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Philippe Gorce, Julien Jacquier-Bret & Johan Merbah. *A predictive model to quantify joint torques and support reaction forces when using a smartphone while standing with support.* Pages: 531-545.

The present study had a dual objective: (1) to present and validate a predictive model of standing posture in the sagittal plane, joint torques and support forces for a smartphone user built from biomechanical principles; (2) propose risk scales for joint torques and reaction forces based on simulations in order to use them into the musculoskeletal disorders prevention. Comparison of the modelled data with experimental measurements (400 tested postures with sample size verification) for calling and texting tasks highlights the model's ability to correctly estimate posture and reaction forces on the ground. The model was able to provide estimates of the range of variation of each parameter for a wide range of environmental conditions as a function of the user body mass index (setting between 12.5 and 50). Joint torques risk scales have been constructed, especially for shoulder and elbow, to characterise the risks incurred by the users.

Practitioner summary: The proposed model enables the postures, joint torques and reaction forces to be estimated from subject's body mass index and environmental configuration without resorting to experimentation, which is relevant in industry. This approach allows the proposition of new scales based on joint torques to reinforce the recommendations for MSDs prevention.

- **Keywords:** Predictive model, musculoskeletal disorders, risk scale, posture, torque/force

Jun Wu, Yi Qiu & Hui Zhou. *Biodynamic response of seated human body to vertical and added lateral and roll vibration.* Pages: 546-560.

The biodynamic response of 12 subjects to single-axis vertical and multi-axis vertical, lateral and roll excitations was studied to advance understanding of the biodynamics. Different from using single-input and single-output (SISO) method, the apparent masses with multiple inputs were estimated by multi-input and single-output (MISO) method, whose advantage was discussed. By studying the relationship between resonance frequencies and excitation magnitudes, the primary resonance frequencies of vertical apparent masses on seat pan and backrest and fore-and-aft cross-axis apparent masses

from vertical acceleration on seat pan had a negative correlation with the weighted root-sum-of-square (r.s.s.) value of excitation magnitudes. Weighting factors of lateral and vertical magnitudes in r.s.s. value were comparable and were much larger than that of roll magnitude. However, the nonlinearity in the apparent mass was more significant or significant only under low r.s.s. value. MISO method appeared more suitable for estimating apparent masses with multiple inputs than SISO method. **Practitioner Summary:** This paper experimentally studies the dependence of the resonance frequencies in the apparent masses of seated human body on the vibration magnitudes to advance understanding of the biodynamics. The sensitivities of resonance frequencies to lateral and vertical magnitudes are comparable, and much higher than that to roll magnitude.

- **Keywords:** Biodynamic response, seated human body, multi-axis vibration, MISO method

Abdullah M. Alzhrani, Kelly R. Johnstone, Elisabeth A. H Winkler, Genevieve N. Healy & Margaret M. Cook. *Using touchscreen mobile devices: when, where and how: a one-week field study.* Pages: 561-572.

This cross-sectional study explored the objectively measured Touchscreen Mobile Device (TSMd) use in free-living conditions. Data on TSMd use, gross body posture (lying, sitting, standing, stepping), and location of use (workplace, home, other) were collected over seven consecutive days from 54 adults (mean \pm SD, 38 ± 10 years). The average duration of TSMd use was 152 ± 91 min/day, with a TSMd engagement of 51 ± 35 times/day. Participants under 30 years spent significantly more time on their TSMd, averaging 230 ± 108 min/day. By location, $54 \pm 17\%$ of use occurred at home and $24 \pm 15\%$ at work. The most common posture adopted during any TSMd use was sitting (77 ± 5 min/day), with participants also spending considerable time lying down in the home environment (39 ± 49 min/day). These findings provide valuable insights into how adults are using TSMds, including the postures and locations of use. Further research is needed on the health and wellbeing implications of these usage patterns. **Practitioner summary:** This study explored Touchscreen Mobile Device (TSMd) use in free-living conditions among 54 adults (mean \pm standard deviation, 38 ± 10 years). Participants under 30 years spent significantly more time on their devices. More than half of the time spent using TSMd occurred at home while sitting and lying down.

- **Keywords:** Touchscreen mobile device, posture, musculoskeletal disorders, activity, sitting workplace

Sean Gallagher & Mary F. Barbe. *The impaired healing hypothesis: a mechanism by which psychosocial stress and personal characteristics increase MSD risk?* Pages: 573-586.

While the effects of physical risk factors on MSD development have been a primary focus of musculoskeletal research, psychological stressors, and certain personal characteristics (e.g. ageing, sex, and obesity) are also associated with increased MSD risk. The psychological and personal characteristics listed above share a common characteristic: all are associated with disruption of the body's neuroendocrine and immune responses resulting in an impaired healing process. An impaired healing response may result in reduced fatigue life of musculoskeletal tissues due to a diminished ability to keep pace with accumulating damage (perhaps repairable under normal circumstances), and an increased vulnerability of damaged tissue to further trauma owing to the prolonged healing process. Research in engineered self-healing materials suggests that decreased healing kinetics in the presence of mechanical loading can substantially reduce the fatigue life of materials. A model of factors influencing damage accrual and healing will be presented. **Practitioner summary:** This article provides a potential reason why musculoskeletal disorder risk is affected by psychosocial stress, age, sex, and obesity.

The reason is that these factors are all associated with a slower than normal healing response. This may lead to faster damage development in musculoskeletal tissues resulting in higher MSD risk.

- **Keywords:** Musculoskeletal disorders, fatigue failure, psychological stress, age, sex, obesity healing

Hamid Norasi, Emmanuel Tetteh, Pramiti Sarker, Gary A. Mirka & M. Susan Hallbeck. *Exploring the relationship between neck flexion and neck problems in occupational populations: a systematic review of the literature.* Pages: 587-603.

A systematic review was conducted to evaluate the relationship between occupational neck flexion angles and neck problems. The synthesised findings were used to answer three research questions: (1) Is there a positive/negative relationship between neck flexion and neck problems? (2) What is the appropriate angular threshold for neck flexion as a risk factor for neck problems? (3) What are the gaps in our current knowledge? A review of 21 papers revealed (1) a consistent positive correlation between neck flexion and neck problems, and (2) a neck flexion angle of 20° as the most evidence-based (not necessarily the best) cut-off angle separating high- and low-risk neck flexion postures. Future research should focus on the (1) continuous collection of three-dimensional neck postures through longitudinal studies to quantify cumulative exposures of neck postures, and (2) development of standard descriptions of 'neck problems' and 'neck flexion' to facilitate the development of a dose-response relationship. **Practitioner summary:** Practitioners depend on thresholds for evaluating neck postural exposure using work assessment tools; however, the scientific basis for this is unclear. This systematic review investigated the angular threshold for neck flexion and found 20° of neck flexion with the greatest evidence-based support as the threshold for high-risk neck postural exposure.

- **Keywords:** Neck postural exposure, neck musculoskeletal disorders, neck pain, cervical spine

Holland M. Vasquez, Justin G. Hollands, Greg A. Jamieson & Michael J. Agnew. *A mirror in the sky: the effects of map format and user expertise on navigation performance and mental workload.* Pages: 604-617.

A novel map display concept named Mirror in the Sky (MitS) has been introduced to improve performance and reduce workload in navigation tasks. However, this display will be novel to most users and as such, an evaluation of MitS in comparison with more conventional map formats is warranted. This study investigated the effects of map display format (MitS vs. north-up and track-up maps) and user expertise on mental workload (MWL) and performance, using both soldiers (experts) and civilians (novices) as participants. Participants followed a prescribed route to a destination in a virtual environment (route following task) while also performing a secondary task (detection response task). Soldiers generally performed better than civilians. Soldiers reported a higher MWL with MitS than with the north-up map, whereas civilians reported a higher MWL with MitS than with the track-up map. Regardless of user expertise, there were performance and workload challenges with MitS, despite its potential. **Practitioner summary:** A new map display concept called Mirror in the Sky (MitS) was compared with two conventional map formats: a north-up and track-up map. The experiment tested soldier and civilian users in a route following task. Both groups got further into the route and had fewer obstacle collisions with north-up and track-up maps than they did with the MitS map. MWL measures generally indicated higher workload with MitS.

- **Keywords:** Navigation, augmented reality, virtual environments, mental workload, military

Kateryna Karpenko, Maureen McEvoy, Lucy K. Lewis & Katia Ferrar. *Schedules of standing and sitting directed by musculoskeletal discomfort in workers transitioning to sit-stand workstations: a cross-sectional study.* Pages: 618-630.

Sit-stand workstations are growing in popularity, however limited guidelines exist regarding optimal schedules of sitting and standing. This was the first known study to observe sit-stand workstation schedules when postural change is based on maintaining musculoskeletal discomfort within 'acceptable' levels. Fourteen healthy adults new to sit-stand workstations completed computer-based work at a sit-stand desk for half a workday. Participants changed between standing and sitting postures each time discomfort reached the maximum acceptable threshold. On average, the amount of standing and sitting was greatest in the first standing (median 40 minutes, interquartile range 40 minutes) and sitting (median 30 minutes, interquartile range 115 minutes) bouts. Average durations spent standing and sitting were lower in all consecutive bouts. Stand-sit ratios indicated an equal amount of standing to sitting or somewhat less standing. The schedules had substantial inter-participant variability. Future studies should consider that optimal schedules may vary with regard to time and be individual-specific. **Practitioner summary:** Refined guidelines are needed regarding effective use of sit-stand workstations. This study proposed a novel method of investigating potentially optimal schedules, in which postural change was based on reaching a threshold of musculoskeletal discomfort. The findings suggest that an optimal schedule may vary with time and be individual-specific.

- **Keywords:** Musculoskeletal discomfort, sitting and standing durations, optimal sit-stand workstation schedule

Laura Rigby, Mona Frey, Kara-lyn Alexander & Diana De Carvalho. *Monitoring calf circumference: changes during prolonged constrained sitting.* Pages: 631-641.

Prolonged sitting has been associated with negative health effects; however, short-term time-varying exposure and response data is lacking. Twenty-two young and healthy participants were seated for 2 hours with the instruction to avoid the confounding effects of large leg movements while calf circumference, perceived discomfort, and lower limb muscle activity were collected. Calf circumference increased significantly (0.90 ± 0.32 cm) during sitting with no statistical differences between sexes. Perceived discomfort increased significantly over time in the low back and gluteal regions ($p = 0.001-0.072$, $\eta_p^2 = 0.080-0.360$). On average, it took 20.31 ± 10.87 minutes of walking for calf measures to return to pre-sitting baseline. These results suggest that sitting for 2 hours without activity breaks may not be advisable and that recovery may take longer than expected. The exposure/response data from this study may be helpful in the design of future studies, with a larger and more general population, aiming to better define recommended duration/activity ratios for sitting-focused occupations. **Practitioner summary:** Leg swelling is a concern in prolonged sitting. In this study of young, healthy participants, we found a 2 hour constrained sitting exposure (controlling for large leg movements) induced significant increases in calf circumference that took an average of 20.31 ± 10.87 min of walking to return to baseline.

- **Keywords:** Calf circumference, prolonged sitting, lower limb, electromyography, walking

Su Fern Beh, Elisa Nicola Holdik, Yu Sun Bin & Janet M. Y. Cheung. *Air travellers' experiences and understanding of jetlag and perceptions of management strategies: a qualitative study.* Pages: 642-658.

Jetlag is largely self-managed by the individual traveller. This paper explores the lived experiences of air travellers, their understanding of jetlag, and their perceptions of management strategies. 32 international travellers (mean age = 31, SD: 15 years; 47% female, mean flight duration = 16, SD: 6 hours) were interviewed. Interviews were recorded, transcribed verbatim and analysed using the Framework Approach. Analysis of the qualitative data revealed three emergent themes: Travel beliefs and experiences, *Impact of jetlag*, and Approaches to jetlag management. Participants' experience of jetlag was described in terms of the entire journey with no distinction made between circadian disruption and travel fatigue. Management strategies revolved around needs for comfort and avoiding fatigue, and were mostly guided by somatic symptom cues, prior travel experiences, or the experiential advice from others. Our findings highlight the need for traveller involvement in co-designing evidence-based interventions for jetlag to enhance their transferability into the real world. **Practitioner summary:** Qualitative findings highlighted jetlag as encapsulating the entire journey, and not limited to post-flight circadian disruptions during international travel. Jetlag management interventions need to address issues of circadian misalignment together with travel fatigue and in-flight discomfort through behavioural and nutritional strategies. Travel context and environmental factors such as airport facilities also influenced perceived jetlag severity.

- **Keywords:** Jetlag, qualitative study, travel fatigue, long-haul flights, health behavior

Yong Peng, Zhifa Wu, Chaojie Fan, Jiahao Zhou, Shengen Yi, Yuexiang Peng & Ke Gao. *Assessment of passenger long-term vibration discomfort: a field study in high-speed train environments.* Pages: 659-671.

This study revealed the mechanism of long-term passenger vibration discomfort in high-speed trains and proposed a novel evaluation model to assess it, while the most popular international standard ISO 2631-1 is unsuitable. Here, a field test was conducted to investigate the long-term passenger vibration comfort in high-speed trains under different operation environments by the measurement of the whole-body vibration (WBV) and the subjective ratings of passenger comfort. During the whole sitting period of high-speed train passengers, the phenomena 'compensatory degradation' and 'discomfort accumulation' were found, which meant that the brief termination of vibration cannot fundamentally alleviate passenger vibration comfort. And the vibration comfort can be evaluated by the product of exposure time and the novel vibration acceleration index we proposed. Meanwhile, high-speed trains with higher velocities or running in tunnel environments have higher frequency-weighted WBV amplitude than open-air and lower velocities, which caused more vibration discomfort of passengers. **Practitioner Summary:** This field study provided data support for ensuring the occupational health of train drivers whose work routes involve a large number of tunnels and improving passenger vibration comfort. Meanwhile, a novel idea was provided for evaluating the vibration comfort of passengers who prolonged exposure to low-amplitude environments.

- **Keywords:** Long-term vibration discomfort, WBV exposures, operation environments, high-speed train