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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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G. van der Perre and G. Lowet 1996 *Bone* **18**(1), Supplement 29S–33S. *In vivo* assessment of bone mechanical properties by vibration and ultrasonic wave propagation analysis. (5 pages, 2 figures, 4 tables, 27 references) (in English)

Authors' Abstract. Vibration analysis and ultrasonic wave propagation analysis were evaluated as non-invasive techniques for *in vivo* assessment of bone mechanical properties. The relation between the resonant frequencies, obtained by vibration analysis, and geometrical and material properties of long bones, is explained using a simple beam model. This simple beam model was validated experimentally in previous work on excised animal bones. *In vitro* measurements were performed on human and animal excised bones from specific osteopenic cases and control groups. Using specific protocols for *in vivo* vibration and ultrasound measurements of the tibia, a population of osteoporotic patients and age-matched controls were tested. From these measurements, it was concluded that the bending rigidity, calculated from the resonant frequencies, in osteoporotic tibiae had decreased as compared to the control group. Also, the ultrasound velocity in the tibial cortex was lower in the osteoporotic group. The latter indicates a change in the bone tissue material properties. On the other hand, immobilization osteoporosis appeared to lead to a decrease in bending rigidity without an observable change in bone tissue material properties. By the combination of vibration analysis and ultrasound velocity measurements, the whole bone's mechanical characteristics as well as the bone tissue properties can be assessed *in vivo*. Since both techniques are non-invasive, they can be used in longitudinal studies for the assessment of bone response on physical loading.

Topics: Biodynamics; Diagnostic applications.

C. M. Checkosky, S. J. Bolanowski and J. C. Cohen 1996 *Journal of Occupational and Environmental Medicine* **38**(6), 593–601. Assessment of vibrotactile sensitivity in patients with carpal tunnel syndrome. (9 pages, 3 figures, 1 table, 52 references) (in English)

Authors' Abstract. The effectiveness of using vibrotactile threshold measures to aid in the diagnosis of carpal tunnel syndrome (CTS) was evaluated. Thresholds for detecting 1, 19 and 300 Hz vibratory stimuli were measured on the fingertips of 24 CTS patients and 20 healthy control subjects. There were no significant differences in threshold for 1 and 300 Hz between the two groups. Although there were significant differences for 10 Hz stimuli, the mean patient threshold was within one standard deviation of the mean threshold for the control group. These results indicate that threshold testing is not a suitable diagnostic tool for CTS. Additionally, we examined whether thresholds were evaluated in the presence of pain. Seven patients reported experiences of pain and no pain sessions. No significant differences in threshold were found between the two pain conditions, indicating that the presence of pain related to CTS does not affect threshold.

Topics: Vibration sense (thresholds); Diagnostic applications.

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B. I. Prilutsky, L. N. Petrova and L. M. Raitsin 1996 *Journal of Biomechanics* **29**(4), 405–415. Comparison of mechanical energy expenditure of joint moments and muscle forces during human locomotion. (11 pages, 8 figures, 0 tables, 46 references) (in English)
Authors' *Abstract*. The mechanical energy expenditure (MEEs) of two human lower extremity models with different sources of mechanical energy—(1) muscles and (2) joint movements—were compared theoretically. Sources of mechanical energy producing movements of Model 1 were eight muscles, three of which were two-joint muscles. Sources of mechanical energy producing movement of Model 2 were net moments at its joints. These sources of mechanical energy were substituted by 11 one-joint muscles, with the assumption that antagonistic muscles did not produce force. Because of this assumption, summed MEE of all joint moments and all one-joint muscles of Model 2 were the same. It was shown that during the same movement the model with two-joint muscles could spend less mechanical energy than the model without two-joint muscles. This economy of mechanical energy realized by two-joint muscles were possible if (i) signs of the muscle at both joints were opposite, (ii) moments produced by the muscle at each of the two joints had the same direction as the net joint moments at these joints, and (iii) muscles crossing these two joints from the opposite side did not produce force. Realization of these three conditions during human locomotion was checked experimentally. Electrical activity of eight lower extremity muscles of ten subjects was measured during treadmill walking and running. Based on this information, the period during which the muscles produce force were estimated. Moments and their power at joints of the lower extremity of two subjects performing walking and running were calculated using kinematics and ground reaction force measurements, and an inverse dynamics approach. It was shown that MEE of models with different sources of mechanical energy appeared to be different during certain periods of the swing phase. However, the magnitude of this difference was probably relatively small.
Topics: Biodynamics (models); Ambulation.

M. L. Magnusson, M. H. Pope, D. G. Wilder and B. Areskoug 1996 *Spine* **21**(6), 710–717. Are occupational drivers at an increased risk for developing musculoskeletal disorders? (7 pages, 1 figure, 14 tables, 61 references) (in English)
Authors' *Abstract*. This study analyzed the role of exposure to driving and other covariates in reports of back, neck, and shoulder pain and resultant disability. Cohorts in Sweden and the United States were compared. The objectives were to establish the effect of mechanical and psychosocial factors in reporting back, neck, and shoulder pain and work loss. There are numerous reports of a positive relationship between back pain and driving. However, exposure data are minimal. The influence of job satisfaction has not been assessed. The physical factors affecting reports of back, neck, and shoulder pain were investigated in a two-country cohort study of bus and truck drivers and sedentary workers. Vibration exposure was obtained by directly measuring the vibration imposed on the driver during a typical work day. Lifting exposure was attained by questionnaire. Cumulative exposure was computed based on work history. Musculoskeletal health information was based on a modified Nordic questionnaire, and other questionnaires recorded the physical and psychosocial aspects of the work environment. Of the sample, 50% reported low back pain, with no difference between countries. The higher risk factors (odds ratios) for back and neck pain were long-term vibration exposure, heavy lifting, and frequent lifting. A combination of long-term vibration exposure and frequent lifting carried the highest risk of low back pain. Work loss from low back pain was influenced by perceived job stress. Vibration (resulting from driving) and lifting cause

back, neck, and shoulder pain, whereas inability to work seems affected by stress at work.
Topics: Injury and disease: Epidemiology.

P. L. S. Li, N. B. Jones and P. J. Gregg 1996 *Medical Engineering and Physics* **18**(7), 596–600. Vibration analysis in the detection of total hip prosthetic loosening. (5 pages, 9 figures, 0 tables, 3 references) (in English)
Authors' Abstract. This present paper reports on experiments which seek to obtain evidence of the usefulness of vibration in the diagnosis of implant loosening by utilizing extra information by considering the amplitude response at all frequencies (within a certain range) as well as spectral analysis of particular waveforms. This frequency response is essentially a study of the manner in which the amplitude of vibration of a system varies as the frequency of an input force of fixed amplitude is varied. The experimental technique involved the application of a sinusoidal force to the distal end of a femur containing an implanted prosthesis and collecting the output signal using an accelerometer placed at the proximal end. The output signal was stored on a computer with a digital signal processing board and subsequently analysed using the two signal processing techniques mentioned above. Data were collected when the implanted prosthesis was secure, and at various stages of loosening. Analysis of these data shows that prosthetic instability can be detected using both modalities of vibration analysis.
Topics: Diagnostic applications; Biodynamics.

K. Popov, H. Lekhel, A. Bronstein and M. Gresty 1996 *Neuroscience Letters* **214**(2–3), 202–204. Postural responses to vibration of neck muscles in patients with unilateral vestibular lesions. (3 pages, 1 figure, 0 tables, 10 references) (in English)
Author's Abstract. Postural responses to vibration applied unilaterally to dorsal neck muscles were recorded with a sway platform in nine patients with unilateral vestibular lesions and 19 normal subjects. In normals, the vibration induced a forward postural deviation. In patients, vibration of the neck contralateral to the lesion induced normal forward sway, whereas ipsilateral vibration resulted in sway of lower amplitude than normal and predominantly in the direction of the lesion or backwards. It is suggested that the proprioceptive error signal introduced by the neck vibration combined with an asymmetrical vestibular input due to a unilateral vestibular lesion provoked an erroneous representation of head position in patients resulting in a redirection of their body sway.
Topics: Body posture; Physiological effects (muscle and nerve).

K. T. Palmer and H. Mason 1996 *Occupational and Environmental Medicine*, **553**, 118–124. Serum endothelin concentrations in workers exposed to vibration. (7 pages, 0 figures, 4 tables, 28 references) (in English)
Authors' Abstract. Endothelin 1 (ET_1) is one of a newly discovered family of potent naturally occurring vasoconstrictors produced by the endothelium. A few publications indicated that the peptide may have a role in idiopathic Raynaud's phenomenon and Raynaud's phenomenon secondary to connective tissue disease. The aim of this study was to compare serum endothelin concentrations in people with vibration induced white finger (VWF) with those of controls exposed to vibration, and unexposed (pure) controls. Male volunteers from a stonemasonry, two quarries, and an insurance company were classified by questionnaire and clinical examination into men with VWF (cases, $n = 31$), exposed controls ($n = 22$), or pure controls ($n = 36$). All subjects were asked to provide two venous blood specimens: a baseline sample after a period of warm equilibrium (30 minutes seated in a warm room and 20 minutes with both hands immersed in a water

bath of 37°C); and again after cold challenge (both hands immersed in a water bath at 6°C for six minutes). Serum concentrations of the 21 amino acid peptide endothelin ET_{1-21} were measured by radioimmunoassay. Baseline concentrations of ET_{1-21} were found to be lower in cases (mean = 12·2 pmol/l) than in the two control groups (mean = 14·7 pmol/l in exposed controls; mean = 14·3 pmol/l in pure controls). Among cases there was a broad inverse relation between severity, as measured by the Griffin blanching score, and baseline ET_{1-21} (Spearman rank correlation coefficient $-0{\cdot}58$, $P < 0{\cdot}001$). Cold challenge provoked an overall rise in ET_{1-21} in all groups, but larger and significant mean absolute and percentage rises were found in cases (4·1 pmol/l and 54%) than in the control groups (2·6 pmol/l and 21% in exposed controls; 1·5 pmol/l and 21% in pure controls). Similar but more obvious differences occurred when controls were compared with those cases who gave a more severe history of disease (Griffin blanching score $\geqslant 24$) and those cases found to blanch after cold challenge. In these case subsets baseline ET_{1-21} was nearly 50% lower than for controls and a four and a half to fivefold greater percentage rise in ET_{1-21} occurred upon cold challenge. Differences were significant. Close matching for age and smoking did not alter the principal findings. No significant differences, whether in baseline or cold response, were found between unexposed and exposed controls. Baseline findings seem to contradict various published series and attempts are made to reconcile the differences. It is suggested that a lower baseline ET_{1-21} in cases may result from a disease compensation mechanism or damage effect. The large relative rise in serum ET_{1-21} when cases are cold challenged may contribute directly or indirectly to vasospasm, but a simple mechanism is unlikely and interpretation is limited by the absence of measurements of forearm blood flow.
Topics: Vibration syndrome (vibration-induced white finger); Physiological effects.

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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.