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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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S. M. Mirbod, R. Inaba and H. Iwata 1997 *Industrial Health* **35**, 212–221. Low back pain among different groups of subjects exposed to hand–arm transmitted vibration. (10 pages, 2 figures, 3 tables, 68 references) (in English).

Authors' Abstract. Objectives: the purpose of this study was to investigate the prevalence of low back pain (LBP) among various groups of subjects exposed to hand–arm transmitted vibration, and to compare the prevalence of LBP of these subjects with that of non-exposed groups. Methods: The subjects of this study were 13 groups of males and 3 groups of females of working population living in a certain city located in the central part of Japan. By means of a questionnaire, interviews, field visits, or annual health examination, information on age, working career, working posture, various types of tools used, and experience of having LBP during the 12 months preceding the completion of the questionnaire were collected. The subjects' ages ranged between 22 and 69 years. All subjects were classified into five categories, and the prevalence of LBP was obtained for them. Results: On the whole, complaints of LBP among male and female green tea and strawberry farmers were most frequent. There was a large variation (16·0–72·2%) in the prevalence of LBP among subjects operating vibrating tools. Among three groups of health care professionals, the prevalence of LBP was in the range of 36·5–53·0%. The senior doctors had less complaints of LBP. The prevalence of LBP among subjects who had sedentary jobs was in the range of 41·7–45·9%, and almost as high as that in blue-collar workers using vibrating tools. The prevalence of LBP among females exposed to hand-arm transmitted vibration was between 26·1 and 63%. The prevalence rates of LBP among vibration exposed subjects were plotted against the vibration magnitude of tools used by the same subjects reported in our previous study; however, no significant correlation could be obtained between the prevalence of LBP and vibration values. Conclusions: Exposure to segmental vibrations is less likely to be a risk factor in increasing prevalence of LBP. A higher prevalence of LBP in some groups provide strong evidence for a dominant work-related aetiology in developing LBP. Regarding data presented in this study and by a review of scientific literature, suggestions for improving working posture were presented. It seemed that to decrease the risk of LBP among these subjects, special attention should be paid to stimulating the adoption of an ergonomic working posture and to ergonomic training.

Topics: injury and disease (general); combined stress (vibration, posture); body posture.

S. Kihlberg and M. Hagberg 1997 *International Archives of Occupational and Environmental Health* **69**, 282–288. Hand–arm symptoms related to impact and non-impact hand-held power tools. (7 pages, 6 figures, 4 tables, 34 references) (in English).

Authors' Abstract. Hand and arm symptoms among workers using impact and non-impact hand-held power tools were investigated in a cross-sectional study and a five-year

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follow-up study. The study population consisted of concrete workers ($n = 103$), truck assemblers ($n = 234$), electricians ($n = 101$), platers ($n = 140$) and lumberjacks ($n = 102$). Of the original 680 subjects, we followed up 312 after five years. A questionnaire concerning ongoing hand and arm symptoms, daily exposure to hand-held power tools, type of tool used, and individual factors was administered. More workers using low frequency impact tools than workers using non-impact tools reported symptoms in the elbows and shoulders. Elbow symptoms were accentuated in the cross-sectional study, while shoulder symptoms were accentuated in the follow-up study. Wrist symptoms were reported by more of those working with high frequency impact tools than of those using only non-impact tools when the analyses were controlled for age, years in the occupation and smoking habits. A possible explanation of the results found in this study is that low frequency impact vibration is transmitted to the upper arm, and thus the elbow and shoulder are at risk, while high frequency impact vibration is attenuated in the hand and wrist and may predominately cause symptoms there.

Topics: vibration syndrome (vibration-induced white finger, neurological, bone and joint); complex vibration (repeated shocks).

C. H. Lewis and M. J. Griffin 1997 *Applied Ergonomics* **28**, 193–201. Evaluating the motions of a semi-submersible platform with respect to human response. (9 pages, 7 figures, 4 tables, 14 references) (in English).

Authors' Abstract. The motions of a semi-submersible drilling platform have been evaluated so as to predict the effects on the comfort and activities of the crew. The horizontal motions at the drill floor exceeded the "average threshold of perception" defined in International Standard 6897 (ISO 6897, 1984) by more than a factor of two; they were about half of the limit for the worst 10 min in five years for "fixed offshore structures where work of a somewhat critical nature is carried out". Other standards predict that the vertical motion would cause vomiting due to motion stickness in less than 5% of unadapted adults within the first 8 h of exposure. The calculated probability of "motion-induced interruptions" (loss-of-balance events) caused by deck motion was negligible. Notwithstanding the above conclusions, it is considered that current standards are insufficient to predict the effects of the motions of ships and floating platforms on the activities of the crew.

Topics: performance effects (psychomotor, postural control); vibration measurements (off-shore structures); criteria and limits.

B. J. Martin and H.-S. Park 1997 *European Journal of Applied Physiology* **75**, 504–511. Analysis of the tonic vibration reflex: influence of vibration variables on motor unit synchronisation and fatigue. (8 pages, 5 figures, 1 table, 31 references) (in English).

Authors' Abstract. The influence of vibration frequency (40, 80, 100, 120, 150, or 200 Hz) at selected displacement amplitudes (0·2, 0·3 mm) on tonic vibration reflex (TVR) characteristics was investigated. The degree of synchronisation of motor unit activity with vibratory stimuli in ten humans was determined using the electromyographic (EMG) activity of the finger and wrist flexor muscles when vibration was applied to the distal tendons of the hand flexor muscles. The EMG spectral analysis indicates that harmonic and subharmonic motor unit synchronisation mechanisms contribute to the modulation of the amplitude of the TVR as the vibration frequency increases. Harmonic

synchronisation deceases while subharmonic synchronisation increases as vibration frequency increases. It is suggested that the synchronisation process influences muscle fatigue, since it forces the driving of motor units, leading to a decrease in contraction efficiency. This phenomenon most probably results from an impairment of excitation–contraction coupling. High frequency vibration (>150 Hz) tends to induce less motor unit synchronisation in a frequency range beyond the known mechanical resonance of biological tissues. The findings of this study may be applied to the design of hand-held power tools, since their vibration triggers the TVR inactive muscles.

Topics: physiological effects (muscle and nerve); limb vibration.

J.-L. Thonnard, D. Masset, M. Penta, A. Piette and J. Malchaire 1997 *Scandinavian Journal of Work, Environment and Health* **23**, 193–198. Short-term effect of hand–arm vibration exposure on tactile sensitivity and manual skill. (6 pages, 2 figures, 1 table, 20 references) (in English).

Authors' Abstract. Objectives. The present study investigated whether the impairment of tactile sensitivity after exposure to vibration disturbs the motor control of precision handling and, if so, whether it can result in an increased risk of injury during or after tasks involving the use of vibrating tools. Methods. Twelve men were manually exposed to vibration from an electric sander for 30 min. Cutaneous sensitivity was quantified by measuring the pressure perception threshold and vibration perception threshold (125 Hz) on the pulp of the second finger. Manipulative skill was evaluated by grip–lift movements and the Purdue pegboard test. Results. The vibration perception threshold increased very significantly from 94·0 dB (0·06 ms^2) before the vibration exposure to 127·5 dB (3·2 ms^{-2}) immediately after the exposure. The pressure perception threshold tended to increase after vibration exposure, although not significantly, but manipulative skill was not altered. Conclusions. Change in vibration perception threshold was not associated with a significant increase in the pressure perception threshold or a perturbation of manual skill. Therefore, in conditions similar to those of our experiment, the safety of a precision task does not appear to be reduced after such vibration exposure.

Topics: limb vibration; performance effects (psychomotor; perceptual mechanisms (thresholds)).

S. M. Mirbod, H. Yoshida, M. Jamali, K. Masamura, R. Inaba and H. Iwata 1997 *International Archives of Occupational and Environmental Health* **70**, 22–28. Assessment of hand–arm vibration exposure among traffic police motorcyclists. (7 pages, 2 figures, 6 tables, 33 references) (in English).

Authors' Abstract. The aims of this study were (1) to evaluate subjective symptoms in the hand–arm system of all traffic police motorcyclists of a city located in the central part of Japan and (2) to assess their hand–arm vibration exposure associated with traffic police motorcycle riding. The study population consisted of 119 motorcycling traffic policemen and 49 male controls. By means of a questionnaire, information on the occupational history and the presence of subjective symptoms in the hand–arm system of all subjects was obtained. Vibration was measured on the handlebars of the representative motorcycles and on the hands of the riders. The 4- and 8-h energy-equivalent frequency weighted acceleration as well as the lifetime vibration dose were calculated for all police motorcyclists. The prevalence of finger blanching in the traffic police motorcyclists was

4·2%, but none of the controls had this symptom. The rates of finger numbness (19·3%), finger stiffness (16·0%), shoulder pain (13·4%), and shoulder stiffness (45·4%) were significantly higher among police motorcyclists as compared with controls. The root-mean-square (RMS) frequency weighted acceleration on the handlebars of police motorcyclists was in the range of 2·2–4·9 m/s^2 RMS. The computed 4- and 8-h energy-equivalent frequency weighted acceleration values were 2·8–4·5 and 2·0–3·2 m/s^2 RMS, respectively. A pattern of increasing percentage prevalence with increasing cumulative vibration dose was noticed. The subjects with a lifetime vibration dose of more than 20·1 $m^2 h^3 s^{-4}$ showed significantly higher prevalence rates for symptoms in the fingers and shoulders as compared with the control group. As occupational vibration exposure of traffic police motorcyclists might be considered a risk factor for the development of symptoms in the hand–arm system of the riders, its evaluation and control is needed for prevention methodology evolution.

Topics: vibration syndrome; vibration measurements (motorcycles).

L. Burström 1997 *International Archives of Occupational and Environmental Health* **69**, 437–446. The influence of biodynamic factors on the mechanical impedance of the hand and arm. (11 pages, 7 figures, 0 tables, 42 references) (in English).

Authors' Abstract. The purpose of this study was to investigate the mechanical impedance of the human hand–arm system during exposure to random vibration under various experimental conditions and to evaluate statistically whether these experimental conditions have any influence on magnitude and phase of the mechanical impedance. A further aim was to compare the obtained results with other investigations where sinusoidal excitation has been used. The mechanical impedance was estimated in ten healthy subjects during exposure to random vibration, with a constant velocity spectrum within the frequency range 4–2000 Hz, by use of a specially designed laboratory handle. In this study, the influence of various conditions, such as vibration direction (X_h, Y_h, Z_h), grip force (25–75 N), feed force (20–60 N), frequency weighted acceleration level (3, 6, 9, 12 m/s^2) and hand and arm posture (five flexions, two abductions) were studied. The outcome showed that the vibration direction and the frequency of the vibration stimuli have a strong significant influence on the impedance of the hand. An increased vibration level resulted in a significantly lower impedance for frequencies over 100 Hz. Increased grip and feed forces led on the other hand to an increased impedance for all frequencies. With regard to hand and arm posture, the results show that the flexion and abduction had a significant contribution for frequencies below 30 Hz. Furthermore, the influence of some of the studied variables had a non-linear effect on the impedance but also differed between different exposure directions. It was concluded, moreover, that the vibration response characteristics of the hand and arm differ, depending upon whether the signal is a discrete frequency signal or a signal consisting of several frequencies.

Topics: limb vibration; biodynamics (mechanical impedance); body posture.

R. C. Littleford, F. Khan, M. O. Hindley, M. Ho and J. J. F. Belch 1997 *Quarterly Journal of Medicine* **90**, 525–529. Microvascular abnormalities in patients with vibration white finger. (5 pages, 0 figures, 5 tables, 22 references) (in English).

Authors' Abstract. *In vivo* nailfold capillary microscopy was performed on 10 men with vibration white finger (VWF) and 10 age-matched male controls. The observed nailfold

capillaries required adaptation of Maricq's classifications and addition of new morphological scoring systems. These new classifications produced numerical scores for assessing capillary: dropout, tortuosity, elongation, visualisation of subpapillary venular plexus, and the degree of disarrangement of nailfold capillary polarity. Application of these new scores showed, for the first time, a complex pattern of abnormal nailfold capillaries in patients with VWF. Capillary dropout was evident in 7/10 patients, with an associated disarrangement in nailfold capillary morphology. Tortuosity of the capillary loops and elongation of their length was observed in 30% of patients. These significant morphological alterations seen in VWF suggest a local small-vessel vasculitis.

Topics: vibration syndrome (vibration-induced white finger).

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.

Readers may like to know that the 1998 UK Group Meeting on Human Response to Vibration will be held at the Palace Hotel, Buxton, Derbyshire from 16–18 September. Information on the conference may be obtained from Ms V. A. McClelland, Health and Safety Executive, DST E4, Room 405, Magdalen House, Trinity Road, Stanley Precinct, Bootle, Merseyside, L20 3QZ, UK. (fax (+44) 151 951 3602).