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Eline M. Meijer; Monique H. W. Frings-Dresen; Judith K. Sluiter. *Effects of office innovation on office workers' health and performance.* Pages 1027–1038.

The implementation of an innovative office concept (e.g. open-plan, flexible workplaces and a paperless office concept) on health and productivity among office workers was evaluated with questionnaires of 138 workers at baseline and 6 and 15 months afterwards. Work-related fatigue, general health, change in health status, upper extremity complaints and perceived productivity were outcomes. No short-term significant differences were found in most outcomes except for quantity of performed work (decrease from 96% to 92%, $p = 0.008$). In the long-term, no significant differences were found in most outcomes except for an increase in general health ($p = 0.011$) and a decrease in prevalences of upper extremity complaints (33% to 22%, $p = 0.021$). Perceived productivity increased significantly 15 months after the implementation. It is concluded that innovative office concepts had no or limited effects on work-related fatigue, health changes and productivity but some positive effects on workers' general health and upper extremity complaints in the long term. Office innovation is being administered often but up to now seldom evaluated on workers' health and productivity.

- **Keywords:** office innovation; office work; health; performance

Herbert Heuer; Mathias Hegele. *Adjustment to a complex visuo-motor transformation at early and late working age.* Pages 1039–1054.

Age-related changes of adjustment to visuo-motor transformations were studied for a complex transformation modelled after those encountered in laparoscopic surgery. Movement times of aimed movements were initially almost identical for the two age groups and diverged in the course of practice. In test phases without visual feedback, no age-related variation of the adaptive shifts and after effects of amplitude and curvature of hand movements were observed, but only of their direction. Directional adaptive shifts were bimodally distributed, with one mode near to perfect adaptation ('adapters') and the other one near to absence of adaptation ('non-adapters'). Among the young participants, adapters were more frequent than among the old participants. These findings extend previous results on age-related changes of adjustment to simple transformations to complex transformations. They are consistent with the claim that age-related changes of adjustment to visuo-motor rotations come about primarily by impairments of strategic corrections. A link is established between basic-research

findings and transformations encountered outside the laboratory: what suffers at higher working age is explicit knowledge of visuo-motor rotations and the strategic corrections based on it. This suggests the provision of opportunities for explicit-knowledge acquisition for those of a higher age.

- **Keywords:** adaptation; ageing; motor skill; visuo-motor transformation

Eleonora P. Westebring-van der Putten; John J. van den Dobbelsteen; Richard H. M. Goossens; Jack J. Jakimowicz; Jenny Dankelman. *Force feedback requirements for efficient laparoscopic grasp control. Pages 1055–1066.*

During laparoscopic grasping, tissue damage may occur due to use of excessive grasp forces and tissue slippage, whereas in barehanded grasping, humans control their grasp to prevent slippage and use of excessive force (safe grasp). This study investigates the differences in grasp control during barehanded and laparoscopic lifts. Ten novices performed lifts in order to compare pinch forces under four conditions: barehanded; using tweezers; a low-efficient grasper; and a high-efficient grasper. Results showed that participants increased their pinch force significantly later during a barehanded lift (at a pull-force level of 2.63 N) than when lifting laparoscopically (from pull-force levels of 0.77 to 1.08 N). In barehanded lifts all participants could accomplish a safe grasp, whereas in laparoscopic lifts excessive force (up to 7.9 N) and slippage (up to 38% of the trials) occurred frequently. For novices, it can be concluded that force feedback (additional to the hand-tool interface), as in skin-tissue contact, is a prerequisite to maintain a safe grasp. Much is known about grasp control during barehanded object manipulation, especially the control of pinch forces to changing loading, whereas little is known about force perception and grasp control during tool usage. This knowledge is a prerequisite for the ergonomic design of tools that are used to manipulate objects.

- **Keywords:** laparoscopy; force feedback; haptic; grasp control; perception

Kay Teschke; Catherine Trask; Pete Johnson; Yat Chow; Judy Village; Mieke Koehoorn. *Measuring posture for epidemiology : comparing inclinometry, observations and self-reports. Pages 1067–1078.*

The objective of this study was to use and evaluate three postural assessment methods for epidemiological studies of back disorders. The methods were: (1) a data-logging inclinometer; (2) observations by trained observers; (3) self-reports by employees. All methods were feasible in 50 heavy industry worksites. Inclinometry provided quantitative measures of flexion-extension (mean 17°, SD 11.2°), lateral flexion (mean 8.5°, SD 2.6°) and trunk movement speed (mean 14.3° per second, SD 4.9° per second). Observations and self-reports provided estimates of time spent in various trunk angles, general postures, materials handling and vehicles. Compared to observations, self-reports under-reported less common tasks, but over-reported task durations. In statistical modelling to determine if observations or self-reports could be used to estimate measured postures, observations accounted for 30 to 61% of the inclinometer measurement variance and self-reports for 33 to 40%. A combination of inclinometry and observations would be an ideal option to provide both depth and breadth of data on postures and other physical exposures for epidemiological research.

- **Keywords:** flexion/extension; lateral flexion; exposure modelling; heavy industry; exposure assessment

Wendela E. Hooftman; Allard J. van der Beek; Bregje G. van de Wal; Dirk L. Knol; Paulien M. Bongers; Alex Burdorf; Willem van Mechelen.

Equal task, equal exposure? : are men and women with the same tasks equally exposed to awkward working postures? Pages 1079–1086.

The aim of the study was to determine whether men and woman with equal tasks perform these tasks in the same way. Video recordings of 37 male and 43 female workers in six task groups were observed, from which data regarding frequency and duration of exposure to awkward postures were derived. These data were also compared to self-reported exposures. The results showed that when level, duration and frequency of exposure were analysed at the same time, men and women had slightly different exposure patterns. However, these differences were not found when duration and frequency were analysed separately. From the questionnaires it appeared that men and women generally report similar exposures, but they seemed to over-report their exposure compared to the observed exposures. It is concluded that gender differences in exposure to awkward postures within the same task were small at most and cannot explain the female excess in musculoskeletal symptoms.

- **Keywords:** gender difference; exposure assessment; observation; questionnaires

E. M. Speklé; M. J. M. Hoozemans; A. J. van der Beek; B. M. Blatter; P. M. Bongers; J. H. van Dieën. Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers. Pages 1087–1103.

The aim of this study was to determine the internal consistency, test-retest reliability and concurrent validity of the RSI QuickScan, a newly developed questionnaire that aims to identify the presumed risk factors for neck, shoulder and arm symptoms in a population of computer workers. The internal consistency was calculated using item analysis. The test-retest reliability and concurrent validity were analysed by calculating the percentage of agreement, Cohen's Kappa and the Ppositive and Pnegative. The concurrent validity was also tested by comparing the results from the new questionnaire with those from the original questionnaires that the current questionnaire was based on, on-site expert observations and direct measurements. The results indicate that the RSI QuickScan is a measurement tool with acceptable internal consistency, reliability and concurrent validity. The questionnaire can be used as a means to rapidly collect data on a large population of office workers and at low cost.

- **Keywords:** questionnaire; reliability; validity; computer work

G. S. Faber; I. Kingma; P. P. F. M. Kuijer; H. F. van der Molen; M. J. M. Hoozemans; M. H. W. Frings-Dresen; J. H. van Dieën. Working height, block mass and one- vs. two-handed block handling: the contribution to low back and shoulder loading during masonry work. Pages 1104–1118.

The goal of this study was to compare the effects of the task variables block mass, working height and one- vs. two-handed block handling on low back and shoulder loading during masonry work. In a mock-up of a masonry work site, nine masonry workers performed one- and two-handed block-lifting and block-placing tasks at varying heights (ranging from floor to shoulder level) with blocks of varying mass (ranging from 6 to 16 kg). Kinematics and ground reaction forces were measured and used in a 3-D linked segment model to calculate low back and shoulder loading. Increasing lifting height appeared to be the most effective way to reduce low back loading. However, working at shoulder level resulted in relatively high shoulder loading. Therefore, it was recommended to organise masonry work in such a way that blocks are handled with the hands at about iliac crest height as much as possible.

- **Keywords:** low back loading; shoulder loading; construction work; lifting

Sakineh B. Akram; James S. Frank. *Stilt walking : how do we learn those first steps?* Pages 1119–1127.

This study examined how young healthy adults learn stilt walking. Ten healthy male university students attended two sessions of testing held on two consecutive days. In each session participants performed three blocks of 10 stilt-walking trials. Angular movements of head and trunk and the spatial and temporal gait parameters were recorded. When walking on stilts young adults improved their gait velocity through modifications of step parameters while maintaining trunk movements close to that observed during normal over-ground walking. Participants improved their performance by increasing their step frequency and step length and reducing the double support percentage of the gait cycle. Stilts are often used for drywall installation, painting over-the-head areas and raising workers above the ground without the burden of erecting scaffolding. This research examines the locomotor adaptation as young healthy adults learn the complex motor task of stilt walking; a task that is frequently used in the construction industry.

- **Keywords:** stilt walking; learning; skill acquisition; balance; adaptation

Hongwei Hsiao; Martin Friess; Bruce Bradtmiller; F. James Rohlf. *Development of sizing structure for fall arrest harness design.* Pages 1128–1143.

Updated harness designs are needed to accommodate diverse populations in the current workforce. This paper determined an improved fall-arrest harness sizing scheme and strap-length configurations for harness design. A 3-D elliptic Fourier analysis (EFA) procedure with 123 coefficients was developed to quantify torso-shape effect on harness fit, based on 3-D data of 108 women and 108 men. The EFA coefficients were then applied to 600 representative body scans from a national database of 2382 participants to establish an improved sizing system. Study outcomes suggested a more upward back D-ring location for women than current unisex designs to accommodate female torso form and mitigate their fit problem. Results also suggested an improved system of three sizes for women and three sizes for men. New harness sizing charts for women and men were proposed accordingly. Using the most current 3-D whole-body digital scanning technology, this study assembled data from a US workforce to establish an improved fall-arrest harness sizing system and strap configurations for men and women. The information is useful for new generation harness designs to reduce the risk of worker injury.

- **Keywords:** construction; falls; torso shape; Fourier; anthropometry

Martin P. H. Smets; James R. Potvin; Peter J. Keir. *Constrained handgrip force decreases upper extremity muscle activation and arm strength.* Pages 1144–1152.

Many industrial tasks require repetitive shoulder exertions to be performed with concurrent physical and mental demands. The highly mobile nature of the shoulder predisposes it to injury. The purpose of this study was to determine the effects of simultaneous gripping, at a specified magnitude, on muscle activity and maximal arm force in various directions. Ten female subjects performed maximal arm exertions at two different heights and five directions using both specified (30% maximum voluntary grip) and preferred (self-selected) grip forces. Electromyography was recorded from eight muscles of the right upper extremity. The preferred grip condition produced grip forces that were dependent on the combination of arm height and force direction and were

significantly greater (arm force down), lower (to left, up and push forward), or similar to the specified grip condition. Regardless of the magnitude of the preferred grip force, specifying the grip resulted in decreased maximal arm strength (by 18-25%) and muscle activity (by 15-30%) in all conditions, indicating an interfering effect when the grip force was specified by visual target force-matching. Task constraints, such as specific gripping demands, may decrease peak force levels attainable and alter muscle activity. Depending on the nature of task, the amount of relative demand may differ, which should be considered when determining safety thresholds.

- **Keywords:** shoulder; strength; electromyography; multitasking; grip

Huey-Wen Liang; Yaw-Huei Hwang; Fu-Han Chang. *Effects of input methods on inter-key press intervals during continuous typing. Pages 1153–1161.*

Two popular input methods for Chinese typing, Microsoft New Phonetic and Boshiamy, were compared in terms of hand and finger loading, key-pressing speed and typing efficiency. Sixteen subjects typed an English and a Chinese text for 30 min each during two test sessions and all keystrokes and their inter-key press intervals were recorded by electronic activity monitoring software. Typing with Microsoft New Phonetic and with Boshiamy was found to have equal hand loadings, but typing with Microsoft New Phonetic was associated with a higher proportion of keystrokes at the number row. The subjects who used Boshiamy typed significantly more words per min than those who used Microsoft New Phonetic, though both groups had similar English typing speeds. The features of requiring fewer keystrokes to build a character and no need to choose matched words among homophones made Boshiamy a more efficient tool, but the risk of musculoskeletal disorders should be studied further. This study examined two input methods for typing Chinese and showed that typing with Boshiamy had a higher efficiency, including a higher proportion of key presses on the home row, required fewer key presses to build characters and resulted in a faster speed than with Microsoft New Phonetic. However, the potential risk of development of upper limb symptoms warrants further study.

- **Keywords:** typewriting; computers; task performance; musculoskeletal disorders

Stuart M. McGill; Chad M. J. Fenwick. *Using a pneumatic support to correct sitting posture for prolonged periods : a study using airline seats. Pages 1162–1168.*

Prolonged sitting with spine flexion has been linked to low back disorders. A variety of mechanisms account for this based on biomechanical and neurological variables. Airline seats typically cause pronounced lumbar flexion due to their hollowed seat back design. A pneumatic support, placed between the seat back and the lumbar spine, was tested to see if lumbar flexion was reduced. Results showed that when the seats were positioned in the upright position, 15 of 20 participants experienced reduced lumbar flexion (by 15° on average) with the support. The study was repeated on the five non-responders with the seatback set in the reclined position. This resulted in another four experiencing less lumbar flexion. Since seated flexion is associated with disc stress, reducing flexion with the support reduced lumbar stress. Spine flexion that results from prolonged sitting is associated with disc stress and pain. The pneumatic support tested here reduced spine flexion. While it is not known why airline seats are designed with no lumbar support, which causes excessive lumbar flexion while seated, the pneumatic support corrected this deficit. Reclining the seatback enhanced this effect.

- **Keywords:** lumbar; support device; range of motion

Woojin Park; Devender P. Singh; Martin S. Levy; Eui S. Jung. *Obesity effect on perceived postural stress during static posture maintenance tasks*. Pages 1169–1182.

Postural stresses related to manual work tasks may be significantly affected by the bodily condition of workers. One such condition is obesity, which is characterised by excess fat mass in the body. This study empirically examined the obesity effect on postural stress during static posture maintenance tasks. In total, 20 obese and 20 non-obese participants performed static box-holding for a set of 84 working postures defined based on the Ovako Working Posture Analysing System. The participants reported postural stresses using the rated perceived exertion scale. Obesity was found to significantly increase postural stress across the 84 working postures and, also, amplify the effects of postural changes on postural stress. The study findings suggest that ergonomic workplace/job design for obese workers would be a challenge requiring a proactive approach and creativity in problem solving. In addition, the use of ergonomic knowledge in design would be more critical when targeting obese than non-obese workers. The study findings are relevant to ergonomic workplace/job design for obese workers.

- **Keywords:** obesity; postural stress; Ovako Working Posture Analysing System; rated perceived exertion; workplace design