Neurological problems associated with exposure to hand-arm vibration

Prof. J. MALCHAIRE

Unité d'Hygiène et de physiologie du travail
Université Catholique de Louvain – UCL

Introduction

Several occupational risk factors for musculoskeletal disorders are now well known (Pujol 1993; Hagberg et al., 1995): efforts, repetitiveness, speed of movements, and postures adopted for working. The present research aims to study the influence of vibration.

The use of vibrating tools is the cause of vascular, osteoarticular, and neurological disorders (Pelmear et al., 1992). These last disorders seem to be the first to appear in the form of tingling, numbness, and disorders of tactile sensitivity...

These disorders are classically listed on a subjective assessment scale: the scale of Stockholm (Brammer et al., 1987). Studies are necessary to establish the relationship between this scale and some tests and to determine the interest of these tests in early diagnosis of these disorders.

The goal of this prospective study is to monitor the evolution of the musculoskeletal and neurosensorial disorders and to study the influence of the use of vibrating tools, taking into account all personal characteristics of the workers and other ergonomic constraints.

The research aims
- to describe the prevalences of neurological problems, as well as their evolution, in a population of workers exposed to vibration;
- to study the relationship between these problems and occupational and non-occupational risk factors;
- to develop a battery of tests in order to study the relationship between subjective complaints and some of these tests and to establish their relevance to early diagnosis of some of these disorders.

Material and methods

A. Population

Three groups of workers were selected.

- A first group of 69 workers exposed to vibration, coming from 6 industrial sectors.
- A second group of 62 people exposed to heavy and repetitive work with regard to the wrists (packers and assemblers in a steel industry).
- A third group selected in the same company consisting of 46 people doing light and non-repetitive work (administrative tasks, control stations...).

B. Protocol of the study

All workers were subjected to:

- a questionnaire of 160 questions, completed during an interview and concerning:
  - personal characteristics (age, weight, size, seniority ...);
  - the person's state of health;
  - life habits and non-occupational activities (tobacco, alcohol, sport, ...);
  - professional activity characteristics;
  - history of musculoskeletal problems concerning regions of the neck, shoulders, elbows, and mainly the wrists and hands.

- a clinical examination (Cock and Masset, 1994) oriented toward the upper limb and more specifically toward detection of neurological disorders at the level of the hands.

- a battery of tests including measurement of:
  - the maximal voluntary prehension force, using a dynamometer;
  - the maximal amplitudes of movements at the level of the wrists;
  - sensory latency times of the median and ulnar nerves;
  - tactile sensitivity to pressure at the level of the pads of the 3d and 5^{th} fingers;
  - thresholds of vibration perception at the level of the same fingers;
  - manual dexterity on the dominant hand.

Each worker had completed this protocol by the time of the first and the second interviews.

In parallel, constraints at the workstations were evaluated:

- biomechanical parameters at the level of the two wrists for each worker (efforts, postures, speed and repetitiveness of movements), by means of surface electromyography and electronic goniometers. The duration of the observations was at least 2 to 3 work cycles.

- vibrations (amplitudes and frequencies) on every vibrating tool, by means of accelerometers and digital recorders, at the workstation, under the real conditions of use of the vibrating tools.

Results

A. Biomechanical constraints on the wrists

Except for group 2 (heavy and repetitive work), for which the angular speeds were greater, biomechanical constraints are on the average greater for workers exposed to vibration and smaller for the control group. Intra-individual variability was smallest for group 1 (vibrations), indicating that these workers as a whole are exposed to these greater constraints.

B. Vibration constraints

Most tools generate both low-frequency and high-frequency vibrations.

The weighted acceleration of personal exposure (A_{EP}) integrates variations in vibration amplitudes encountered during work and the daily or weekly exposure time. It was evaluated for every workstation by taking the mean of the results of random measurements on the different workers. A_{EP} varies from 2.5 to 10

ms^{-2} and the vibration dose, equal to $A_{EP}\ T^{0,5}$ (T being number of exposure years), varies from 4 to 28 ms^{-2} year $^{0,5.}$

C. Cross-sectional study

Prevalences of musculoskeletal disorders (TMS) are greatest for the neck (45%) and above all the wrists, with respectively 70%, 55%, and 30% complaints for groups 1, 2, and 3.

The clinical examination shows a greater number of pathologies (mainly tenosynovites and cysts) for groups 1 and 2.

Neurological complaints are also observed more often for group 1: prevalence of 40% as opposed to less than 20% in the two other two groups. These complaints are also distinctly more chronic. On the basis of the symptoms mentioned, the neurological problems are not severe according to the Stockholm scale, as 80% of complaints are at level 1.

The results of the different functional and sensory tests are weakly correlated ($R < 0.4$). This demonstrates their complementarity. These results depend on certain worker characteristics: mainly age, weight, and height. These characteristics were therefore taken into account in the analysis of relationships between tests and complaints.

The only results differentiating workers with and without neurological complaints are a reduction of maximal flexion of the wrist (5° on the average) and an increased pressure perception threshold (0.2). These slight differences do not permit individual diagnosis nor do they corroborate, therefore, the score on the Stockholm scale.

The MS and neurological complaints correlate essentially with the biomechanical and vibration work constraints.

Strength parameters emerge again for both types of complaints, while vibration parameters are associated only with the neurological complaints.

D. Prospective study

For new or aggravated MS complaints at the level of wrists, the respective incidences for the three groups are 14.7%, 9.7%, and 6.2%. For neurological complaints, they are 12.5%, 5.1%, and 2.5%.

Incidences of MS and neurological disorders are significantly higher for workers exposed to vibration.

Parameters associated with the development of severe "neurological" complaints are: maximal extension of the wrist, the pressure perception threshold, the vibration perception threshold at 250 Hz, and the sensory latency time. However, one cannot predict on an individual basis the development of such complaints by means of these tests. Again it does not appear possible to determine threshold values for classifying people with and without disorders with satisfactory sensitivity and specificity. The functional and sensory tests thus cannot be used to predict the development of severe complaints.

The prospective study shows again that the development of severe MS complaints is essentially related to strength parameters, while development of severe neurological disorders is mainly associated with exposure to vibration.

A model for predicting the risk of development of neurological disorders has been calculated according to the acceleration of personal exposure.

Conclusions

. The review of the literature takes stock of the present state of knowledge of the problem of MS disorders related or not to vibration (vibration syndrome, HAVS).

. This study and the previous one (Malchaire, 1995) describe the situation in Belgium concerning TMS of the upper limbs and neck.

. The development of neurological disorders is essentially associated with constraints at the workstation and mainly to exposure to vibration.

. The results, however, do not permit a discussion of the validity of frequency weighting of ISO 534. This point, as well as the short-term evolution of neurological disorders, is studied in the study complementary to this research.

. Value limits proposed by the draft European guideline 93/C77/02 are: threshold values (1 ms^{-2}), action values (2,5 ms^{-2}), and ceiling values (5 ms^{-2}). The corresponding probabilities of development of neurological disorders would be respectively 10%, 15%, and 25%.

. The functional and sensory tests show slight differences between groups of workers but do not make possible an individual diagnosis. Results underline the necessity of several complementary tests.

. Workers exposed to hand-arm vibration constitute a population particularly at risk both for MS and neurological disorders. Vibration must therefore be controlled in priority. Two reference books should help to determine these control measures: one on prevention of the risk due to the use of vibrating tools (Malchaire, 1998) and the other on prevention of the MS disorders (Malchaire and Indesteege, 1997).