



HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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M. Fritz, 1998 *Medical and Biological Engineering and Computing*, **36**, 686–692. Three-dimensional biomechanical model for simulating the response of the human body to vibration stress. (7 pages, 7 figures, 2 tables, 44 references) (In English) *Author's Abstract*. Several investigations have revealed that long-term exposure to whole-body vibrations can induce low back pain. In analogy to materials handling, the health risk can be assessed if the force transmitted in the spine during vibration are known. To estimate the forces a biomechanical model has been developed in which the human trunk, neck, head and arms are represented by 16 rigid bodies. An additional body simulates the vibrating seat. The bodies are connected by visco-elastic joint elements, and 56 force elements imitate the trunk and neck muscles. The motion equations are derived by the dynamics of systems of rigid bodies, and the motions are simulated in three directions. The frequency-response functions between the accelerations of the seat and the head satisfactorily correspond to data reported in the literature. The spine forces are composed of a static part, due to body posture, and a vibration-induced part. The relation between the oscillating parts of the forces transmitted from seat to pelvis and the spine forces are also described by frequency response functions. To assess the health risk the simulated spine forces must be compared with the strength of the spine, bearing in mind that this is dependent on the number of load cycles.

Topics: Biodynamics (models)

V. S. Gurfinkel, Yu.S. Levik, O. V. Kazennikov, and V. A. Selionov, 1998 *European Journal of Neuroscience*, **10**(5), 1608–1612. Locomotor-like movements evoked by leg muscle vibration in humans. (5 pages, 5 figures, 1 table, 16 references) (in English)

Authors' Abstract. We attempted to elicit automatic stepping in healthy humans using appropriate afferent stimulation. It was found that continuous leg muscle vibration produced rhythmic locomotor-like stepping movements of the suspended leg, persisting up to the end of stimulation and sometimes outlasting it by a few cycles. Air-stepping elicited by vibration did not differ from the international stepping under the same conditions, and involved movements in hip and knee joints with reciprocal electromyogram (EMG) bursts in corresponding flexor and

extensor muscles. The phase shift between evoked hip and knee movements could be positive or negative, corresponding to "backward" or "forward" locomotion. Such an essential feature of natural human locomotion as alternating movements of two legs, was also present in vibratory-evoked led movements under appropriate conditions. It is suggested that vibration evokes locomotor-like movements because vibratory-induced afferent input sets into active state the central structures responsible for stepping generation.

Topics: Ambulation, Physiological effects (muscle and nerve).

T. Ishitake, H. Ando, Y. Miyazaki, and F. Matoba 1998 *Kurume Medical Journal*, **45**(1), 59–62. Changes of visual performance induced by exposure to whole-body vibration. (4 pages, 3 figures, 1 table, 9 references) (in English)

Authors' Summary. To clarify the effects of whole-body vibration (WBV) on visual performance, visual acuity and a self-rated assessment of difficulties in visible perception were determined after various frequencies of vibration in six healthy males. Two different sitting postures, an erect posture and a muscle-relaxed posture, were used. Sinusoidal vertical vibrations at 10 frequencies (8, 10, 12.5, 16, 20, 25, 31.5, 40, 63.5 and 80 Hz) were applied to the seated subjects for 20 s. The magnitude of acceleration at each vibration frequency was maintained at 2.5 m s^{-1} (r.m.s.). The visual performance was evaluated by a standard visual acuity test and a self-rated assessment for difficulties in visible perception. The disturbances of visual performance were dependent on the vibration frequency ($p < 0.01$, ANOVA) with a maximum reduction of visual acuity at a frequency of 12.5 Hz. The disruption of the visual performance was more severe with the erect posture than with the muscle relaxed posture. In conclusion, short-term WBV exposure can effect visual performance, depending on the vibration frequency and the sitting posture. The visual acuity and self-rated assessment of disturbances of vision may be influenced by the resonance frequency of the eyeball.

Topics: Performance effects (vision).

P. Broede, T. Bruening, and B. Griefahn, 1998 *Aviation, Space, and Environmental Medicine*, **69**(10), 986–991. Equivalent sensation curves of simultaneous lateral and vertical sinusoidal whole-body vibration. (6 pages, 3 figures, 4 tables, 18 references) (in English)

Authors' Abstract. Background: To evaluate the effects of whole-body vibration on discomfort, the sensitivity to different frequencies as well as to different vibration axes must be regarded. The experimental study investigates the significance of lateral relative to vertical motions in the sensation of dual axis sinusoidal vibrations in sitting posture. The results are discussed in the context of the evaluation procedure proposed in the international standard ISO 2631. Methods: The experiments, in which 31 volunteers (16 female, 15 male, 19–51 yr) participated, used the method of adjustment. The subjects compared a single-axis reference motion ($a_w = 1.25 \text{ m s r.m.s.}$) with a dual-axis test motion of the same frequency. The magnitude of the test signals component along the reference-axis was kept constant at a fractional level of the reference magnitude (10, 25, 50, 75 or 90%). The component perpendicular to the reference-axis was adjusted by the subjects until

the test signal was rated as being equally as strong as the references. Both vertical and lateral reference motions were applied. The frequencies used were 1.6, 3.15, 6.3 and 12.5 Hz). Results: The shape of the resulting right-downwards bent equivalence curves was reasonably well fitted using the frequency weightings and evaluation procedure of ISO 2631. However, there were considerable quantitative discrepancies for frequencies above 1.6 Hz with an underestimation of the effects of lateral vibrations by a factor of 1.5–2. Therefore, it is concluded that lateral vibrations above 1.6 Hz need more weight in the evaluation of discomfort caused by multi-axis whole body vibrations.

Topics: Subjective assessment, Complex vibration (multiple axis).

M. Turner, and M. J. Griffin, 1999 *Ergonomics*, **42**(3), 444–461. Motion sickness in public road transport: passenger behaviour and susceptibility. (18 pages, 6 figures, 3 tables, 27 references) (in English)

Authors' Abstract. The aim of this research was to identify personal and environmental factors influencing individual susceptibility to motion sickness during road transport. A questionnaire survey of 3256 coach travellers was conducted. Information on passenger characteristics, travel regularity, activity during travel, use of anti-motion sickness drugs and self-reported motion sickness susceptibility were collected over 56 private hire coach journeys. Details of the travel environment (visibility, temperature and seating) were also recorded. The relationship of these variables with passenger illness and more specific symptoms of motion sickness are examined. Overall 28.4% of passengers reported feeling ill, 12.8% reported nausea and 1.7% reported vomiting during coach travel. Travel sickness decreased with increasing passenger age and greater travel experience. Females were more likely to report feeling ill during coach travel than males by a ratio of four to three. Poor forward visibility was found to increase sickness. Passenger illness occurrence was approximately three times higher for passenger with no view of the road ahead (mean, 34.6%) compared with passengers who could see the road ahead extremely well (mean, 12.7%). No relationships were found between the occurrence of travel sickness and temperature or time of travel. Differences in the pattern of sickness responses exhibited by coach travellers suggest: (1) habituation through greater travel regularity may occur independently of reductions in travel sickness that occur with age; (2) females are more affected by poor visibility than males; and (3) the incidence of travel sickness could be significantly reduced by improving the external visibility afforded to passengers:

Topics: Motion sickness (causes, symptoms, prevention).

P. Cawley, B. Pavlakovic, D. N. Allyne, R. George, T. Back and N. Meredith 1998, *Proceedings of the Institution of Mechanical Engineers*, **212** (Part H) (4), 265–272. The design of a vibration transducer to monitor the integrity of dental implants. (8 pages, 12 figures, 2 tables references) (in English)

Authors' Abstract. Bone-anchored titanium implants are being used increasing to provide support for prostheses replacing missing teeth in edentulous and partially dentate patients. A technique is required to monitor bone formation at the implant–tissue interface during healing, and also to check whether there has been

bone loss from around the top of the implant. One possible method is to screw a beam into the implanted fixture and to measure the first flexural resonance frequency of the resulting system. This resonance frequency is affected by both the exposed length of fixture and the stiffness of the interface between the implant and the bone. This paper describes the design of a beam-like transducer for clinical trials of the technique. The sensitivity of the transducer resonance frequency to the changes of interest is dependent on the thickness and length of the beam element. However, the choice of these dimensions is constrained by the need to avoid closely spaced resonances. The performance of different transducer shapes and the influence of the thickness and length of the beam element in the transducer has been studied. The results have been used to finalize a transducer design for the clinical trials.

Topics: Biodynamics, Diagnostic applications.

K. Palmer, G. Crane, and H. Inskip 1998 *Occupational and Environmental Medicine*, **55**(10), 716–721. Symptoms of hand-arm vibration syndrome in gas distribution operatives. (6 pages, 0 figures, 4 tables, 26 references) (in English)

Authors' Abstract. Objectives—To survey the prevalence and severity of hand-arm vibration syndrome symptoms (HAVS), and to estimate past and current exposure to hand-held vibrating tools in a sample of gas distribution operatives breaking and reinstating road surfaces. Methods—153 gas distribution operatives (participation rate 81%) from three company districts were assessed by an administered questionnaire, a clinical examination, and a simple cold challenge test to the hands. Exposure histories were taken aided by a picture album of past and current tools. Information was obtained from several sources on the likely vibratory characteristics of those tools. Estimates were thus obtained of the frequency of blanching and neurological complaints in operatives, and their lifetime hours of exposure and lifetime dose of vibration. Results—On average, the sample had spent 16 years in employment involving use of vibratory tools, 24% had symptoms or signs of blanching after use of tools in the industry; 46% had troublesome persistent complaints of paraesthesiae or numbness, and these symptoms extended into the hand or arms in 18% of workers. In 5.9% the distribution of symptoms was suggestive of carpal tunnel syndrome; and of ulnar nerve entrapment in a further 3.9%. The risks of blanching and neurological complaints rose significantly with lifetime hours of use of vibrating tools and lifetime dose of vibration. Symptoms were generally mild and apparent only after a prolonged interval, but there were exceptions, and cases had occurred after lower recent exposures. Conclusions—It has been suggested that aspects of the gas distribution operative's work mitigate the risk normally anticipated from use of pneumatic road breaking tools. By contrast our data suggest that symptoms of HAVS do occur, given sufficient exposure, a finding relevant not only to gas supply workers, but also to workers from other industries who break and repair road surfaces.

Topics: Vibration syndrome (vibration-induced white finger, nerve).

M. Bovenzi, B. Alessandrini, R. Mancini, M.G. Cannav, and L. Centi, 1998 *International Archives of Occupational and Environmental Health*, **71**, 493–498.

A prospective study of the cold response of digital vessels in forestry workers exposed to saw vibration. (6 pages, 0 figures, 6 tables, 20 references) (in English) *Authors' Abstract*. Objectives: To investigate the occurrence of vibration-induced white finger (VWF) and the cold response of digital vessels in a group of 68 forestry workers who underwent a first clinical examination in 1990 and were then re-examined in 1995. Methods: The forestry workers were divided into three groups: group A ($n = 27$), active workers who did not have VWF in 1990 and continued to use chain saws; B ($n = 29$), workers who did not have VWF in 1990 and retired before 1995; and group C ($n = 12$), active or retired workers who had VWF in 1990. The subjects underwent a medical interview, a complete physical examination, and a cold provocation test, which were performed by the same physicians at both surveys. The cold test consisted of measurement of the finger systolic blood pressure (FSBP) after local cooling to 10°C expressed as a percentage of the pressure recorded at 30°C (FSBP $_{0,10}^*$). Results: Three new cases of VWF occurred during the follow-up period among workers who had used only antivibration (AV) chain saws. The vasoconstrictor response to cold was unchanged in group A and improved in group B ($P < 0.001$). A significant decrease in VWF symptoms and abnormal response to cold was observed in group C ($P < 0.05$). As a result of preventive measures curtailing saw usage time in the VWF workers, the daily vibration exposure in group C was lower in 1995 than 1990 ($P = 0.02$). In the retired workers, FSBP $_{0,10}^*$ was positively related to the time since the cessation of work with chain saws ($P < 0.01$). Conclusions: The findings of this follow-up study indicate that a reduction in or cessation of exposure to vibration has a beneficial effect on finger-blanching symptoms and the cold response of digital vessels. The occurrence of new cases of VWF in subjects whose work experience was limited to AV chain saws argues for the maintenance of health surveillance in these workers.

Topics: Vibration syndrome (vibration-induced white finger, nerve).

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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.