Journal of Sound and Vibration (2001) **238**(5), 909–912
doi:10.1006/jsvi.2000.3326, available online at http://www.idealibrary.com on IDEAL®

HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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P. Holmlund, R. Lundström and L. Lindberg 2000 *Applied Ergonomics* **31**, 415–422. Mechanical impedance of the human body in vertical direction. (8 pages, 5 figures, 2 tables, 14 references) (in English).
Authors' Abstracts. The mechanical impedance of the human body in sitting posture and vertical direction was measured during different experimental conditions, such as vibration level (0·5–1·4 m/s^2), frequency (2–100 Hz), body weight (57–92 kg), relaxed and erect upper body posture. The outcome shows that impedance increases with frequency up to a peak at about 5 Hz after which it decreases in a complex manner which includes two additional peaks. The frequency at which the first and second impedance peaks occurs decreases with higher vibration level. Erect, compared with relaxed body posture resulted in higher impedance magnitudes and with peaks located at somewhat higher frequencies. Heavy persons show higher impedance magnitudes and peaks at lower frequencies.
Topics: Biodynamics (mechanical impedance).

L. Burström and S. H. Bylund 2000 *Scandinavian Journal of Work, Environment and Health* **26**, 32–36. Relationship between vibration dose and the absorption of mechanical power in the hand. (5 pages, 1 figure, 2 tables, 18 references) (in English).
Authors' Abstract. Objectives—The aim of this study was to examine the relationship between calculated vibration dose and the measured absorption of vibration power in the human hand, as well as the measured grip and feed forces applied by the subjects. Methods—The study was carried out with 10 healthy subjects. A special handle was used during the measurements. The influence of four different vibration levels with different durations during a test period of 5 min was investigated. The number of exposure intervals varied between 1 and 5. The same overall equivalent acceleration was used in all the experiments. Results—There is a significant difference between the calculated vibration dose and the amount of measured absorption of power. A higher acceleration level leads to significantly higher absorption. Furthermore, the outcome shows that rest periods contribute to a lower absorption of power in the hand and also lower feed forces. Conclusions—This study supports the hypothesis that vibration-free rest periods give the human organism an opportunity to recover.
Topics: Biodynamics (mechanical impedance); hand-transmitted vibration.

M. Bovenzi, C. J. Lindsell and M. J. Griffin 2000 *Occupational and Environmental Medicine* **57**, 422–430. Acute vascular responses to the frequency of vibration transmitted to the hand. (9 pages, 2 figures, 3 tables, 24 references) (in English).
Authors' Abstract. Objectives—To investigate the acute effects of the frequency of hand-transmitted vibration on finger circulation. A further aim was to investigate whether

0022-460X/00/500909 + 04 $35.00/0

the frequency weighting assumed in current standards for hand-transmitted vibration reflects the haemodynamic changes which occur in the fingers exposed to vibration with different frequencies but with the same frequency-weighted acceleration magnitude. Methods—Finger skin temperature (FST) and finger blood flow (FBF) were measured in the middle fingers of both hands of 10 healthy men. With a static load of 10 N, the right hand was exposed for 15 min to the following root-mean-square (rms) acceleration magnitudes and frequencies of vertical vibrations: 5·5 m/s^2 at 16 Hz; 11 ms^2 at 31·5 Hz; 22 m/s^2 at 63 Hz; 44 $ms/^2$ at 125 Hz; and 88 m/s^2 at 250 Hz. These exposures to vibration produce the same frequency-weighted acceleration magnitude (5·5 m/s^2 rms) according to the frequency weighting included in the international standard ISO 5349. A control condition consisted of exposure to the static load only. Finger circulation was measured before application of the vibration and static load and at fixed intervals during exposure to vibration and a 45 min recovery period. Results—No significant changes in finger circulation were found with only the static load. The FST did not change significantly during or after acute exposure to vibration. In the vibrated right finger, exposures to vibration with frequencies of 31·5–250 Hz provoked a greater reduction in FBF than did vibration of 16 Hz or the static load only. In the non-vibrated left finger, the FBF measured with vibration at each frequency of 63–250 Hz was significantly lower than that measured with static load only. The reduction in FBF during exposure to vibration with any frequency was stronger in the vibrated finger than in the non-vibrated finger. In both fingers, there was a progressive decrease in FBF after the end of exposure to vibration with frequencies of 31·5–250 Hz. The higher the frequency of vibration, the stronger the decrease in FBF in both fingers during recovery. Conclusions—Acute exposures to vibration with equal frequency-weighted magnitude reduce the FBF in both vibrated and non-vibrated fingers for frequencies between 31·5 and 250 Hz. The extent of digital vasoconstriction after exposure to vibration increases with increasing frequency. The frequency weighting given in current standards tends to overestimate the vasoconstriction associated with acute exposure to vibration frequencies around 16 Hz.
Topics: Physiological effects (cardiovascular); hand-transmitted vibration.

J. Luo, H. Sakakibara, S.-K. Zhu, T. Kondo and H. Toyoshima 2000 *International Archives of Occupational and Environmental Health* **73**, 281–284. Effect of vibration magnitude and repetitive exposure on finger blood flow in healthy subjects. (4 pages, 0 figures, 3 tables, 25 references) (in English).
Authors' Abstract. In order to study the effect of the magnitude of vibrations and repetitive exposure on finger blood flow, we exposed 10 healthy subjects to three experimental conditions: (1) vibration of 3·16 m/s^2 at 60 Hz, (2) vibration of 31·6 m/s^2 at 60 Hz, and (3) no vibration, as a control. Under the experimental conditions, the right hand was exposed to 5 min vibration three times, with intervening 5 min rests. Meanwhile, the blood flows of both middle fingers were continuously measured with a blood flow meter based on the thermal diffusion method. Finger blood flow was significantly decreased in both hands with exposure to vibrations of 3·16 and 31·6 m/s^2. Increased magnitude of vibration tended to enhance the decrease in finger blood flow in both hands, and repeated exposure to vibration had cumulative effects on the decrease in finger blood flow in the unexposed left hand.
Topics: Physiological effects (cardiovascular); hand-transmitted vibration.

T. Armstrong, C. Bir, J. Foulke, B. Martin, L. Finsen and G. Sjøgaard 1999 *Ergonomics* **42**, 146–159. Muscle responses to simulated torque reactions of hand-help power tools. (14 pages, 6 figures, 1 table, 34 references) (in English).

Authors' Abstract. The aim of this work was to investigate physiological responses to torque reaction forces produced by hand-held power tools used to tighten threaded fasteners. Such tools are used repetitively by workers in many industries and often associated with upper limb musculoskeletal complaints. The tools considered for stimulation in this study had straight handles and required from 100 to 400 ms to tighten fasteners to a peak torque of 1·0–2·5 N m and from 50 to 150 ms for the torque to decay to zero. A tool stimulator was constructed to apply a programmed torque profile to a handle similar to that of a straight in-line power screwdriver. Wrist flexor and extensor surface EMGs and handle position were recorded as subjects held handles subjected to controlled torque loads that tended to flex the wrist. It was found that: (1) very high EMG values occurred even though torques were of short duration (50–600 ms) and the peak torques were low (7–28% of maximum strength); (2) high EMGs in anticipation of torque are directly related to torque build-up rate and peak torque; (3) high-peak flexor and extensor EMGs during and following torque onset are related to torque build-up rate and peak torque; (4) minimum time of peak EMGs of 72–87 ms following the onset of torques with 50 ms build-up suggests the contribution of an extensor muscle stretch reflex component; delayed peak for longer build-ups suggests a central control of muscle force in response to torque; (5) angular excursions of handles increase with decreasing torque build-up time and increasing torque magnitude causes increasing eccentric work; (6) the results show that the slow torque build-up times (450 ms) correspond to minimum peak EMGs; and (7) accumulated EMGs increase with increasing torque and torque build-up times. Further studies are needed to evaluate fatigue and muscluoskeletal injuries associated with prolonged periods of tool use.
Topics: hand-transmitted vibration; physiological effects (muscle and nerve).

H.-S. Park and B. Martin 1999 *International Journal of Industrial Ergonomics* **23**, 629–632. Short communication: Effects of hand vibration on reflex behaviors and pain perception—a pilot study. (4 pages, 0 figures, 7 tables, 7 references) (in English).
Authors' Abstract. This research investigated the effects of hand vibration on the protective reflex responses and perception of the stimulus intensity. Electrical pulses were applied to the wrist to elicit the flexor muscles. Changes of the reflex response were measured using the surface electromyographic activities from the hand flexor muscles, and were analyzed as a function of vibration frequency and initial level of grip force. Psychophysical experiment was also performed to assess the effects of hand vibration on perception of the electrical stimulus. The reflex responses were stronger during vibration, and were more visible at lower vibration frequencies and higher muscle contraction level. During vibration, a poor correlation was found between the reflex responses and stimulus perception.
Topics: hand-transmitted vibration; physiological effects (muscle and nerve).

B. P. Kattel and J. E. O. Fernandez 1999 *International Journal of Industrial Ergonomics* **23**, 595–608. The effects of rivet guns on hand-arm vibration. (14 pages, 3 figures, 9 tables, 24 references) (in English).

Authors' Abstract. The objective of this study was to investigate the effects of rivet guns of hand–arm vibration. Vibration data were collected from five male and female subjects using 12 rivet guns (from four different manufactures depicted here as types 1–4 with large, medium, and small sizes in each type) at three different postures (neutral, $\frac{1}{3}$ maximum flexion, and $\frac{1}{3}$ maximum ulnar deviation) and two different levels of applied force (8 and 12 lb). The results of analysis indicated that the level of vibration entering the hand was significantly higher for type 4 and large size than for other types and sizes. Comparing with ISO standard, type 4 rivet guns could be used for less than 30 min in a day. Results of

detailed analysis and the ergonomic ramifications as well as practical applications of this finding are discussed in the body of the paper.
Topics: hand-transmitted vibration; vibration measurements (hand tools).

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 Prof. M. J. Griffin, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, SO*17 1*BJ, England.*