Vibration Injury Network

Research Network on Detection and Prevention of Injuries due to Occupational Vibration Exposures

The diagnosis of disorders caused by hand-transmitted vibration: Southampton Workshop 2000

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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 disorder (vibration-induced white finger), the principal symptom and sign involves attacks of well-demarcated finger blanching (Raynaud's phenomenon); a low finger systolic blood pressure following cooling is

indicative of vibration-induced white finger and a 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 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 risks.

Key words Hand-transmitted vibration, symptoms, signs, objective tests, vibration-induced white finger, hand-arm vibration syndrome

Introduction

Hand-transmitted vibration may contribute to various disorders of the vascular, neurological and musculoskeletal systems of the body [1, 7]. These disorders can result in disability and handicap to the affected person, with loss of work and impaired quality of life. There are also costs to employers and welfare systems.

The early diagnosis of disorders caused by hand-transmitted vibration may help to prevent the progression of disorders and serious disability. Sensitive and specific methods of detecting problems and their progression may assist the affected individual, help to advance knowledge of the causes of disorders and lead to improved means of protection from injury.

The purpose of the Southampton Workshop 2000 was to bring together experts in the diagnosis of disorders caused by hand-transmitted vibration so as to identify the current state of knowledge, current uncertainties and future needs. Papers presented at the workshop provided a foundation for four panel discussions. This paper records the general conclusions from the panel discussions.

Vascular disorders

The principal vascular disorder associated with exposure to hand-transmitted vibration is vibration-induced white finger, a type of secondary Raynaud's phenomenon [1, 7, 12]. It was recognised that this may take several different forms but the nature of the disorder, the symptoms and signs are most commonly as listed in Table 1.

Objective methods of measuring finger circulation following finger cooling are considered helpful but currently insufficient to identify the severity of vibration-

induced white finger. This vascular disorder may vary between fingers so it is desirable to assess all fingers when performing objective tests of finger circulation.

The diagnosis of vibration-induced white finger must recognise that there exist other causes of similar symptoms and signs. The diagnosis cannot be made without knowledge that there has been significant exposure to hand-transmitted vibration. Although current standards suggest methods of calculating the risk of finger blanching from exposure to hand-transmitted vibration, the estimates can be only approximate in a group of exposed persons, not applicable to all tools, and never sufficient to predict disorder in an individual [2, 8, 10].

Neurological disorders

There is clear evidence that work with vibratory tools can result in a wide variety of neurological disorders [1, 7, 11], especially those involving sensory mechanisms (Table 2).

Current experience suggests that symptoms of neurological disorders can exist without detectable signs, and signs of neurological changes can exist without symptoms [11]. Numbness and tingling are common but there can be neurological changes without these symptoms. A thorough neurological and musculoskeletal examination is required for the interpretation of any objectives tests. Diagnosis must consider the work history and medical history, the results of physical examination, objective tests and other factors that might have contributed to symptoms, signs and test results [11].

Neurological disorders might arise from either the effects of hand-transmitted vibration or as a result of other aspects of the work. There are currently no

established means of predicting neurological disorders from the severity of exposures to hand-transmitted vibration [2, 8].

Musculoskeletal disorders

Although users of vibratory tools may report musculoskeletal symptoms (e.g. ache, pain, stiffness) in the fingers, hand, wrist, arm and/or shoulder, the pathogenesis of the disorders affecting the musculoskeletal system can be varied and difficult to determine [1, 7, 9], (Table 3).

There are no minimal signs of musculoskeletal disorders: symptoms can exist without signs (i.e. without abnormal results using common objective tests).

There is some evidence that work with hand-held percussive tools producing low frequency vibration (or repeated shocks) of high magnitude (e.g. chipping hammers, road breakers, quarry drills) may be associated with abnormal radiological findings in the wrist and elbow joints (e.g. premature osteoarthrosis, exostoses at the sites of tendon insertion) [1, 5].

The relative importance of hand-transmitted vibration and other ergonomic and psychosocial risk factors in the causation of musculoskeletal disorders is often unclear [9]. Indeed, there is currently no established exposure-response relationship between the physical characteristics of occupational exposures to hand-transmitted vibration and the development of any musculoskeletal disorder [2].

The diagnostic process

The method of obtaining information prior to differential diagnosis can be important. Table 4 lists the generally preferred approach, although iteration around the proposed order will often be necessary.

For health screening and health surveillance it may be sufficient to use questionnaires, often completed by a trained interviewer questioning workers. There should be some measure of quality control to check the accuracy of responses obtained when using questionnaires.

For some purposes, and in some countries, medical doctors will be required to perform some, or all, of the diagnosis, especially when a change of employment or litigation is under consideration. Currently, the diagnosis of neurological and musculoskeletal disorders is complex and requires the examination and opinion of a suitable expert who is in possession of the results of objective test results.

Diagnosis may be performed for several reasons, including deciding on future employment. Where there is reason to believe that the work caused or contributed to the onset or development of a vascular, neurological or musculoskeletal disorder, it is considered inappropriate to allow a worker to return to the same work without arranging for changes to the work that are likely to lessen the risks.

Discussion

There is a need to improve the methods of reporting symptoms arising from vascular, neurological and musculoskeletal disorders associated with work involving hand-transmitted vibration. This includes the interpretation of specific words and affects the

reporting and application of scientific studies and also the application of current methods of reporting symptoms.

There is scope for improving scales for reporting the extent of symptoms and signs: current scales for vibration-induced white finger confound the effects of frequency and extent of blanching [6, 13], and the so-called ‘sensorineural stages’ of the effects of hand-transmitted vibration employ terms that have not been defined (e.g. reduced sensory perception, reduced tactile perception, manipulative dexterity), [4].

Conclusions

By definition, vibration-induced white finger is caused by exposure to hand-transmitted vibration. A necessary symptom (which is also a sign) of vibration-induced white finger is an attack of well-demarcated finger blanching. In workers exposed to hand-transmitted vibration, a low finger systolic blood pressure measured following provocative cooling is indicative of vibration-induced white finger and a zero finger systolic blood pressure can confirm an attack of Raynaud's phenomenon [3, 12].

Neurological and musculoskeletal disorders can arise from 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 [9, 11]. Such disorders may be more easily identified as being caused by the work than by exposure to hand-transmitted vibration per se.

A person found to have developed a disorder induced by either vibration or the work situation should not be returned to the same vibration exposure or work without any changes that can reasonably be expected to lessen the risks of the disorder.

References

1. Bovenzi M (1998) Hand-transmitted vibration. In: Stellman JM (ed) Encyclopaedia of Occupational Health and Safety, 4th edn. ILO, Geneva, Vol II, pp 50.7-50.12
2. Bovenzi M (1998) Exposure-response relationship in the hand-arm vibration syndrome: an overview of current epidemiology research. Int Arch Occup Environ Health 71: 509-519
3. Bovenzi M (2001) Finger systolic blood pressure indices for the diagnosis of vibration-induced white finger. Int Arch Occup Environ Health #:##
4. Brammer AJ, Taylor W, Lundborg G (1987) Sensorineural stages of the hand-arm vibration syndrome. Scand J Work Environ Health 13: 279-283
5. Gemne G, Saraste H (1987) Bone and joint pathology in workers using hand-held vibrating tools. An overview. Scand J Work Environ Health 13: 290-300
6. Gemne G, Pyykkö I, Taylor W, Pelmear PL (1987) The Stockholm Workshop scale for the classification of cold-induced Raynaud's phenomenon in the hand-arm vibration syndrome (revision of the Taylor-Pelmear scale). Scand J Work Environ Health 13: 275-278
7. Griffin MJ (1990) Handbook of human vibration. Academic Press, London
8. Griffin MJ (1997) Measurement, evaluation, and assessment of occupational exposures to hand-transmitted vibration. Occup Environ Health 54: 73-89
9. Hagberg M (2001). Clinical assessment of musculoskeletal disorders in workers exposed to hand-arm vibration. Int Arch Occup Environ Health #:##
10. International Organization for Standardization (1986) Mechanical vibration - Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration. ISO 5349. ISO, Geneva
11. Nilsson T (2001). Neurological diagnosis: aspects on bedside and electroneurophysiological examinations. Int Arch Occup Environ Health #:##
12. Olsen N (2001). Physiological and diagnostic aspects of vibration-induced white finger. Int Arch Occup Environ Health #:##
13. Palmer KT, Coggon DN (1997) Deficiencies of the Stockholm vascular grading scale for hand-arm vibration. Scand J Work Environ Health 23: 435-439

Table 1. Vibration-induced white finger

The nature of the vibration-induced white finger:
Vibration-induced white finger is a disorder characterised by complete episodic closure of digital blood vessels. Both central and local pathogenic mechanisms may be involved. The pathogenesis of vibration-induced white finger is not yet fully understood.
Symptoms of vibration-induced white finger:
A necessary symptom for the diagnosis of vibration-induced white finger is the occurrence of attacks of well-demarcated finger blanching (Raynaud's phenomenon). • Attacks of blanching normally commence with blanching in the distal phalanges and may extend to other more proximal phalanges before receding to the distal phalanges and recovery. • Blotchiness (patches of blanching) may occur during onset or recovery from an attack. • Anaesthesia will occur during an attack of blanching but numbness may not be noticed. • There may be a sequence of colour changes in which blanching is followed by cyanosis and redness, sometimes accompanied by pain. • Attacks are mainly provoked by exposure to cold conditions (including dampness) but cold will not necessarily provoke an attack. • Persons with vibration-induced vascular disorders may feel their fingers to be abnormally cold, even without a blanching attack.
Signs and objective tests of vascular disorder:
A sufficient sign of vibration-induced white finger is the observation of an attack of well-demarcated finger blanching. •Finger systolic blood pressures measured following cooling of the digits to 15°C and 10°C will often be low in persons with vibration-induced white finger; an approximately zero finger systolic blood pressure can verify an attack of Raynaud's phenomenon. •Finger rewarming times following cold exposure may be prolonged. •Standardisation of cold provocation (rewarming) tests is desirable. •Tests are recommended on all potentially affected digits on both hands. •Current objective tests (finger systolic blood pressures and rewarming times following cold provocation) do not indicate the severity of vibration-induced white finger and are therefore not required if an attack of finger blanching has been witnessed.
Other considerations:
• Vascular damage caused by hand-transmitted vibration should be distinguished from primary Raynaud's phenomenon and other causes of secondary Raynaud's phenomenon. • Effects of age, smoking, medication and vasoactive agents should be taken into account.
Minimal vibration exposure required for diagnosis:
Regular exposure to vibration known to be capable of causing vibration-induced white finger.

Table 2. Neurological disorders caused by work with vibratory tools.

The nature of the neurological disorders:
Neuropathy to peripheral, mainly the sensory but sometimes also the motor, nervous system, related to work with vibrating machines in which there may be: • Disorders of end organs • Nerve fibre dysfunction resembling entrapment neuropathy • Diffuse or multi-focal neuropathy • Any of the nerves of the upper limbs may be affected by hand-transmitted vibration. • The disorder is not necessarily confined to digits but may extend to the palm and the arms. • The involvement of the autonomic nervous system has been considered, but this was not the subject of the workshop
Symptoms of neurological disorders:
There are no minimal symptoms of neurological disorders caused by hand-transmitted vibration because manifestations of disorder can pass unnoticed by affected persons. • Numbness and tingling are commonly reported. • It is desirable to unify the terminology for the description of symptoms in different languages.
Signs and objective tests of neurological disorders:
There are no minimal signs of neurological disorder: symptoms can exist without signs. • A thorough neurological and musculoskeletal physical examination is a pre-requisite for the diagnosis and interpretation of any objective tests. • Useful objective measures include sensory tests (e.g. thresholds for heat, cold and vibration and aesthesiometry) and electrodiagnostic testing. • Standardisation of tests is desirable.
Other considerations:
• Endocrine, metabolic, and immunologic disorders, traumatic injuries, infections, polyneuropathies, and idiopathic focal neuropathies should be excluded. • Effects of age, smoking, alcohol, medication and neurotoxic agents should be taken into account.
Minimal vibration exposure required for diagnosis:
Exposure to vibration known to be capable of causing neurological disorders. • There is currently no established exposure-response relationship between the physical characteristics of occupational exposures to hand-transmitted vibration and the development of neurological disorders.

Table 3. Musculoskeletal disorders caused by work with vibratory tools.

The nature of the musculoskeletal disorders:
The pathophysiological mechanisms underlying musculoskeletal disorders in workers using vibratory tools are often unclear.
Symptoms of musculoskeletal disorders:
• The most common symptom of musculoskeletal disorders is pain (type, onset and location of pain should be explored). • It is desirable to unify the terminology for the description of symptoms of musculoskeletal disorders in different languages.
Signs and objective tests of musculoskeletal disorders:
There are no minimal signs of musculoskeletal disorders: symptoms can exist without signs. • A thorough neuromuscular and skeletal physical examination is a pre-requisite for the diagnosis and interpretation of any objective tests of musculoskeletal disorders. • Work with low-frequency percussive tools may be associated with an increased occurrence of abnormal radiological findings in the wrist and elbow joints (e.g. premature osteoarthrosis, exostoses at the sites of tendon insertion).
Other considerations:
• Systemic inflammatory disorders, neuromuscular diseases, endocrine disorders, traumatic injuries, infections or tumors should be excluded. • Confounding and effect-modifying variables (e.g. gender, age, smoking, and other personal characteristics) should be taken into account.
Minimal vibration exposure required for diagnosis:
• The relative importance of hand-transmitted vibration and other ergonomic and psychosocial risk factors in the causation of musculoskeletal disorders is often unclear. • There is currently no established exposure-response relationship between the physical characteristics of occupational exposures to hand-transmitted vibration and the development of any musculoskeletal disorder.

Table 4. The diagnostic process

The natural order for diagnosis: – personal history, – work history, – medical history, – symptom history, – physical examination, – laboratory testing, – differential diagnosis. • With suitable quality control, questionnaires may be sufficient for health screening and health surveillance. • For a change of employment, and claims involving the courts, a specially trained medical doctor will often be required. • A person found to have developed a disorder induced by either vibration or the work situation should not be returned to the same vibration exposure or work without any changes.

Workshop Programme

Session 1: Vascular Disorders

Chairman: Judith Allen and Ronnie Lundström

Olsen N.

Physiological and diagnostic aspects of vibration-induced white finger

Bovenzi M

Finger systolic blood pressure indices for the diagnosis of vibration-induced white finger

Harada N

Diagnostic significance of cold-stress tests for evaluating vascular disorders in the hand-arm vibration syndrome

Panel Discussion 1:

The nature of vascular disorders caused by hand-transmitted vibration

Chairmen: Judith Allen and Ronnie Lundström

Session 2: Experience from surveys

Chairmen: Keith Palmer and Niels Olsen

Yamada S, Futatsuka M, Harada N, Sakakibara H

Clinical symptoms from exposure to hand-transmitted vibration taking age and vibration exposure into consideration

Lawson IJ and McGeoch KL

A medical assessment process in a large volume of medico-legal compensation claims for hand-arm vibration syndrome

Session 3: Staging and Grading

Chairmen: Shin'ya Yamada and Massimo Bovenzi

Byrne P, Coughlin PA, Kent PJ, and Kester RC

Objective investigation of vascular dysfunction in patients with the hand-arm vibration syndrome

Palmer KT, Griffin MJ, Sydall H, Cooper C, Coggon D

The clinical grading of Raynaud's phenomenon and vibration-induced white finger: relation between finger blanching and difficulties in using the upper limb

Allen JA, McGrann S, McKenna KM

Use of questionnaire screening for Vibration White Finger in a high risk industrial population.

Panel Discussion 2:

The process of diagnosing of vascular disorders caused by hand-transmitted vibration.

Chairmen: Shin'ya Yamada and Niels Olsen

Session 4: Neurological Disorders

Chairmen: Ian Lawson and Mats Hagberg

****Nilsson T***

Neurological diagnosis: aspects on bedside and electroneurophysiological examinations

****Lundström R***

Diagnosis of neurological disorders - aspects of quantitative sensory testing

Session 5: Experience with neurological and other tests

Chairmen: Noriaki Harada and Ronnie Lundström

****Lindsell CJ and Griffin MJ***

Normative data for standardised diagnostic tests of the vascular and neurological effects of the hand-transmitted vibration

Maeda S, Sakakibara H and Yonekawa Y

Thermotactile threshold testing - Part 1: Measurement conditions

****Sakakibara H, Maeda S and Yonekawa Y***

Thermotactile threshold testing - Part 2: Screening of vibration-induced neuropathy

****Morioka M and Griffin MJ***

Dependence of vibrotactile thresholds on the psychophysical method

Session 6: Experience with neurological tests

Chairmen: Hisataka Sakakibara and Tohr Nilsson

Coughlin PA, Kent PJ, Kester RC

The role of aesthesiometry to detect changes in digit sensibility in patients with the hand-arm vibration syndrome

Harazin B, Kuprowski J and Koronowski R

Repeatability of the vibrotactile perception in healthy subjects - a pilot study

****Whitehouse D and Griffin MJ***

A comparison of vibrotactile thresholds obtained using different diagnostic equipment: the effect of contact conditions

Session 7: Experience from special studies

Chairmen: Kenneth McGeoch and Massimo Bovenzi

***Tominaga Y**

No vibration white finger in sand rammer user

Saha N, Coughlin PA, Kent PJ and Kester RC

Cessation of vibration exposure in patients with the hand-arm vibration syndrome does not prevent disease progression

Yamada S

National regulation for diagnostics in health surveillance and compensation of hand-transmitted vibration injury

Panel Discussion 3:

Neurological disorders caused by hand-transmitted vibration and their diagnosis.

Chairmen: Mats Hagberg and Noriaki Harada

Session 8: Musculoskeletal disorders

Chairmen: Tohr Nilsson and Noriaki Harada

***Hagberg M**

Clinical assessment of musculoskeletal disorders in workers exposed to hand-arm vibration

***Haward BM and Griffin MJ**

Normative data for grip strength and manual dexterity tests

***Toibana N, Ishikawa N and Sakakibara H**

Measurement of manipulative dexterity in patients with hand-arm vibration syndrome

Panel Discussion 4:

Conclusions on the identification and quantification of disorders caused by hand-transmitted vibration.

Chairmen: Massimo Bovenzi and Michael Griffin

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