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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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This selection of abstracts is taken from the Proceedings of a workshop on the "Diagnosis of disorders caused by hand-transmitted vibration" held at the University of Southampton, 11th to 13th September, 2000. Published in: 2002 *International Archives of Occupational and Environmental Health* **75**.

M. J. Griffin and M. Bovenzi 2002 *International Archives of Occupational and Environmental Health* **75**, 1–5. The diagnosis of disorders caused by hand-transmitted vibration: Southampton Workshop 2000. (5 pages, 0 figures, 4 tables, 13 references) (in English).
Authors' Abstract. Objectives—To identify the current state of knowledge, current uncertainties and future needs related to the diagnosis of disorders associated with the use of vibratory hand-held tools. Method—An international workshop was convened with invited experts, medical doctors, scientists and engineers familiar with hand-transmitted vibration and the diagnosis of vascular, neurological and musculoskeletal disorders. This paper records the general conclusions from four panel discussions. Results—For the most common vascular disorders (vibration-induced white finger), the principal symptom and sign involves attacks of well-demarcated finger blanching (Raynaud's phenomenon); low finger systolic blood pressure following cooling is indicative of vibration-induced white finger and zero finger systolic blood pressure can confirm an attack of Raynaud's phenomenon. For neurological disorders, some symptoms can exist without detectable signs and some signs can exist without symptoms; numbness and tingling are commonly reported but neurological changes may be present without these symptoms. The pathogenesis of musculoskeletal disorders in users of vibratory tools is not clear; symptoms may include pain that may not be associated with abnormal results in objective tests. For both neurological and musculoskeletal disorders, a thorough neuromuscular and skeletal examination is required; diagnosis must consider the work history and medical history, the results of physical examination and any objective tests in addition to other factors (e.g., age, smoking, alcohol, systemic disorders, medication and neurotoxic agents) that might have contributed to symptoms, signs and test results. Conclusions—While vibration-induced white finger is caused by vibration, some neurological and musculoskeletal disorders are the result of work with vibratory tools where the separate roles of vibration, repetitive movements, grip and push forces, non-neutral postures and any other ergonomic stressors are often unclear. Such disorders may be more easily identified as being caused by the work rather than by exposure to hand-transmitted vibration *per se*. A person found to have developed disorders induced by either vibration or the work situation should not be returned to the same vibration exposure or work without any changes expected to lessen the risk.
Topics: Vibration syndrome (General).

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N. Olsen 2002 *International Archives of Occupational and Environmental Health* **75**, 6–13. Diagnostic aspects of vibration-induced white finger. (8 pages, 0 figures, 4 tables, 40 references) (in English).

Author's Abstract. Vibration-induced white finger (VWF) is a secondary type of Raynaud's phenomenon (RP) caused by exposure to hand–arm vibration. The present review concerns the cold-provoked attack of RP in vasospastic VWF. It concentrates on the most common clinical and laboratory methods used to diagnose RP in vibration-exposed subjects. Some physiological aspects of the attack of RP are mentioned to elucidate the diagnostic principles of the tests. Anamnestic diagnostics by medical interviews and questionnaires as well as cold-provocation tests with detection of finger colour, finger systolic blood pressure (FSP), recovery time of finger skin temperature and recovery time of normal nail colour after nail compression are mentioned. The discriminative capacity and the reproducibility of the tests are discussed. Cold-provocation tests with detection of finger colour or zero FSP during cooling are recommended to be used if an attack of RP has to be registered for diagnostic or medico-legal purposes in individual cases. An abnormal reduction in FSP during cooling makes a history of RP very probable and is a suitable laboratory test for groups of subjects. Both recovery tests may be useful screening tests in field studies of vibration-exposed subject groups.

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

N. Harada 2002 *International Archives of Occupational and Environmental Health* **75** 14–19. Cold-stress tests involving finger skin temperature measurement for evaluation of vascular disorders in hand–arm vibration syndrome: review of the literature. (6 pages, 0 figures, 2 tables, 32 references) (in English).

Author's Abstract. Cold-stress tests are used for evaluating vascular disorders in the hand–arm vibration syndrome, and the value of such tests based on finger skin temperature measurement has been investigated. However, there is a wide difference in the test conditions among countries and researchers. Standardization of the cold-stress tests is currently under discussion within the International Organization for Standardization. We reviewed various aspects of the cold-stress tests involving finger skin temperature, hand immersion time and other test conditions, and evaluated their diagnostic significance. Water temperature varied from 0 to 15°C and hand immersion time varied from 0·5 to 20 min. The cold-stress tests are associated with relatively severe suffering, thus higher temperature of cold water and shorter time of immersion are desirable. To date, however, there has not been sufficient data indicating diagnostic value in a test method involving cold water at around 15°C. Diagnostic value is also influenced by other test conditions, such as room temperature, season, use of ischemia during immersion. For standardization of the cold-stress test involving finger skin temperature measurement, these factors must be considered together with water temperature and immersion time.

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

M. Bovenzi 2002 *International Archives of Occupational and Environmental Health* **75**, 20–28. Finger systolic blood pressure indices for the diagnosis of vibration-induced white finger. (9 pages, 1 figure, 8 tables, 26 references) (in English).

Author's Abstract. Objectives—To compare the accuracy of several finger systolic blood pressure indices (FSBPIs) for the diagnosis of cold-induced Raynaud's phenomenon in vibration-exposed worker groups with different prevalence of vibration-induced white finger (VWF). Methods—The finger systolic blood pressure (FSBP) in a test finger at 10°C as a percentage of the pressure at 30°C, corrected for the change in systolic blood pressure in a reference finger [FSBPI(A)] or the arm [FSBPI(B)], was measured in 455 healthy controls

and 874 workers exposed to hand-transmitted vibration (HTV). The following FSBPIs were also calculated: FSBPI(C), as the ratio between FSBP in the test finger at 10°C and FSBP in the same finger at 30°C; and FSBPI(D), as the ratio of FSBP to arm systolic blood pressure, FSBP(0), in the cooled finger was taken as an objective sign of Raynaud's attack with complete closure of the digital arteries. Results—On a group basis, all FSBPIs could discriminate between the controls and the HTV workers. In the vibration-exposed worker population, the FSBPIs were significantly lower in the subjects affected with VWF than in those without vasospastic symptoms. The lower normal limits of FSBPIs were derived from the results of the cold test in the controls and were found to vary from 50 to 60%. The FSBPI(A) showed the best sensitivity for the detection of cold-induced digital arterial hyper-responsiveness in both the total sample HTV workers (sensitivity 87%) and most of the vibration-exposed groups with different prevalence of VWF (sensitivity from 79 to 100%). The results of the receiver operating characteristic analysis suggested a higher diagnostic accuracy of FSBP(A) when compared with the global performance of the other FSBPIs. In the whole sample of HTV workers, the predictive value of a positive cold test varied from 73% [FSBPI(D)] to 89% [FSBP(0)] and that of a negative test ranged between 89% [FSBP(0)] and 97% [FSBPI(A)]. Conclusions—The findings of this investigation and clinical experience suggest that a discriminating threshold of FSBP(A) $< 60\%$ during finger cooling to 10°C is an appropriate diagnostic criterion for the detection of abnormal cold response in the digital arteries of most vibration-exposed workers with a true history of symptoms of finger whiteness at the medical interview.
Topics: Vibration syndrome (vibration-induced white finger).

C. J. Lindsell and M. J. Griffin 2002 *International Archives of Occupational and Environmental Health* **75**, 43–54. Normative data for vascular and neurological tests of the hand–arm vibration syndrome. (12 pages, 4 figures, 6 tables, 48 references) (in English).
Authors' Abstract. Objectives—To assist occupational professionals to interpret the results of standardized test for components of the hand–arm vibration syndrome by presenting data for healthy subjects and identifying the effects of some of the confounding variables. Method—Thermal thresholds, vibrotactile thresholds, the finger skin temperature (FST) response to cold provocation and percentage finger systolic blood pressures (%FSPB) were measured by standardized procedures. Normative data were obtained for healthy men of working age (17–62 years) during 237 experimental sessions encompassing 10 different studies. Hot thermal thresholds and cold thermal thresholds were assessed independently with 38 subjects; 152 measurements of both hot and cold thresholds were made. Vibrotactile thresholds were measured at several locations on 81 subjects, giving a total of 216 measurements at 125 and 31·5 Hz. The FST response to cold provocation at 15°C was monitored by thermocouples throughout a 2-min settling period, a 5-min immersion period and a 10-min recovery period. A total of 302 measurements were made on 70 subjects. The %FSBPs were measured in four test fingers and one reference finger by strain-guage plethysmography. Measurements were made on 97 subjects. A total of 351 measurements was made at 15°C, with 341 measurements at 10°C. Results—Normative data and some example normal limits are presented in other studies. Age was found to influence thermal thresholds, vibrotactile thresholds and the FST response to cold provocation; older subjects exhibited deteriorated vascular and neurological function. Room temperature was found to influence %FSBPs and the FST response to cold provocation; warmer environments resulted in improved vascular response to cold. Outdoor temperature had a small effect on the FST response to cold provocation and on the vibrotactile thresholds. Thermal thresholds showed some influence of smoking habits and of the FST measured prior to testing. For all four tests, any differences between measurement locations were small and

there were no differences between left-handed and right-handed subjects. Conclusions—The current data can assist occupational health professionals to interpret the results of the standardized tests. Comparison with the current data is considered valid for men of working age. Age and room temperature should be recognized as being capable of causing changes in neurological and vascular function.
Topics: Vibration syndrome (vibration-induced white finger).

T. Nilsson 2002 *International Archives of Occupational and Environmental Health* **75**, 55–67. Neurological diagnosis: aspects of bedside electrodiagnostic examinations in relation to hand–arm vibration syndrome. (13 pages, 0 figures, 6 tables, 113 references) (in English).
Authors' Abstract. Objectives—The objective of this paper, was to direct attention to the diagnostic strategy and clinical approach necessary in the diagnosis of neuropathy in workers exposed to vibration. The purpose encompassed evaluation of selected aspects of bedside and electrodiagnostic examinations with respect to biological validity and the ability to distinguish between subjects with and without neuropathy. Methods—The neurological examinations viewed were restricted to those applicable to the upper extremity and neck system. A MEDLINE search was performed through the clinical service of PubMed searching for the following terms: nerve-conduction, Tinel's tests, Phalen's test, tendon reflex, two-point discrimination test, abduction external rotation test and Spurling test. Retrieved articles were discussed both in relation to the test accuracy and the validity aspects of the tests. Results—The evidence in support of the view that neurological tests can accurately distinguish between subjects with and without neuropathy specifically addressing hand–arm vibration syndrome was sparse. The initial number of diagnostic hypotheses could be reduced by progressively ruling our diseases based on negative results of highly sensitive tests. As the possible diagnostic alternatives become fewer, the use of positive results from highly specific tests are more effective. The information value of the various diagnostic tests is determined by the change in pre to post-test probability of target disorder, which depends on the prevalence of the disorder and the likelihood ratios of the tests. The review showed that target disease characteristics influence the test outcome as well as the choice of "gold standard" and the population domain of the studies. Conclusions—The selection of various bedside examinations and diagnostic electrophysiological tests should be dependent on the clinical context, the history and results from successive diagnostic tests.
Topics: Vibration syndrome (neurological).

R. Lundström 2002 *International Archives of Occupational and Environmental Health* **75**, 68–77. Neurological diagnosis—aspects of quantitative sensory testing methodology in relation to hand–arm vibration syndrome. (10 pages, 0 figures, 2 tables, 113 references) (in English).
Author's Abstract. Objective—The objectives are to summarize the fundamental neurophysiological base for quantitative sensory testing (QST), and to discuss associated methodological and practical aspects necessary to consider with respect to applicability and reliability as a screening or diagnostic aid for vibration-induced sensory neuropathy. Results—QST is the use of psychophysical techniques to measure the intensity of stimuli needed to produce specific sensory perceptions. The physical components are graded stimuli presented to the skin, eye or ear. The psychological component is mental recognition of the physical stimulus. Sensory modalities are named after the subjective feelings elicited, i.e., touch, pressure, vibration, warmth, cold and thermal pain. Since an exposure to vibration may cause symptoms and signs of sensory neuropathy in the hand and arm, the use of QST as an aid for screening and diagnosis has gained an increasing interest. The

"Stockholm Workshop" classification scale for sensorineural stages also requires QST. Further, QST has also spread into many other areas, such as in the screening and diagnosis of peripheral neuropathy or polyneuropathy induced by different types of illness, exposure to toxic substances, compression and nerve entrapment. Conclusions—QST is in general easy to perform, usually not associated with pain (except thermal pain), suitable for screening and can readily be conducted in the field. QST is, however, known to be susceptible to the effects of multiple covariates and test methodologies. It is thus important that the relative influence on test results from all significant covariate are identified, and to standardize test methodology accordingly before QST can become a reliable and useful tool for diagnostic and screening purposes in the field of vibration-induced sensory neuropathy. The sensitivity, specificity and reliability of different methods for QST for this type of disorder is still very much unknown. Lack of normative values, standardization of methods and of a "gold standard" for the presence of sensory neuropathy are some reasons.
Topics: Vibration syndrome (neurological).

M. Hagberg 2002 *International Archives of Occupational and Environmental Health* **75**, 97–105. Clinical assessment of musculoskeletal disorders in workers exposed to hand–arm vibration. (9 pages, 0 figures, 4 tables, 49 references) (in English).
Author's Abstract. Objectives—To describe the clinical assessment of musculoskeletal disorders among vibration-exposed workers and to review the experimental and epidemiological studies of the effects of vibration on the musculoskeletal system of the upper limbs. Methods—A total of 212 references in English was found in PubMed for the years 1980–2000 that dealt with clinical assessment. Many of these references were reviews and few were original research dealing with test performance in diagnostic procedures. Results—The reported effects on bone are osteoporosis and cysts in the hands. Experiments have shown injuries to muscle cells in animals and additional physiological loading of muscles in humans by vibration. Low-frequency vibration exposure of high magnitude was associated with osteoarthrosis in the elbow, wrist and acromioclavicular joint and symptoms in the elbow and shoulder. Impacts, jerks and blows with high-energy transfer to the hands at low frequency might have the potential to result in musculoskeletal disorders considering the general model for injuries. Furthermore, the observered associations with vibration exposure and musculoskeletal disorders might result from the strong dynamic and static joint loading and the repetitive hand–arm motions required in tasks where hand-held machines are used. The clinical assessment of musculoskeletal disorders in workers exposed to hand–arm vibration consists of the clinical and exposed history and evaluation of the physical and laboratory findings. Since most patients with musculoskeletal disorders who are exposed to vibration are also exposed to other ergonomic stressors, accommodation of the injured worker has to take the whole work system into account (task, technology, environment and organization). Conclusions—The scientific evidence that vibration *per se* is a risk factor for musculoskeletal disorders is still weak although there is strong evidence that job tasks with vibrating machines are associated with musculoskeletal disorders. The clinical assessment of musculoskeletal disorders in exposed patients imposes special requirements.
Topics: Vibration syndrome (musculoskeletal).

Other papers presented at the workshop and appearing in the same issue of the International Archives of Occupational and Environmental Health, are:
K. T. Palmer, M. J. Griffin, H. Syddall, C. Cooper and D. Coggon 2002 *International Archives of Occupational and Environmental Health* **75**, 29–36. The clinical grading of

Raynaud's phenomenon and vibration-induced white finger: relationship between finger blanching and difficulties in using the upper limb.

J. A. ALLEN, S. MCGRANN and K. M. MCKENNA 2002 *International Archives of Occupational and Environmental Health* **75**, 37–42. Use of questionnaire for vibrating white finger in a high risk industrial population.

M. MORIOKA and M. J. GRIFFIN 2002 *International Archives of Occupational and Environmental Health* **75**, 78–84. Dependence of vibrotactile thresholds on the psychophysical measurement method.

D. J. WHITEHOUSE and M. J. GRIFFIN 2002 *International Archives of Occupational and Environmental Health* **75**, 85–89. A comparison of vibrotactile thresholds obtained using different diagnostic equipment: the effect of contact conditions.

H. SAKAKIBARA, S. MAEDA and Y. YONEKAWA 2002 *International Archives of Occupational and Environmental Health* **75**, 90–96. Thermotactile threshold testing for the evaluation of sensory nerve function in vibration-exposed patients and workers.

N. TOIBANA, N. ISHIKAWA and H. SAKAKIBARA 2002 *International Archives of Occupational and Environmental Health* **75**, 106–110. Measurement of manipulative dexterity in patients with hand–arm vibration syndrome.

B. M. HAWARD and M. J. GRIFFIN 2002 *International Archives of Occupational and Environmental Health* **75**, 111–119. Repeatability of grip strength and dexterity tests and the effects of age and gender.

S. YAMADA 2002 *International Archives of Occupational and Environmental Health* **75**, 120–128. National regulations for diagnostics in health surveillance, therapy and compensation of hand-transmitted vibration injury in Japan.

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.