

Ergonomics– rok 2012, ročník 55

Číslo 8



Jamie C. Gorman, Eric E. Hessler, Polemnia G. Amazeen, Nancy J. Cooke & Steven M. Shope. *Dynamical analysis in real time: detecting perturbations to team communication*. Pages 825-839.

Dynamical systems methods characterise patterns of change over time. Typically, such methods are applied only after data collection is complete. However, brief disturbances – *perturbations* – can occur as a process unfolds and can result in undesirable outcomes if not acted on. The application of dynamics in real time would be useful for detecting these sudden changes. Real-time analysis was accomplished by updating dynamical estimates simultaneously across different window sizes. We calculated the largest Lyapunov exponent, a measure of dynamical stability, to detect a perturbation to team communication in a simulated uninhabited air vehicle (UAV) reconnaissance mission. The perturbation consisted of information demands from a confederate that occurred unexpectedly during performance of a UAV mission. We demonstrate the use of real-time methods in detecting that perturbation as it occurred. In application, this technique would have enabled real-time intervention. Extensions of the real-time dynamical method to other domains of psychological inquiry are discussed.

Practitioner Summary: A real-time dynamical analysis method that was developed to detect unexpected perturbations in team communication is described. The use of the method is demonstrated on perturbed communication from a three-person uninhabited air vehicle command-and-control team. The generalisability of the method is considered with respect to physiological and motor coordination dynamics.

- **Keywords:** dynamical systems, Lyapunov exponent, perturbation, real-time analysis, team communication

Juergen Sauer, Chung-Shan Kao & David Wastell. *A comparison of adaptive and adaptable automation under different levels of environmental stress*. Pages 840-853.

The effectiveness of different forms of adaptive and adaptable automation was examined under low- and high-stress conditions, in the form of different levels of noise. Thirty-six participants were assigned to one of the three types of variable automation (adaptive event-based, adaptive performance-based and adaptable serving as a control condition). Participants received 3 h of training on a simulation of a highly automated process control task and were subsequently tested during a 4-h session under noise exposure

and quiet conditions. The results for performance suggested no clear benefits of one automation control mode over the other two. However, it emerged that participants under adaptable automation adopted a more active system management strategy and reported higher levels of self-confidence than in the two adaptive control modes. Furthermore, the results showed higher levels of perceived workload, fatigue and anxiety for performance-based adaptive automation control than the other two modes.

Practitioner Summary: This study compared two forms of adaptive automation (where the automated system flexibly allocates tasks between human and machine) with adaptable automation (where the human allocates the tasks). The adaptable mode showed marginal advantages. This is of relevance, given that this automation mode may also be easier to design.

- **Keywords:** adaptive automation, adaptable automation, performance, stress

Anat Ostrovsky, Joseph Ribak, Avihu Pereg & Dan Gatton. *Effects of job-related stress and burnout on asthenopia among high-tech workers.* Pages 854-862.

Eye- and vision-related symptoms are the most frequent health problems among computer users. The findings of eye strain, tired eyes, eye irritation, burning sensation, redness, blurred vision and double vision, when appearing together, have recently been termed 'computer vision syndrome', or asthenopia. To examine the frequency and intensity of asthenopia among individuals employed in research and development departments of high-tech firms and the effects of job stress and burnout on ocular complaints, this study included 106 subjects, 42 high-tech workers (study group) and 64 bank employees (control group). All participants completed self-report questionnaires covering demographics, asthenopia, satisfaction with work environmental conditions, job-related stress and burnout. There was a significant between-group difference in the intensity of asthenopia, but not in its frequency. Burnout appeared to be a significant contributing factor to the intensity and frequency of asthenopia. This study shows that burnout is a significant factor in asthenopic complaints in high-tech workers.

Practitioner Summary: This manuscript analyses the effects of psychological environmental factors, such as job stress and burnout, on ocular complaints at the workplace of computer users. The findings may have an ergonomic impact on how to improve health, safety and comfort of the working environment among computer users, for better perception of the job environment, efficacy and production.

- **Keywords:** bank employees, computer vision syndrome, eye strain, job stress, ocular complaints

T. Bosch, S.E. Mathiassen, D. Hallman, M.P. de Looze, E. Lyskov, B. Visser & J.H. van Dieën. *Temporal strategy and performance during a fatiguing short-cycle repetitive task.* Pages 863-873.

This study investigated temporal changes in movement strategy and performance during fatiguing short-cycle work. Eighteen participants performed six 7-min work blocks with repetitive reaching movements at 0.5 Hz, each followed by a 5.5-min rest break for a total duration of 1 h. Electromyography (EMG) was collected continuously from the upper trapezius muscle, the temporal movement strategy and timing errors were obtained on a cycle-to-cycle basis, and perceived fatigue was rated before and after each work block. Clear signs of fatigue according to subjective ratings and EMG manifestations developed within each work block, as well as during the entire hour. For most participants, timing errors gradually increased, as did the waiting time at the near target. Changes in

temporal movement strategy were negatively correlated with changes in the level and variability of EMG, suggesting that an adaptive temporal strategy offset the development of unstable motor solutions in this fatiguing, short-cycle work.

Practitioner Summary: Sustained performance of operators is essential to maintain competitiveness. In this study of repetitive work, participants gradually changed their temporal movement strategy, for possibly alleviating the effects of fatigue. This suggests that in order to effectively counteract fatigue and sustain performance, industrial production should allow extensive spatial and temporal flexibility.

- **Keywords:** temporal movement strategy, performance, fatigue, repetitive work, EMG

Krishna Asundi, Peter W. Johnson & Jack T. Dennerlein. *Variance in direct exposure measures of typing force and wrist kinematics across hours and days among office computer workers.* Pages 874-884.

To determine the number of direct measurements needed to obtain a representative estimate of typing force and wrist kinematics, continuous measures of keyboard reaction force and wrist joint angle were collected at the workstation of 22 office workers while they completed their own work over three days, six hours per day. Typing force and wrist kinematics during keyboard, mouse and idle activities were calculated for each hour of measurement along with variance in measurements between subjects and between day and hour within subjects. Variance in measurements between subjects was significantly greater than variance in measurements between days and hours within subjects. Therefore, we concluded a single, one-hour period of continuous measures is sufficient to identify differences in typing force and wrist kinematics between subjects. Within subjects, day and hour of measurement had a significant effect on some measures and thus should be accounted for when comparing measures within a subject.

Practitioner Summary: The dose response relationship between exposure to computer related biomechanical risk factors and musculoskeletal disorders is poorly understood due to the difficulty and cost of direct measures. This study demonstrates a single hour of direct continuous measures is sufficient to identify differences in wrist kinematics and typing force between individuals.

- **Keywords:** exposure assessment, upper extremities, musculoskeletal disorders, electrogoniometers, force plate

Yan Qu, Jaejin Hwang, Kyung-Sun Lee & Myung-Chul Jung. *The effect of camera location on observation-based posture estimation.* Pages 885-897.

This study used the observation-based method showing images on computer to evaluate angle estimation errors of 8 body segments in 3 motion planes at up to 28 segment angles and 5 camera locations with respect to goniometric measurements. Thirty observers participated in evaluating segment angles. Forearm (9.9°) and thigh (9.5°) had smaller errors than hand (14.0°) and foot had the smallest error (8.7°) due to its narrow range of motion (ROM). Errors were small with camera locations perpendicular to motions in the planes, such as 90° camera location for the flexion and extension of arm (6.3°), forearm (7.9°), thigh (6.5°), and leg (8.1°) in the sagittal plane. Segments had small errors of 3.1°, 4.6°, and 3.8° at segment angles of -90°, 0° and 90°, respectively. Care should be taken when estimating angles by the observation-based method for a specific segment motion and viewing direction is suggested to be perpendicular to the motion plane.

Practitioner Summary: Some companies may not allow many cameras or have obstacles for working posture evaluation in the workplace. These study results can be a guideline on proper selection of the number of cameras and their locations for a specific segment and its motion of interest to reduce visual segment angle estimation errors.

- **Keywords:** visual estimation error, whole body segment, motion plane, camera location

Kieran O'Sullivan, Mary O'Keeffe, Leonard O'Sullivan, Peter O'Sullivan & Wim Dankaerts. *The effect of dynamic sitting on the prevention and management of low back pain and low back discomfort: a systematic review. Pages 898-908.*

Dynamic sitting has been proposed to reduce low back pain (LBP) and/or low back discomfort (LBD) while sitting. This is supported by studies suggesting that subjects with LBP assume more static, sustained postures while sitting. This systematic review investigated the effect of dynamic sitting on LBP among subjects with LBP and the development of LBD among pain-free subjects. Electronic databases were searched by two independent assessors. All prospective studies which compared the effect of a dynamic sitting condition on LBP or LBD to another sitting condition were eligible, with no minimum follow-up period applied. The quality of the included studies was assessed using the PEDro scale. Seven high-quality studies were eligible, including five crossover studies and two randomised controlled trials. The results suggest there is currently no evidence to support the use of dynamic sitting as a stand-alone approach in the management of LBP.

Practitioner Summary: This systematic review investigated the effect of dynamic sitting on LBP or LBD. Seven high-quality studies met the inclusion and exclusion criteria. Overall, the evidence suggests that dynamic sitting approaches are not effective as a stand-alone management approach for LBP.

- **Keywords:** dynamic sitting, back pain, discomfort, systematic review

Bazil Basri & Michael J. Griffin. *Equivalent comfort contours for vertical seat vibration: effect of vibration magnitude and backrest inclination. Pages 909-922.*

This study determined how backrest inclination and the frequency and magnitude of vertical seat vibration influence vibration discomfort. Subjects experienced vertical seat vibration at frequencies in the range 2.5–25 Hz at vibration magnitudes in the range 0.016–2.0 ms⁻² r.m.s. Equivalent comfort contours were determined with five backrest conditions: no backrest, and with a stationary backrest inclined at 0° (upright), 30°, 60° and 90°. Within all conditions, the frequency of greatest sensitivity to acceleration decreased with increasing vibration magnitude. Compared to an upright backrest, around the main resonance of the body, the vibration magnitudes required to cause similar discomfort were 100% greater with 60° and 90° backrest inclinations and 50% greater with a 30° backrest inclination. It is concluded that no single frequency weighting provides an accurate prediction of the discomfort caused by vertical seat vibration at all magnitudes and with all backrest conditions.

Practitioner Summary: Vertical seat vibration is a main cause of vibration discomfort for drivers and passengers of road vehicles. A frequency weighting has been standardised for the evaluation of vertical seat vibration when sitting upright but it was not known whether this weighting is suitable for the reclined sitting postures often adopted during travel.

- **Keywords:** backrest angle, ride comfort, frequency weighting

G.S. Paddan, N.J. Mansfield, C.I. Arrowsmith, A.N. Rimell, S.K. King & S.R. Holmes. *The influence of seat backrest angle on perceived discomfort during exposure to vertical whole-body vibration*. Pages 923-936.

National and International Standards (e.g. BS 6841 and ISO 2631-1) provide methodologies for the measurement and assessment of whole-body vibration in terms of comfort and health. The EU Physical Agents (Vibration) Directive (PAVD) provides criteria by which vibration magnitudes can be assessed. However, these standards only consider upright seated (90°) and recumbent (0°) backrest angles, and do not provide guidance for semi-recumbent postures. This article reports an experimental programme that investigated the effects of backrest angle on comfort during vertical whole-body vibration. The series of experiments showed that a relationship exists between seat backrest angle, whole-body vibration frequency and perceived levels of discomfort. The recumbent position (0°) was the most uncomfortable and the semi-recumbent positions of 67.5° and 45° were the least uncomfortable. A new set of frequency weighting curves are proposed which use the same topology as the existing BS and ISO standards. These curves could be applied to those exposed to whole-body vibration in semi-recumbent postures to augment the existing standardised methods.

Practitioner Summary: Current vibration standards provide guidance for assessing exposures for seated, standing and recumbent positions, but not for semi-recumbent postures. This article reports new experimental data systematically investigating the effect of backrest angle on discomfort experienced. It demonstrates that most discomfort is caused in a recumbent posture and that least was caused in a semi-recumbent posture.

- **Keywords:** whole-body vibration, human comfort, backrest angle

Wen-Ruey Chang, Simon Matz & Chien-Chi Chang. *Stochastic distribution of the required coefficient of friction for level walking - an in-depth study*. Pages 937-945.

This study investigated the stochastic distribution of the required coefficient of friction (RCOF) which is a critical element for estimating slip probability. Fifty participants walked under four walking conditions. The results of the Kolmogorov–Smirnov two-sample test indicate that 76% of the RCOF data showed a difference in distribution between both feet for the same participant under each walking condition; the data from both feet were kept separate. The results of the Kolmogorov–Smirnov goodness-of-fit test indicate that most of the distribution of the RCOF appears to have a good match with the normal (85.5%), log-normal (84.5%) and Weibull distributions (81.5%). However, approximately 7.75% of the cases did not have a match with any of these distributions. It is reasonable to use the normal distribution for representation of the RCOF distribution due to its simplicity and familiarity, but each foot had a different distribution from the other foot in 76% of cases.

Practitioner Summary: The stochastic distribution of the required coefficient of friction (RCOF) was investigated for use in a statistical model to improve the estimate of slip probability in risk assessment. The results indicate that 85.5% of the distribution of the RCOF appears to have a good match with the normal distribution.

- **Keywords:** friction requirement, friction demand, statistical distribution, human locomotion

Errol R. Hoffmann & Ilyas H. Sheikh. *Goal-directed aimed movements with path obstructions*. Pages 946-962.

Studies are reported in which participants moved from a starting position to a final target, but moved around obstacles that prevented a direct path being taken. Seven experiments are reported in which subjects made multiple-component movements, defined by changes in the direction of movement, but without intervening targets (or stopping points) between components. It was found that components of movement time did not interact, contrary to the results of Gan and Hoffmann (1988b). Gan, K. C. and Hoffmann, E. R. 1988b. Sequential ballistic movement. *Ergonomics*, 31 (10) : 1421 – 1436 .

[View all references](#)) for cases where there was an intervening target, and that component times could be added. For ballistic components, the time for the movement was linearly related to the square root of the total amplitude of movement; for components that were visually controlled, the time was related to Fitts' Index of Difficulty based on the total amplitude of movement and the final target size. Results are compared to data for movements with intervening targets, where the movement integration hypothesis is valid.

Practitioner Summary: Many movements, particularly to inaccessible places, cannot be made directly, but must be made about obstacles in the path. This research shows how times for these movements can be quantified in terms of the direct path length and the size and location of the obstacles.

- **Keywords:** visually controlled movements, ballistic movements, obstructions to direct movement

Miguel Acuna & Andrew R. Karduna. *Wrist activity monitor counts are correlated with dynamic but not static assessments of arm elevation exposure made with a triaxial accelerometer*. Pages 963-970.

There is evidence in the literature of a link between workplace arm elevation exposure and atraumatic shoulder injuries. However, there are several methods that can be used to assess this exposure. The goal of the present study was to compare the outcomes of an activity monitor attached to the wrist and a triaxial accelerometer mounted on the humerus. Twenty-one workers wore both sensors over the course of a full workday. While the activity monitor data was not significantly correlated with any static humeral parameters, it was strongly correlated with all dynamic parameters. The use of a simple, commercially available activity monitor might offer an inexpensive alternative for the assessment of a large number of subjects over multiple workdays to determine the relationship between dynamic motion and occupation shoulder injuries in the future.

Practitioner Summary: Arm overuse has been linked to occupation-related shoulder injuries. An activity monitor attached to the wrist and a triaxial accelerometer mounted on the humerus were compared in a field trial. The results demonstrate that, under certain conditions, a commercially available activity monitor might be a useful tool for exposure assessment.

- **Keywords:** shoulder, exposure, accelerometers, overuse injuries

