Journal of Sound and Vibration (1998) **210**(5), 715–720

HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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This selection of abstracts is taken from the 1997 meeting of the United Kingdom Informal Group on Human Response to Vibration, held at the Institute of Sound and Vibration Research, University of Southampton, on 17–19 September.

R. Blüthner, H. Seidel, B. Hinz, and M. Schust. Timing of back muscles during whole-body vibration with transients—its significance for the internal spinal loads. (12 pages, 5 figures, 1 table, 16 references) (in English).
Authors' Abstract. To examine the responses of back muscles to whole-body vibration (WBV) consisting of a sinusoidal "background" (4 Hz r.m.s. acceleration 0·52 m s^{-2}) and ten interspersed periods with peak-to-peak amplitudes ("transients") that varied in three steps (3·5, 7·2, and 11·1 m s^{-2}), six surface electromyograms (EMGs) were obtained from different back muscles of eight subjects and three different sitting postures (relaxed = R, bent forward = B and straight erect = E). The rectified undistorted EMGs and the force at the interface vibrator/subject of all subjects were averaged. The myoelectric activity at R was minimal, B and E were accompanied by a high basic EMG activity and pronounced responses to the transients. The timing of the maximum EMG responses varied. A non-linear increase of the internal load was predicted with rising amplitudes of transients. The threshold for this prominent unfavourable biological effect might be located between 3·5 and 5 m s^{-2}.
Topics: Physiological effects (muscle and nerve); Injury and disease (chronic).

B. Griefahn, P. Bröde and W. Jaschinski. Fixation disparity and visual contrast thresholds during separate and simultaneous lateral and vertical whole-body vibrations (5 Hz, 1·2 m s^{-2}). (11 pages, 5 figures, 1 table, 18 references) (in English).
Authors' Abstract. This paper concerns the hypothesis that whole-body vibrations transmitted through the seat impair oculomotor alignment and degrade spatial retinal resolution. The decrement was assumed to increase gradually from single-axis lateral via single-axis vertical and dual-axis linear to dual-axis circular motions. Fourteen men and six women (19–26 yrs) with good binocular vision took part in two experimental sessions where either fixation disparity or contrast threshold for vertically and horizontally oriented test patterns were determined during five conditions. The latter comprised a control ($a_z = a_y = 0$) and four conditions where 5 Hz sinusoidal vibrations of 1·2 m s^{-2} r.m.s. were applied separately, either vertically or laterally or simultaneously in both directions, once without and once with a phase shift of 90° thus causing dual-axis linear or circular motions. The variability of vertical fixation disparity and the contrast thresholds for horizontal gratings increased whenever the subjects were exposed to vertical motions (alone or combined with lateral motions). The results indicate an increased difficulty to recognise properly characters and graphic patterns that contain horizontal lines. The greater difficulty for binocular alignment may eventually cause asthenopic complaints.

0022–460X/98/100715 + 06 $25.00/0/sv981402

Topics: Perceptual mechanisms (vision).

H.-P. Mischer. Investigation about the inner dynamic characteristics of polyurethane foam and outside conditions, which influence the vibration comfort of car seats. (12 pages, 13 figures, 0 tables, 3 references) (in English).
Authors' Abstract. The main objective of the investigation presented in this paper is to find out which inside characteristics of polyurethane foam and which outside conditions define the vibration comfort of car seat cushions. To find the inside characteristics, various measurements with variations of polyurethane foams have been carried out. It was not possible to define the vibration comfort by "static" foam properties such as density, hardness, foam system etc. Physical dynamic characteristics, gained by a dynamic compression test of the foam, rule the vibration comfort of polyurethane foam. A calculation of the vibration comfort, using these dynamic characteristics and a simple model for the occupant gave good correlation to measurements with test persons. To investigate the influence of outside conditions on the vibration comfort of polyurethane foam, repeated tests at changing temperatures and humidities for long duration with cushion samples have been done. Again, there was a correlation between the dynamic characteristics and the measured vibration comfort. A worsening of the vibration comfort in the first 30 min of a test could be seen for all foam parts, with a good recovery between test repetitions. Humidity seems to have more influence than temperature.
Topics: Seating.

X. Wu., S. Rakheja and P.-É. Boileau. Study of biodynamic functions of human response to whole-body vertical vibration. (14 pages, 3 figures, 7 tables, 11 references) (in English).
Authors' Abstract. The biodynamic response behaviour of the seated human body subject to vertical vibration has invariably been reported in terms of driving point mechanical impedance (DPMI) or apparent mass (APMS), and seat-to-head transmissibility (STHT). While the DPMI and APMS biodynamic response functions describe a relationship between the driving force and the resulting motion at the human–seat interface, the STHT function describes the vibration transmission characteristics through the human body. In this study, the relationships between the different biodynamic response functions are established through theoretical analysis of four reported biodynamic models. The results show that the APMS and DPMI yield inherently different primary resonant frequency, although related by definition. The APMS yields more consistent primary resonant frequencies, while DPMI data reveals considerably more variations in both the resonant frequency and resonant amplitude, when subject to variations in model parameters, representing the differences in human physical characteristics. The results derived from the analysis reveal that APMS is very similar to STHT for all the four models after being normalized with respect to the total mass of each model, and both functions yield very close primary resonant frequency. The above conclusions are further supported by some experimental data. On the basis of these results, the APMS is considered to be a more desirable function than DPMI to describe the biodynamic behaviour of a group of human subjects exposed to whole-body vertical vibration, due to its smaller variation in primary resonant frequency. Furthermore, the proposed relationship between APMS and STHT may lead to simplified biodynamic model development.
Topics: Biodynamics (general).

M. Bovenzi. Finger systolic blood pressures during cold provocation in vibration exposed workers employed in selected industrial activities. (12 pages, 0 figures, 5 tables, 12 references) (in English).

Authors' Abstract. The change in finger systolic blood pressure (FSBP) at 15°C and 10°C as a percentage of the pressure at 30°C (FSBP%) was measured in a control group of 455 healthy men not exposed to hand-transmitted vibration and in 822 workers who used various types of vibrating tools in selected industrial activities (grinders = 100, shipyard workers = 132, caulkers = 65, mechanics = 140, construction workers = 148, stone workers = 41, foundry workers = 31, forest workers = 165). FSBPs during local cooling were measured according to the technique suggested by Nielsen and Lassen. The prevalence of Raynaud's phenomenon was 1·1% in the controls, while that of VWF varied from 9% in the grinders to 51·6% in the foundry workers. After adjustment for age, smoking and drinking habits, FSBP% at 15°C and 10°C were significantly lower in the various vibration exposed worker groups than in the controls ($p < 0{\cdot}01$). On a group basis, the mean change in FSBP at 10°C was inversely related to the prevalence of VWF ($p < 0{\cdot}01$) and the estimated daily vibration exposure ($p < 0{\cdot}005$). In the control men, the lower limits for $FSBP\%_{10^{\circ}}$ ranged between 70% (mean − 2S.D.) and 60% (mean − 3S.D.). Using these values of $FSBP\%_{10^{\circ}}$ as discriminating thresholds between normal and pathological responses of the finger arteries to cooling, the sensitivity of the cold test to detect digital vasospasm in the vibration-exposed workers varied from 86% to 100%, the specificity from 90% to 94%, and the positive predictive value from 68% to 74%. These results confirm that the measurement of FSBP during cold provocation is a useful laboratory test to reveal VWF objectively. The findings of this study seem to suggest a quantitative relationship between cold induced digital arterial hyperresponsiveness and occupational exposure to hand-transmitted vibration.
Topics: Vibration syndrome (vibration-induced white finger; diagnosis).

H. Sakakibara, L. Jin, S.-K. Zhu, M. Hirata and M. Abe. Cardiac autonomic nervous response to cold in VWF patients. (10 pages, 5 figures, 2 tables, 10 references) (in English).
Authors' Abstract. We measured cardiac autonomic nervous response to cold in 22 patients with vibration-induced white finger (VWF) and 19 healthy controls with the mean age of 59·3 and 59·1 years, respectively. The autonomic nervous function was assessed by the power spectral analysis of hear rate variability that provides the low-frequency component (LF; 0·02–0·5 Hz) and the high-frequency component (HF: 0·15–0·40 Hz). The normalized HF component power (HF%) is considered to reflect parasympathetic activity, and the LF% reflecting both the sympathetic and parasympathetic activity. The LF/HF ratio is thought to show a measure of sympatho-vagal balance, an index of sympathetic activity. Subjects lay supine, and their ECG and finger skin temperature were measured in immersion of right hand in 10°C cold water for 10 min. Before the cold exposure, the LF%, HF%, LF/HF ratio and finger skin temperature were not significantly different between VWF patients and the controls. However, during the exposure, the local cold exposure significantly increased the LF/HF ratio and decreased finger skin temperature of both hands in VWF patients compared with the controls. After the exposure, the rewarming of skin temperature was delayed in VWF patients, although the LF/HF ratio was not different between the two groups. The present results indicate that VWF patients show an enhanced sympathetic response to cold, and thereby a greater decrease in finger skin temperature during cold exposure.
Topics: Vibration syndrome; physiological responses (cardiovascular; central nervous system).

M. Gautherie, M. Zupan, and J. P. Walter. Pathophysiological and clinical differences between vibration-induced and other secondary Raynaud syndromes. (12 pages, 2 figures, 3 tables, 10 references) (in English).

Authors' Abstract. A clinical examination and a temperature-measuring cold stress test were performed on 2156 patients complaining of Raynaud's phenomenon, of which 699 were workers occupationally exposed to vibration and 1462 were subjects who had never been exposed to vibration. The clinical staging was assessed according to the Stockholm Workshop scale. The thermobiological staging utilized special data processing software to assign each finger a score and a stage that represented a degree of severity or the dysthermia found in response to cold stress. The aim of the study was to investigate whether differences exist between the two groups of patients with regard to the topography of the finger blanching attacks. The distribution of the hands by clinical state did not show significant differences between vibration-exposed and non-exposed patients. By contrast, the distribution by thermobiological score and stage indicated that the topography of dysthermia differed between the right and left hand and also from one finger to another in 93% and 92% of the vibration-exposed patients, but only in 6% and 9% in the non-exposed patients, respectively. All of the patients not exposed to vibration who had an asymmetrical and heterogeneous topography of dysthermia and a history of chronic smoking or/and chronic disease, mainly diabetes and systemic disease. These findings suggest that a standardized finger temperature-measuring cold stress test as performed in this study may help the occupational physician to assess the relative importance of vibration exposure as an aetiological component of the finger balancing attacks.
Topics: Vibration syndrome (vibration-induced white finger; diagnosis).

S. Kitazaki. The apparent mass of the foot and prediction of floor carpet transfer function. (13 pages, 11 figures, 1 table, 5 references) (in English).
Authors' Abstract. The driving point apparent masses of the feet of seated subjects in response to vertical vibration have been measured. Firstly, the apparent masses of a single subject were measured in various conditions so as to identify factors affecting the response. Subsequently, the apparent masses of ten subjects were measured for prediction of the carpet transfer function. The subjects, wearing various types of shoes, sat on a car seat mounted on a vibrator platform and also placed their feet on the platform with two different knee angles at 90° and 110°. They were exposed to vertical random vibration with a frequency range between 0·5 and 100 Hz and a magnitude of 1·0 m/s^2 r.m.s. Vertical force and acceleration were measured at the interface between the right foot of the subjects and the vibrator platform, and the apparent masses were calculated. The mean apparent mass of the foot of the ten subjects with the knee angle at 90° showed four resonance-like peaks at 5, 7·5, 12 and 30 Hz. In the apparent mass measured with the knee angle at 110°, the 12 Hz resonance disappeared and 30 Hz resonance shifted to 35 Hz. The larger knee angle also increased the modulus of the apparent mass between 5 Hz and 10 Hz and decreased below 5 Hz and above 10 Hz, and the effect was most significant between 10 and 35 Hz. It has been hypothesized that the response may be contributed from motion of the leg bones with rotational motion of the leg joints, vertical motion of the body mass and the foot–shoe mass. The transmissibility of a floor carpet was predicted, combining the measured transmissibility loaded by a rigid mass and the estimated apparent mass. The prediction was compared with the mean transmissibility of the same carped measured with 12 subjects and showed good agreement below 100 Hz.
Topics: Biodynamics (impedance); Anti-vibration devices (carpets).

T. Derwinski. Ride quality in elevators. (13 pages, 6 figures, 0 tables, 16 references) (in English).
Authors' Abstract. Elevator Ride Quality is a metric used in the elevator industry to assess the response of a passenger to the vibration and noise environment in the elevator during

transfer between floors. Many different measurement techniques have been employed industry wide, using both frequency and time domain techniques, with and without frequency weighting. A brief summary of the history of the development of measurement techniques will be given, followed by details regarding the application of this type of measurement, and ending with a summary of some current world-wide activities within the elevator industry regarding standardization.
Topics: Ride measurement (elevators).

Other papers presented at the meeting were as follows.
C. M. Nelson. Hand-transmitted vibration assessment—a comparison of results using single axis and triaxial methods.
T. Ward. Vibration emission testing of road breakers and pick hammers.
S. J. Clampton. Vibration exposure of pneumatic tools in the shipbuilding industry.
J. R. Venor. Effect of accelerometer mounting mass on the impulse mechanical impedance and vibration of steering wheels.
D. G. Wilder, A. R. Aleksiev, M. L. Magnusson, M. H. Pope, K. F. Spratt and V. K. Goel. Muscular responses to sudden load: a tool to evaluate fatigue.
R. Blüthner, H. Seidel and B. Hinz. Can reflex-mechanisms explain the timing of back muscles during sinusoidal whole-body vibration and transients?
D.-S. Gong. The effects of the magnitude and the bandwidth of horizontal floor vibration on postural responses in standing posture.
B. Harazin. Study of effects of whole-body vibration on visual acuity.
J. Giacomin. In-vehicle measurement of the apparent mass of small children.
K. Ebe. Effect of thickness on static and dynamic characteristics of polyurethane foams.
G. L. Crocco and M. R. Kinkelaar. The relationship between the vibrational characteristics of polyurethane foam and ride comfort: a study using the SEAT method.
L. Wei and M. J. Griffin. The influence of contact area, vibration magnitude and static force on the dynamic stiffness of polyurethane seat foam.
P. Donati. Transfer of knowledge from the lab to the fields: suspension seat diagnosis.
M. R. Peckham. Influence of chin strap, cheek pads and ear defenders on the transmission of vibration from head to helmet in combat helmets whilst running.
B. Hinz, R. Blüthner and H. Seidel. On the human response to whole-body vibration transmitted by operator seats—biodynamics and subjective assessment.
T. Ji. The use of structural dynamics methods in the study of biodynamic properties of the human whole-body.
N. J. Mansfield. A consideration of alternative non-linear lumped parameter models of the apparent mass of a seated person.
K. K. Shina and A. Shanker. Vibration modelling and analysis of human body through anthropomorphic modelling.
K. L. Mills. Influence of backrest and vision during exposure to nauseogenic fore-and-aft oscillation.
N. A. Webb. Comparison of vection and motion sickness in a real and virtual reality optokinetic drum.
S. R. Holmes. Electrogastric activity during a control condition and as a measure of motion sickness on exposure to yaw oscillation.
N. Harada, M. Iwamoto, M. S. Lasker, I. Hirosawa and M. Nakamoto. Factors influencing finger skin temperature during cold exposure test for diagnosing hand–arm vibration syndrome—effects of room temperature, seasonal condition and food intake.
M. Demic, J. Lukic and Z. Milic. Effects of random vibrations on human fatigue.

W. Pielemeier, V. Jeyabalan, R. C. Meier and N. C. Otto. Just noticeable differences in vertical vibration for subjects on an automobile seat.

A. D. Brunning and A. J. Day. Customer perception of in vehicle comfort.

H. Seidel, M. Schust, H. Seidel, R. Blüthner and H. J. Rothe. Subjective evaluation of the effects of noise with a different tonality combined with random low-frequency whole-body vibration.

M. Hirata, H. Sakakibara, S. Yamada, T. Hashiguchi, N. Toibana, H. Koshiyama and H. Hirano. Medial plantar nerve conduction velocities among patients with vibration syndrome.

K. Nishiyama and K. Toada. Dependency of the temporary threshold shift of vibratory sensation on exposure period of the hand–arm vibration.

A. Piette and J. Malchaire. Temporary variation of the vibration perception threshold after an exposure to vibration.

M. Morioka and S. Maeda. Measurement of tapping vibration of a long cane for visually handicapped person.

C. J. Lindsell. Vibrotactile thresholds: effects of contact forces and skin indentation.

S. Hewitt. An inter laboratory evaluation of the reproducibility of the ISO 10819 test for anti-vibration gloves.

G. S. Paddan. Effect of pull force on the transmission of vibration through the finger to the fingernail.

R. Lundström, P. Holmlund and B. Jacobsson. Hand–arm vibration data base on Internet.

P. Brereton. A CD-ROM to help managers control the risk of injury from exposure to hand-arm vibration at work.

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.

Copies of the proceedings of the 1997 U.K. Group on Human Response to Vibration may be obtained from: Mrs H. Smith, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, SO17 1BJ, England (facsimile (+ 44)1703 592927). The cost is £35 (plus £5 postage and packing).

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.