 11079 Standard prevent a reliable assessment of cold environments with *DLE* systematically overestimated. Therefore *IREQ* model has been theoretically investigated trying to help both neophytes and skilled ergonomists on the best practice to be followed.

- **Keywords:** required insulation (*IREQ* model), cold exposure, clothing thermal insulation, duration limit exposure, ISO Standard 11079