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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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M. Rangayyan, S. Krishnan, G. D. Bell, C. B. Frank and K. O. Ladly 1997 *IEEE Transactions on Biomedical Engineering* **44**, 1068–1074. Parametric representation and screening of knee joint vibroarthrographic signals. (8 pages, 4 figures, 6 tables, 24 references) (in English).

Authors' Abstract. We have been investigating analysis of knee joint vibration or vibroarthographic (VAG) signals as a potential tool for non-invasive diagnosis and monitoring of cartilage pathology. In this paper, we present a comprehensive comparative study of different parametric representations of VAG signals. Dominant poles and cepstral coefficients were derived from autoregressive models of adaptively segmented VAG signals. Signal features and a few clinical features were used as feature vectors in pattern classification experiments based on logistic regression analysis and the leave-one-out method. The results using 51 normal and 39 abnormal signals indicated the superior performance of cepstral coefficients in VAG signal classification with an accuracy rate of 75.6%. With 51 normal and 20 abnormal signals limited to chondromalacia patella, cepstral coefficients again gave the highest accuracy rate of 85.9%.

Topics: diagnostic applications.

R. E. Maser, M. J. Lenhard and G. S. DeCherney 1997 *American Journal of Hypertension* **10** (9 part 1), 1044–1048. Vibratory thresholds correlation with systolic blood pressure in diabetic women. (5 pages, 0 figures, 2 tables, 20 references) (in English).

Authors' Abstract. Previous studies have suggested a potential association of elevated blood pressure (BP) and the development of diabetic neuropathy for individuals with insulin-dependent diabetes mellitus. In this study, we examined an association between BP and vibratory thresholds (assessment modality of large sensory nerve fiber function) for 33 participants with non-insulin dependent diabetes mellitus. There were 19 women and 14 men aged 58 ± 7 (mean $\pm$ SD) years, with diabetes duration of 7 ± 6 years and a body mass index of 29 ± 5 kg/m^2. None of the individuals were taking any medications that lower BP and all were negative for the presence of microalbuminuria. Vibratory thresholds were determined at three visits using a two-alternative, forced-choice procedure. BP was assessed by 24-h ambulatory BP monitoring. As expected, vibratory thresholds were higher for men than women ($6{\cdot}3 \pm 4$ versus $4{\cdot}2 \pm 3$ vibration units) but there was no statistical difference after controlling for height. In multivariate analyses with vibratory thresholds as the dependent variable, duration of diabetes ($P < 0{\cdot}01$), age ($P < 0{\cdot}01$) and systolic BP (*SBP*) ($P < 0{\cdot}01$) explained approximately 70% of the overall variability of the gender-specific (i.e., female) model. The variability was similar (i.e., 70–73%) no matter which SBP measure was available for modelling. In terms of diastolic blood pressure (DBP)

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measures, only the percentage of abnormal readings (i.e., >90 mm Hg) for day DBP was found to be independently associated with vibratory thresholds for women. The association of BP and large sensory nerve fiber dysfunction for non-nephropathic diabetic women found in this cross-sectional study warrants further investigation.
Topics: vibration sense (thresholds); diagnostic applications.

M. Fritz 1997 *Aviation*, *Space*, *and Environmental Medicine* **68**, 512–519. Estimation of spine forces under whole-body vibration by means of a biomechanical model and transfer functions. (8 pages, 6 figures, 0 tables, 36 references) (in English).
Authors' *Abstract*. Background: several investigations reveal that long-term exposure to whole-body vibrations can induce degenerative changes in the lumbar spine. In analogy to the activities of lifting, carrying loads, an assessment of the health risk should be possible if the forces transmitted in the spine during vibration stress are known. Methods: to estimate the spine forces a biomechanical model was developed. In the model the human trunk, neck, and head were represented by 10 rigid bodies connected by visco-elastic elements. Some 56 force elements imitated the muscles of the body. The motion equations of the model were derived by means of the dynamics of systems of rigid bodies. Results: the transfer functions of the model accelerations in the x and z directions satisfactorily corresponded to data reported in the literature. Transfer functions were computed between the forces transmitted from the seat to the pelvis and in the lumbar spine, respectively. Conclusions: the forces between seat and pelvis were measured, then the spine forces were computed by means of the transfer functions. To assess the health risk the computed forces must be compared with the strength of the spine because the strength is dependent on the age and gender of the worker and decreases with the number of load cycles.
Topics: biodynamics (models, transmissibility); injury and disease.

P. Lindström, U. Lindblom and T. Brismar 1997 *Journal of Neurology*, *Neurosurgery*, *and Psychiatry* **63**, 346–350. Delayed recovery of nerve conduction and vibratory sensibility after ischaemic block in patients with diabetes mellitus. (5 pages, 2 figures, 1 table, 30 references) (in English).
Authors' *Abstract*. Objectives—to determine if the recovery of nerve function after ischaemic block is impaired in patients with diabetes mellitus relative to healthy controls. Methods—median nerve impulse conduction and vibratory thresholds in the same innervation territory were studied in patients with diabetes mellitus ($n = 16$) and age matched controls ($n = 10$) during and after 30 min of cuffing of the forearm. Results—cuffing caused a 50% reduction of the compound nerve action potential (CNAP) after 21·9 (SEM 1·6) min in patients with diabetes mellitus and after 10·6 (0·7) min in controls. After release of the cuff the half life for CNAP recovery was 5·13 (0·45) min in patients with diabetes mellitus and <1 min in controls. At seven minutes after release of the cuff CNAP was fully restored in the controls whereas in patients with diabetes mellitus CNAP had only reached 75·1 (4·1)% of its original amplitude. After onset of ischaemia it took 14·6 (1·9) min in patients with diabetes mellitus before the vibratory threshold was doubled, whereas this took 5·8 (0·8) min in controls. After release of the cuff half time for recovery of vibratory threshold was 8·8 (1·0) min in patients with diabetes mellitus and 2·6 (0·3) min in controls. Ten minutes after the cuff was released the

threshold was still raised (2·0 (0·3)-fold) in the diabetes mellitus group, whereas it was normalized in controls. Among patients with diabetes mellitus the impaired recovery correlated with older age, higher HbA1c, and signs of neuropathy, but not with blood glucose. Conclusions—after ischaemia there is a delayed recovery of nerve conduction and the vibratory sensibility in patients with diabetes mellitus. Impaired recovery after ischaemic insults may contribute to the high frequency of entrapment neuropathy in patients with diabetes mellitus.
Topics: vibration sense (thresholds); diagnostic applications.

A. Sörensson, L. Burström 1997 *International Archives of Occupational and Environmental Health* **70**, 199–204. Transmission of vibration energy to different parts of the human hand–arm system. (6 pages, 5 figures, 0 tables, 18 references) (in English).
Authors' *Abstract*. The aim of this study was to investigate the transmission of vibration energy to three selected points along the hand arm (knuckle, wrist and elbow) and to compare the energy transmission for two different kinds of vibration exposures, i.e., random and sinusoidal. The transmission of vibration energy was estimated for ten subjects during exposure to random (within the frequency range 20–5000 Hz) and sinusoidal vibration at eight different frequencies (20, 40, 80, 160, 320, 630, 1250 and 1600 Hz). The random and sinusoidal vibrations had a frequency-weighted acceleration level of 3 m/s^2. The energy transmission was determined by simultaneous vibration measurements at the vibrating handle and in the hand–arm system. The measurements were made with a laser velocity transducer and specially constructed equipment. The grip and feed forces were held constant at 40 N. The results show that the energy transmission decreases with the distance from the source. The results also show that the energy transmission is dependent on the frequency for the random vibration exposures. No clear frequency dependence of the energy transmission could be found for sinusoidal vibrations. It may also be concluded that there are differences in the energy transmission due to types of exposure, sinusoidal vibration showing higher transmission of energy to the hand-arm system than random vibration, especially at higher frequencies.
Topics: biodynamics (transmissibility; energy absorption); hand-transmitted vibration.

J. F. Golding and J. R. R. Stott 1997 *Journal of Vestibular Research* **7**, 421–428. Objective and subjective time courses of recovery from motion sickness assessed by repeated motion challenges. (8 pages, 3 figures, 0 tables, 11 references) (in English).
Authors' *Abstract*. The aim of this study was to determine whether the time course of recovery of tolerance, as assessed objectively by rechallenge with motion, paralleled the subjective recovery from motion sickness. Subjects ($n = 20$) were exposed to 5 pairs of nauseogenic motion challenges in which the time interval between the end of the first and the start of the second of each pair ranged from 15 min to 2 h. The cross-coupled motion challenge had an incrementing profile of rotational velocity from 4° to 92° s^{-1} in steps of 4° s^{-1} every 30 s, with 8 head movements per 30 s, of approximately 45°, and was continued to the point of moderate nausea. Objective loss of tolerance decreased from 15 min to 60 min after the first challenge, but increased again at 2 h. By contrast, most individuals reported subjective recovery by 15 min to 30 min. It was concluded that there is

an underlying effect of motion sickness that sensitises the response to subsequent motion for a period of at least 2 h. This underlying objective effect can occur in the absence of subjective symptoms, has a slower time course than the subjective recovery from symptoms and appears to be non-monotonic.
Topics: motion sickness; coriolis stimulation.

J. L. Velay, F. Allin and A. Bouquerel 1997 *Vision Research* **37**, 2631–2638. Motor and perceptual responses to horizontal and vertical eye vibration in humans. (8 pages, 1 figure, 1 table, 35 references) (in English).
Authors' Abstract. Previous studies have shown that low amplitude/high frequency mechanical vibration applied to the human eye muscle results in the illusory movement of a luminous spot fixated in total darkness. The aim of the present study was to investigate whether a vibration-induced motor response also occurs in eye muscles, and to check whether the visual illusions actually result from the proprioceptors being activated by the vibration, or whether they are simply due to the retinal slip induced by the reflex eye movement. The effects of the vibratory stimuli on the inferior rectus (IR) and lateral rectus (LR) muscles were evaluated by recording subjects' eye position changes. When applied to the IR muscle, vibration effectively elicited an upward visual illusion accompanied by a small downward ocular rotation, whereas when applied to the LR muscle, it also induced horizontal visual illusion, which was less frequent and weaker than the vertical one, but no ocular rotation. We concluded that visual illusions of this kind cannot be attributable to the retinal motion of the image of the fixated point. The difference between the vertical and horizontal vibratory responses is discussed as regards the particular role that oculo-muscular proprioception may play in the vertical muscles.
Topics: performance effects (vision).

P. T. Ricci 1997 *Perceptual and Motor Skills* **85**(3 part 1), 1091–1098. Possible interaction between vibration thresholds by sex and motor dominance in the index finger and big toe. (8 pages, 0 figures, 2 tables, 23 references) (in English).
Author's Abstract. Two studies suggest a possible interaction among sex, motor dominance, and vibrotactile threshold for the great toe and index finger. In Study 1 a forced-choice procedure with the Vibration II (Physitemp Instruments, Inc.) was used; a significant interaction between sex and foot dominance for vibratory threshold was noted with no main effects for the great toe. The greatest difference between men and women was on the non-dominant side on the foot. Study 2 replicated Study 1 using the index finger as well as the great toe and used the Semmes–Weinstein monofilament test for cross-modal comparison. A method of limits procedure was used to increase the generalizability of the data. A similar interaction was found between sex and motor dominance for the index finger but not the great toe. This was attributed to skewing of data for the toe. No effects were found for the Semmes–Weinstein test. Possible usefulness in detecting neuropathies is considered. Larger normative studies including variables such as age, height, and weight are required for generalizable conclusions.
Topics: vibration sense (thresholds); subject type (sex).

NOTE: copies of all papers in this section will be found in the Human Response to Vibration Literature Collection at the Institute of Sound and Vibration

Research, University of Southampton. The papers may be used by persons visiting the Institute.

Contributions to the Literature Collection are invited. They should be sent to Professor M. J. Griffin, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, SO17 1BJ, England.