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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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A. Kumar, M. Varghese, D. Mohan, P. Mahajan, P. Gulati and S. Kale (1999) *Spine*, **24**, 2506–2515. Effect of whole-body vibration on the low back. A study of tractor-driving farmers of north India. (10 pages, 4 figures, 8 tables, 40 references) (in English)
Authors' Abstract. Study Design. A retrospective cohort study of tractor-driving farmers (study group) and non-tractor-driving farmers (control group) matched for age, gender, generic/ethnic group, land-holding, and work routines. Objectives. To determine, using magnetic resonance imaging and clinical investigations, the effect of whole-body vibrations on the back in tractor-driving farmers. Summary of Background Data. Low back pain and pathologic changes in the lower backs of tractor drivers have been reported. However, no study with a control group matched for work-related risk factors has been reported. Methods. Fifty tractor-driving farmers were compared with 50 non-tractor-driving farmers matched for age, gender, ethnic group, land-holding, and work routine. Both groups were interviewed for details of work routine, assets held, family profile, and vibration exposure to assess the influence of these parameters on signs and symptoms of backache. Magnetic resonance image was done to assess the effect of exposure on whole-body vibration and degenerative changes in the back. Vibration measurements were also done on tractors to observe the actual severity of the vibrations. Results. Regular work-related backache was more common among tractor-driving farmers (40%) than among non-tractor-driving farmers (18%, $P = 0{\cdot}015$). Anthropometric evaluation showed abdominal girth and weight to be significantly higher in tractor-driving farmers ($P = 0{\cdot}006$ and $0{\cdot}046$, respectively), whereas height and arm span were similar between the two groups. Clinical examination for evidence of disc or facet degeneration showed no difference between the two groups. Evaluation of magnetic resonance images of tractor-driving farmers and non-tractor-driving farmers by an orthopaedic surgeon, radiologist, and neurosurgeon showed degenerative changes to be similar between the two groups ($P > 0{\cdot}050$). Conclusions. Tractor-driving farmers reported backache more often than non-tractor-driving farmers, but no significant objective differences on clinical or magnetic resonance imaging evaluation were found between the two groups.
Topics: Injury and disease; physiological effects (muscle and nerve, skeletal).

K. T. Palmer, M. J. Griffin, H. Bednall, B. Pannett and D. Coggon (2000) *Occupational and Environmental Medicine* **57**, 218–228. Prevalence and pattern of occupational exposure to hand transmitted vibration in Great Britain: findings from a national survey (11 pages, 4 figures, 4 tables, 31 references) (in English)
Author's Abstract. Objectives. To estimate the number of workers in Great Britain with significant occupational exposure to hand-transmitted vibration (HTV). Also, to identify the occupations and industries, where such exposures arise, and the main source of exposures. Methods. A questionnaire was posted to 22 194 men and women aged 16–64,

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comprising 21 201 subjects selected at random from age–sex registers of 34 general practices in England, Scotland, and Wales, and a further 993 subjects selected at random from the central pay registers of the three armed services. Among other things, the questionnaire asked about exposure to sources of HTV in current and earlier employment. Responses were assessed by occupation and industry, and prevalence estimates for the country as a whole were derived from census information on occupational and industrial populations nationally. Estimates were also made in exposed workers of the average daily dose of vibration ($A(8)$ root mean squared (rms)) for the past week, based on their reported sources and durations of exposure. Results. Useable questionnaires were returned by 12 907 subjects (overall response rate 58%). From these it was estimated that some 4·2 million men and 667 000 women in Great Britain are exposed to HTV at work in a 1 week period, and that personal daily exposures to vibration exceed a suggested action level equivalent to 2·8 m/s^2 for 8 h ($A(8) > 2{\cdot}8$ m/s^2 rms) in at least 1·2 million men and 44 000 women. High estimated doeses ($A(8) > 5$ m/s^2 rms) arose most often in bricklayers and masons, gardeners and groundsmen, carpenters and joiners, electricians and electrical maintenance fitters, and builders and building contractors. The industries where high $A(8)$ values most often arose were construction, motor vehicle repair and maintenance, manufacture of basic metals, and agriculture. The most common sources of exposure were hammer drills, hand-held portable grinders, and jigsaws. Conclusions. Exposure to HTV is surprisingly prevalent, and preventive measures and health surveillance may be warranted for many men in Britain. Control strategies should focus on prevention at source, with priority according to the common sources of exposure and the occupations in which significant exposures tend to arise. Many vibratory tools that are common in Britain have been overlooked in previous surveys, highlighting an important focus for future research.
Topics: Injury and disease; hand-transmitted vibration; vibration syndrome; exposure time; criteria and limits.

K. T. Palmer, M. J. Griffin, H. Bednall, B. Pannett and D. Coggon (2000) *Occupational and Environmental Medicine* **57**, 229–236. Prevalence and pattern of occupational exposure to whole body vibration in Great Britain: findings from a national survey (8 pages, 3 figures, 5 tables, 17 references) (in English)
Author's Abstract. Objectives. To estimate the number of workers in Great Britain with significant occupational exposure to whole-body vibration (WBV) and to identify the common sources of exposure and the occupations and industries where such exposures arise. Methods. A postal questionnaire was posted to a random community sample of 22 194 men and women of working age. Among other things, the questionnaire asked about exposure to WBV in the past week, including occupational and common non-occupational sources. Responses were assessed by occupation and industry, and national prevalence estimates were derived from census information. Estimates were also made of the average estimated daily personal dose of vibration (eVDV). Results. From the 12 907 responses it was estimated that 7·2 million men and 1·8 million women in Great Britain are exposed to WBV at work in a 1 week period if the occupational use of cars, vans, buses, trains, and motor cycles is included within the definition of exposure. The eVDV of $>$ 374 000 men and 9000 women was estimated to exceed a proposed British Standard action level of 15 $m/s^{1{\cdot}75}$. Occupations in which the estimated exposures most often exceeded 15 $m/s^{1{\cdot}75}$ included forklift truck and mechanical truck drivers, farm owners and managers, farm workers, and drivers of road goods vehicles. These occupations also contributed the largest estimated numbers of workers in Great Britain with such levels of exposure. The highest estimated median occupational eVDVs were found in forklift truck drivers, drivers of road goods vehicles, bus and coach drivers, and technical and wholesale sales representatives, among

whom a greater contributions to total dose was received from occupational exposures than from non-occupational ones; but in many other occupations the reverse applied. The most common sources of occupational exposure to WBV are cars, vans, forklift trucks, lorries, tractors, buses, and loaders. Conclusions. Exposure to whole-body vibrations is common, but only a small proportion of exposures exceed the action level proposed in British standards, and in many occupations, non-occupational sources are more important than those at work. The commonest occupational sources of WBV and occupations with particularly high exposures have been identified, providing a basis for targeting future control activities.
Topics: Injury and disease; exposure time; criteria and limits.

M. Cherniack, J. Clive and A. Seidner (2000) *Occupational and Environmental Medicine* **57**, 341–347. Vibration exposure, smoking, and vascular dysfunction. (7 pages, 0 figures, 7 tables, 33 references) (in English)
Authors' Abstract. Objectives. Vibration white finger (VWF), also known as "occupational Raynaud's phenomenon", is marked by arterial hyperresponsiveness and vasoconstriction during cold stimulation. The impact of tobacco use, and by extension stopping smoking, on the long-term course of the disease has been inconclusively characterized. The objectives of this study included assessment of the impact tobacco use on symptoms and on objective tests in shipyard workers exposed to vibration, and in guaging the natural history of the disorder after stopping exposure and changing smoking patterns. Methods. In a cross-sectional investigation, 601 current and former users of pneumatic tools were evaluated subjectively for cold-related vascular symptoms, and tested by cold challenge plethysmography. There was follow up and subsequent testing of 199 members of the severely effected subgroup of smokers and non-smokers, many of whom had stopped smoking in the interval between tests. Effects of smoking and stopping smoking on symptoms and plethsymographic results were assessed. Results. Symptoms and measured abnormal vascular responses related to cold were more severe in smokers than in non-smokers. Follow up of 199 severely effected members of the cohort, all removed from exposure for 2 years, indicated that smokers were almost twice as likely to have more severe vasospasm (test finger/control finger systolic blood pressure % (FSBP%) <30) than were non-smokers ($-32{\cdot}2\%$ versus $17{\cdot}4\%$). Fifty three subjects who stopped smoking during the interval between tests improved, and were indistinguishable from non-smokers similarly exposed to vibration. Additional physiological benefits of stopping smoking were still apparent at further follow up examination, 1 year later. Improvements evident on plethysmography were not accompanied by improvements in symptoms, which were unaffected by smoking. Conclusions. Smoking seems to delay physiological improvements in response to cold challenge in workers with VWF, after the end of exposure to vibration. Symptoms were less likely to improve over time than digital blood pressure, and were less affected by smoking.
Topics: physiologic effects (cardiovascular); vibration syndrome (vibration-induced white finger).

A. E. Sklar and N. B. Sarter (1999) *Human Factors* **41**, 543–552. Good vibrations; tactile feedback in support of attention allocation and human-automation coordination in event-driven domains. (10 pages, 7 figures, 1 table, 24 references) (in English)
Authors' Abstract. Observed breakdowns in human–machine communications can be explained, in part, by the nature of current automation feedback, which relies heavily on focal visual attention. Such feedback is not well suited for capturing attention in case of unexpected changes and events or for supporting the parallel processing of large amounts of

data in complex domains. As suggested by multiple-resource theory, one possible solution to this problem is to distribute information across various sensory modalities. A simulator study was conducted to compare the effectiveness of visual, tactile, and redundant visual and tactile cues for indicating unexpected changes in the status of an automated cockpit system. Both tactile consitions resulted in higher detection rates for, and faster response times to, uncommanded mode transitions. Tactile feedback did not interfere with, nor was its effectiveness affected by, the performance of concurrent visual tasks. The observed improvement in task-sharing performance indicates that the introduction of tactile feedback is a promising avenue towards better supporting human–machine communication in event-driven, information-rich domains.
Topics: Performance effects; perceptual mechanisms (vibrotactile).

J. Förstberg (2000). *Doctoral Thesis*, *Railway Technology*, *Department of Vehicle Engineering*, *Royal Institute of Technology*, *TRITA-FKT Report* 2000:28, *ISSN* 1103-470*X*, *ISRN KTH/FKT/D* - 00/28 - *SE*. Ride comfort and motion sickness in tilting trains (215 pages, 74 figures, 63 tables, 183 references) (in English)
Author's Abstract. This thesis presents a systematic study of human responses to different motions and strategies of car body tilt control regarding ride comfort, working/reading ability and motion sickness on high-speed tilting trains. Experiments with test subjects were performed in a tilting train on curved track as well as in a moving vehicle simulator. The study is multi-disciplinary, combining knowledge and methods from the fields of railway technology, human factors and vestibular science. The main experiment in a tilting train was performed with about 75 seated test subjects, mainly students from Linköping University, making three test runs. In total, these subjects participated in about 210 individual test rides, each with a duration of about 3 h. Additional tests on comfort disturbances with pushbutton technique have been reported in the project. The simulator experiments used a total of about 75 subjects making some 320 test rides each of about 30 min duration. Test motions consisted of combinations of horizontal (lateral) acceleration and roll, together with either roll or horizontal acceleration. Rate of change of horizontal acceleration (jerk) and roll velocity were of the same order of magnitude as in tilting train environment, but horizontal acceleration alone was about half the magnitude. Horizontal and vertical vibrations from a tilting train were added to the test motions, and train seats and interior train noise were also introduced to create a "train feeling". Test designs and methodology have been developed during the course of the experiments. The test subjects answered questionnaires, four times per test run in the train experiment and each 5 min in the simulator experiment. The investigation variables were: examined average ride comfort, estimated ability to work or read, and occurrence of symptoms of motion sickness (dizziness, nausea and not feeling well). Lateral and vertical accelerations together with roll motions were monitored and recorded for later evaluation. Results from the train experiments show that the estimated average ride comfort was about 4 on a 5° scale, which indicates "good". Results also show that a reduced tilt compensation of the lateral acceleration while curving together with a reduced tilt velocity of the car body reduces the provocation of motion sickness. However, a reduction in tilt compensation may produce an increased number of comfort disturbances due to lateral acceleration in the car body. Regression analysis shows that motion doses from roll acceleration may be used to predict the incidence of motion sickness. The simulator experiments show that the primary sources of provocation of nausea and motion sickness are the motion doses from roll and lateral acceleration in the horizontal plane. The study proposes a hypothesis and a model of provocation of motion sickness. It is shown that motion sickness has a time of decay, or leakage. A model for this leakage is proposed. The determinative types of motion for

provocation of nausea and motion sickness in tilting trains are identified and future tilting train and/or simulator experiments are proposed in order to further investigate their influence.
Topics: motion sickness (causes of); complex vibration (multiple axis); vehicle ride (rail).

G. A. Hampel and W.-R. Chang (1999) *International Journal of Industrial Ergonomics* **23**, 489–498. Body height change from motor vehicle vibration. (10 pages, 5 figures, 2 tables, 26 references) (in English)
Authors' *Abstract*. Seventeen (17) subjects were exposed to tri-axial vehicle whole-body vibration for approximately 3 h, and measured hourly for body height. The control was the same environment, but no vibration. A broad band predominately z-axis acceleration (1·6–10 Hz), with a mean level of 0·885 m/s^2 at the seat, was generated by a semi-truck tractor driven on secondary roads. The dominant one-third octave band of the vibration at the seat was 2 Hz with an acceleration magnitude of 0·521 m/s^2. At the end of the first hour, the results indicated a subject growth by 1·14 mm when exposed to vibration and a shrinkage of nearly equal amounts without vibration. In the second and third hours, subjects followed the natural tendency to shrink under both conditions. At the end of the third hour, the subject height with vibration was 2·23 mm higher than without vibration.
Topics: physiological effects (general).

L. Burström and A. Sörensson (1999) *International Journal of Industrial Ergonomics* **23**, 585–594. The influence of shock-type vibrations on the absorption of mechanical energy in the hand and arm. (10 pages, 4 figures, 2 tables, 42 references) (in English)
Authors' *Abstract*. In recent years there has been a discussion as to whether shock-type vibration from hand tools has stronger effects on the hand–arm system in comparison with non-impulsive vibration. The purpose of the investigation is to compare the influence of these two types of vibration on the absorption of mechanical energy in the human and on the grip and feed forces applied by the subjects. The energy absorption has been measured by the use of a specially designed laboratory handle. The grip and feed forces applied by the subject to the handle were measured simultaneously. In the study two different frequency-weighted acceleration levels were used. The outcome showed that the vibration exposure levels made a significant contribution to the vibration absorption as well as to the strength of the grip and feed forces. Moreover, it was found that the hand forces decrease while the absorption of energy increases during the experiment. Futhermore, the influence of shock-type exposure gave a significantly higher hand forces and absorption of energy compared with the non-impulsive explosure. It was, therefore concluded that the vibration response characteristics of the hand and arm differ, depending upon whether the exposure is of shock or non-impulsive type.
Topics: hand-transmitted vibration; biodynamics (energy absorption).

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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, SO17 1BJ, England.