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Minou Weijs-Perrée, Lorell Buck, Rianne Appel-Meulenbroek & Theo Arentze. *Location choices of face-to-face interactions in academic buildings: an experience sampling approach*. Pages: 1499-1514.

Although it is recognised that face-to-face interactions are important for sharing interests and (new) knowledge, it remains unknown how and where students and university employees interact in academic buildings. Therefore, the aim of this study is to analyse the location choice for face-to-face interactions in an academic building, including several personal- and interaction characteristics. An Experience Sampling Method (ESM) was used to collect data on 643 face-to-face interactions during two weeks in the Flux building at Eindhoven University of Technology, the Netherlands. In general, students more often interacted in meeting rooms than teaching staff, and support staff interacted less in eat/drink areas and the hallways than other users. Unexpectedly, some of the lectures took place outside of traditional project-/lecture space. Real estate managers of university campuses could use these results to create better interactive work environments that stimulate face-to-face interactions among employees and students of different departments. **Practitioner Summary:** Based on longitudinal data of ftf interactions among students and employees in an academic building, results showed that ftf interaction characteristics, compared to personal characteristics, are most important for explaining the location choice of interactions. These insights could help to design academic work environments that optimise the support of interactions.

- **Keywords:** Academic building, physical work environment, face-to-face interaction (ftf), Experience Sampling Method (ESM), location choice

Kayla M. Fewster, Maureen F. Riddell, Surabhi Kadam & Jack P. Callaghan. *The need to accommodate monitor height changes between sitting and standing*. Pages: 1515-1523.

Recently, the rate at which sit-to-stand workstations are being introduced into the workplace has seen a dramatic increase. Aside from adjusting the height of the desk when transitioning from sitting to standing, there is a lack of literature regarding the necessary adjustments to other equipment associated with the workstation. To better understand some of these limitations, 16 participants stood and sat at a sit-to-stand

workstation while adhering to current Canadian Standards Association (CSA) Guidelines for Office Ergonomics. Transitioning between sitting and standing while adhering to CSA guidelines resulted in a 3.9 cm difference in monitor height relative to work surface between sitting and standing. Results from this investigation support the notion that monitor height adjustments relative to the work surface are necessary when utilising sit-to-stand workstations – with the implementation to practice message being that both sitting and standing configurations need to be assessed and accommodated in the workstation configuration. **Practitioner summary:** Limited guidelines exist in the necessary adjustments to equipment associated with sit-to-stand workstations. Transitioning between sitting and standing resulted in a 3.9 cm difference in monitor height relative to work surface between sitting and standing. This supports that monitor height adjustments relative to the workstation are necessary when using sit-to-stand workstations.

- **Keywords:** Office ergonomics, sit to stand workstation, sit-stand, monitor height, lumbar spine

Suwalee Namwongsa, Rungthip Puntumetakul, Manida Swangnetr Neubert & Rose Boucaut. *Effect of neck flexion angles on neck muscle activity among smartphone users with and without neck pain*. Pages: 1524-1533.

This study examined the differences in neck muscle activity at various neck flexion angles in smartphone users with and without neck pain. Forty-four participants performed texting tasks for 1 min and 30 s. Neck muscle activity and pain in the neck were measured at different neck flexion angles. There was a difference in neck muscle activity for each of the neck flexion angles; the Cervical Erector Spinae (CES) muscle activity increased while the Upper Trapezius (UT) muscle activity decreased when at increased neck flexion angles. At neck flexion angle of 0°–15°, the activity of both CES and UT muscles were acceptably low. Smartphone users with neck pain had slightly higher muscle activity levels than smartphone users without neck pain. In conclusion, smartphone users should consider adopting neck flexion angles between 0 and 15 degrees during smartphone use as there is an association between this neck flexion angle range and reduced CES muscle activity. **Practitioner summary:** This study demonstrated that both smartphone users with and without neck pain should try to keep their neck flexion angle between 0° and 15° when using their smartphone. This would reduce neck muscle activity and the risk of developing neck disorders associated with smartphone use.

- **Keywords:** Neck flexion angle, neck muscle activity, smartphone users

Juan Rabal-Pelay, Cristina Cimarras-Otal, Andrés Alcázar-Crevillén, Juan Luis Planas-Barraguer & Ana Vanessa Bataller-Cervero. *Spinal shrinkage, sagittal alignment and back discomfort changes in manufacturing company workers during a working day*. Pages: 1534-1541.

Prolonged standing and lifting heavy loads are risk factors for the appearance of low back pain in work. The aim of this study was to observe changes in the height, spinal sagittal alignment, and the lumbar and dorsal discomfort perception in assembly line workers. Cross-sectional study, 40 assembly line workers (6 females). Height, sitting height, grades of thoracic kyphosis and lumbar lordosis and perceived spine discomfort, before and after the working day, were determined. Thoracic and lumbar sagittal alignment was compared between discomfort developers and no developers. There was a significant decrease in the height and sitting height of the workers at the end of the day. Thoracic and lumbar curvature increased significantly, as did the perceived lumbar discomfort. Workers on the assembly line, in a prolonged standing work, suffer an increase in lumbar

discomfort, and changes in height and thoracic and lumbar curvatures. **Practitioner summary:** Spinal shrinkage, sagittal alignment and back discomfort (upper and lower back), were analysed in assembly line workers in prolonged standing during a workday. Assembly line workers suffer a decrease in height, an increase in their thoracic and lumbar curvature, and in lumbar discomfort throughout their workday.

- **Keywords:** Low back discomfort, lumbar lordosis, prolonged standing, spinal shrinkage, assembly workers

Pongsatorn Saiklang, Rungthip Puntumetakul, Manida Swangnetr Neubert & Rose Boucaut. *Effect of time of day on height loss response variability in asymptomatic participants on two consecutive days*. Pages: 1542-1550.

Ergonomists measure height loss in relation to loads imposed on the spine. It is difficult to interpret whether height loss responses recorded on different days are accurate due to natural daily fluctuations in height loss and measurement variability. The objective of this research was to investigate whether the variability of height loss in the sitting position is affected by time of day and to analyse day-to-day variability in asymptomatic participants. Fifty asymptomatic participants attended two sessions (morning and afternoon) of stadiometry testing on four separate days. The results showed that a variability of height loss response changes in excess of 0.886 mm in morning and 1.128 mm in afternoon between days indicates that an intervention itself has influenced height loss. Future investigations on height loss in sitting should take these results into consideration to confidently state that an intervention has influenced height loss response at each time of day. **Practitioner summary:** Daily fluctuation creates difficulties when interpreting whether height losses recorded on different days and times are intervention related. Seated stadiometry measures on different days and times of day demonstrated specific levels of natural variation. Changes above 0.886 mm (morning) and 1.128 mm (afternoon) can be attributed to intervention effects.

- **Keywords:** Variability, height loss, stadiometry, diurnal variation

Nasser Rezzoug, Xuguang Wang, Vincent Hernandez & Philippe Gorce. *Maximal isometric force exertion predicted by the force feasible set formalism: application to handbraking*. Pages: 1551-1562.

The aim of this study was to test the capacity of the force feasible set formalism to predict maximal force exertion during isometric handbraking. Maximal force exertion and upper-limb posture were measured with a force sensor embedded in a handbrake and an optoelectronic system, respectively. Eleven subjects participated in the experiment which consisted of exerting the maximal force in isometric conditions considering five hand brake positions relative to the seat H-point. Then, maximal force was predicted by the force feasible set obtained from an upper-limb musculoskeletal model. The root-mean-square (RMS) of the angle between measured and predicted forces was 8.4° while the RMS error (RMSE) for amplitude prediction was 95.4 N. However, predicted, and measured force amplitudes were highly correlated ($r = 0.88$, $p < 0.05$, slope = 0.97, intercept = 73.3N) attesting the capacity of the model to predict force exertion according to the subject's posture. The implications in the framework of ergonomics are then discussed. **Practitioner summary:** Maximal force exertion is of paramount importance in digital human modelling. We used the force feasible set formalism to predict maximal force exertion during handbraking from posture and anthropometric data. The predicted and measured force orientation showed a RMS of 8.4° while amplitude presented a RMSE of 95.4 N with a strong correlation ($r = 0.88$, $p < 0.05$, slope 0.97, intercept 77.3 N).

- **Keywords:** Upper-limb, force feasible set, musculoskeletal modelling

Danilo Corrêa Silva, Luis Carlos Paschoarelli & Fausto Orsi Medola. *Evaluation of two wheelchair hand rim models: contact pressure distribution in straight line and curve trajectories*. Pages: 1563-1571.

Manual wheelchairs are essential for people with disabilities or limited mobility. However, manual propulsion causes biomechanical loads, including contact pressures on the palms of the hands. The hand rim design has received little attention over time, remaining almost unchanged since its creation. This study investigated how two different designs of such devices – one standard and another with a contoured design – influence the contact pressure on the surface of the hands. The procedures included a figure-of-eight shape propulsion task on a regular floor, using both models on a wheelchair. A pressure-mapping system coupled with a pair of fabric gloves recorded the data. The results show that the contoured hand rim provides lower pressure in most of the analysed regions. Considering that manual propulsion is performed during a considerable part of the day as a routine activity, improving the hand rim interface may benefit the user's comfort and safety during wheelchair use. **Practitioner summary:** The design of the hand rim used in wheelchair propulsion influences the contact pressure on the hands. Conventional round tube rims tend to concentrate high levels of pressure on the distal phalanges and metacarpal regions. A contoured design generally provides better stability and promotes the distribution of pressure.

- **Keywords:** Wheelchair, hand rim, disability ergonomics, contact pressure, product design

Anthony J. Treweek, Michael J. Tipton & Gemma S. Milligan. *Development of a physical employment standard for a branch of the UK military*. Pages: 1572-1584.

A Physical Employment Standard (PES) was developed for the British Royal Air Force Regiment (RAF Regt). Twenty-nine RAF Regt personnel completed eight critical tasks wearing Combat Equipment Fighting Order (31.5 kg) while being monitored for physical and perceptual effort. A PES was developed using task simulations, measured on 61 incumbents. The resultant PES consists of: 1) a battlefield test involving task simulations: single lift and point-of-entry (psss/fail); timed elements (react to effective enemy fire and crawl) set at 95th performance percentile; casualty evacuation (CASEVAC) casualty drag and CASEVAC simulated stretcher carry completed without stopping. 2) a Multi Stage Fitness Test level 9.10 to assess aerobic fitness to complete a tactical advance to battle. The task-based PES should ensure RAF Regt personnel have a baseline level of fitness to perform and withstand the physical demands of critical tasks to at least a minimum acceptable standard. **Practitioner summary:** A Physical Employment Standard (PES) was developed for the British RAF Regiment by measuring the physiological demands of critical tasks on a representative cohort of incumbent personnel. A task-based PES should ensure that only those candidates, irrespective of gender, race or disability, with the necessary physical attributes to succeed in training and beyond, are selected.

- **Keywords:** Critical tasks, physiological demands, direct task simulations, minimum standard, method of best practice

Matthijs Koedijk, Peter G. Renden, Raôul R. D. Oudejans & R. I. (Vana) Hutter. *Training for the job: evaluation of a self-defence training programme for correctional officers*. Pages: 1585-1597.

We investigated to what extent correctional officers were able to apply skills from their self-defence training in reality-based scenarios. Performance of nine self-defence skills were tested in different scenarios at three moments: before starting the self-defence

training programme (Pre-test), halfway through (Post-test 1), and after (Post-test 2). Repeated measures analyses showed that performance on skills improved after the self-defence training. For each skill, however, there was a considerable number of correctional officers (range 4–73%) that showed insufficient performance on Post-test 2, indicating that after training they were not able to properly apply their skills in reality-based scenarios. Reality-based scenarios may be used to achieve fidelity in assessment of self-defence skills of correctional officers. **Practitioner summary:** Self-defence training for correctional officers must be representative for the work field. By including reality-based scenarios in assessment, this study determined that correctional officers were not able to properly apply their learned skills in realistic contexts. Reality-based scenarios seem fit to detect discrepancies between training and the work field.

- **Keywords:** Reality-based scenarios, self-defence training, correctional officers, performance, representative learning design

Arie Adriaensen, Riccardo Patriarca, Anthony Smoker & Johan Bergström. *A socio-technical analysis of functional properties in a joint cognitive system: a case study in an aircraft cockpit*. Pages: 1598-1616.

In a socio-technical work domain, humans, device interfaces and artefacts all affect transformations of information flow. Such transformations, which may involve a change of auditory to visual information & vice versa or alter semantic approximations into spatial proximities from instruments readings, are generally not restricted to solely human cognition. This paper applies a joint cognitive system approach to explore a socio-technical system. A systems ergonomics perspective is achieved by applying a multi-layered division to transformations of information between, and within, human and technical agents. The approach uses the Functional Resonance Analysis Method (FRAM), but abandons the traditional boundary between medium and agent in favour of accepting aircraft systems and artefacts as agents, with their own functional properties and relationships. The joint cognitive system perspective in developing the FRAM model allows an understanding of the effects of task and information propagation, and eventual distributed criticalities, taking advantage of the functional properties of the system, as described in a case study related to the cockpit environment of a DC-9 aircraft. **Practitioner Summary:** This research presents the application of one systemic method to understand work systems and performance variability in relation to the transformation of information within a flight deck for a specific phase of flight. By using a joint cognitive systems approach both retrospective and prospective investigation of cockpit challenges will be better understood.

- **Keywords:** FRAM, joint cognitive system, complex systems, abstraction hierarchy, systems ergonomics

Michael F. Rayo, Emily S. Patterson, Mahmoud Abdel-Rasoul & Susan D. Moffatt-Bruce. *Using timbre to improve performance of larger auditory alarm sets*. Pages: 1617-1629.

Identifiability and perceived urgency were compared for two sets of alarms in a healthcare inpatient setting. One contained currently used alarms where possible, with new sounds added as needed. The other was designed together, was more heterogenous, used timbre to encode intended similarities and explicitly encoded intended urgency across the set. Twenty nurses reported the identity and perceived urgency of the sounds in each set. Participants correctly identified the sound (0.89 *vs.* 0.77) and alarm category (0.93 *vs.* 0.82) more often in the new set than in the baseline set. In addition, multiple sounds in the new set were more identifiable. The new sounds also had a larger range of perceived urgency and better urgency match. The results indicate that timbre is well-suited to encode alarm groupings in larger alarm sets and that this, along with increased heterogeneity and explicit urgency mapping, improves alarm set performance.

Practitioner summary: Clinical alarms are frequently misidentified. We found that making alarms more acoustically rich, using timbre to convey alarm groups, and explicitly encoding intended urgency improved identifiability and urgency match. These findings can be used to improve alarm performance across all safety-critical industries.

- **Keywords:** Alarms and warnings, human-machine systems, patient safety, health care ergonomics, sound and noise