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Rheumatic effects of vibration at work

Keith T. Palmer, Professor [a, *], Massimo Bovenzi, Professor [b, 1]

[a] Medical Research Council Lifecourse Epidemiology Unit, University of Southampton, ARUK-MRC Centre for Work and Musculoskeletal Heath, Southampton General Hospital, Southampton SO16 6YD, UK
[b] Clinical Unit of Occupational Medicine, Department of Medical Sciences, University of Trieste, Trieste 34100, Italy

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A B S T R A C T

Occupational exposures to vibration come in many guises, and they are very common at a population level. It follows that an important minority of working-aged patients seen by medical services will have been exposed to this hazard of employment. Vibration can cause human health effects, which may manifest in the patients that rheumatologists see. In this chapter, we identify the health effects of relevance to them, and review their epidemiology, pathophysiology, clinical presentation, differential diagnosis and vocational and clinical management. On either side of this, we describe the nature and assessment of the hazard, the scale and common patterns of exposure to vibration in the community and the legal basis for controlling health risks, and we comment on the role of health surveillance in detecting early adverse effects and what can be done to prevent the rheumatic effects of vibration at work.

The nature and measurement of vibration at work

Vibration is an oscillatory motion, characterised by the frequency of the oscillatory cycle, its magnitude and its direction. Its potential to cause injury is believed to relate to the average intensity of energy imparted to tissues.

* Corresponding author. Tel.: +44 (0)23 80777624; fax: +44 (0)23 80704021.
E-mail addresses: ktp@mrc.soton.ac.uk (K.T. Palmer), bovenzi@units.it (M. Bovenzi).
[1] Tel.: +39 (0)40 3992313; fax: +39 (0)40 368199.

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The magnitude of oscillatory motion can be quantified in terms of its maximum displacement or velocity, but it is normally expressed in terms of its acceleration, and time-averaged (the so-called 'root-mean-square (r.m.s.) magnitude'). The frequency of motion is expressed in cycles per second (hertz). Biodynamic investigations have shown that the response of the body to vibration is frequency dependent, and to account for this, standards for exposure evaluation weight the frequencies of measured vibration according to the assumed effects at each frequency. Frequency weightings are applied to measurements taken in three axes at right angles to one another, sited at the boundary between the body and the vibration (e.g., using accelerometers mounted on the handle of a powered tool or the seat of a vibrating vehicle). 'Dose' of vibration is based on specific relationships between the duration of exposure and vibration magnitude defined in the International Organisation of Standardisation (ISO) standards [1,2], allowing the daily vibration exposure to be re-expressed in terms of the equivalent acceleration that would impart the same energy over an 8-h reference period (a notional average working day). This is called the $A(8)$ (m/s^2 r.m.s.). Partial doses from several sources can be summed to an equivalent daily dose: inventories of sources, data on vibration magnitude from equipment handbooks or suppliers' information sheets and online ready reckoner calculators supplied in the UK by the Health and Safety Executive (HSE) [3] allow employers to estimate workers' exposures relative to control and surveillance standards set in European law.

In practice, two forms of vibrations are distinguished: hand-transmitted vibration (HTV) from handheld powered tools, with potential impacts on the upper limb, and whole-body vibration (WBV) from vehicles, and sometimes platforms, with potential impacts on the spine. For each type of vibration, two exposure limits are specified in the UK and European legislation [4] as follows:

(1) An exposure action value (EAV), representing the daily amount of exposure above which employers must act to control exposure. For HTV, this is an $A(8)$ of 2.5 m/s^2 r.m.s., and for WBV, it is 0.5 m/s^2 r.m.s.
(2) An exposure limit value (ELV), representing the maximum amount an employee may be exposed to on any given day: 5 m/s^2 r.m.s. for HTV and 1.15 m/s^2 r.m.s. for WBV (Doses of WBV can also be expressed in other units, but for simplicity we ignore this in the present account.).

Health surveillance is required for workers who remain regularly exposed above the EAV. These values have been translated into guidelines based upon typical patterns of exposure. For example, the use of hammer-action tools for >1 h/day, or of some rotary-action tools for >2 h/day regularly is likely to exceed the ELV for HTV, and the EAV may be breached by as little as 15 min/day of exposure to certain hammer-action tools [5] (Some employers employ a 'traffic-light' labelling system to identify tools with the worst characteristics.).

This summary of current approaches to risk assessment and control suggests a precise understanding of the exposure–response relationship, and a precise cut-off for safe practice. In fact, the ISO standard is predicated on the assumption that ~10% of a population exposed at the EAV will still suffer vascular effects over a period of ~12 years, and other formulae for summing the vibration dose accumulated over a lifetime have been found to approximate cross-sectional and longitudinal data on disease risks more closely than the official assessment standard. Similarly, the limit values for WBV have more to do with discomfort and tolerance than a well-described relationship between vibration dose and health effects on the spine.

Common sources of exposure

Exposure to HTV arises from many sources, including chainsaws, handheld grinders, concrete breakers, metal polishers, power hammers and chisels, needle scalers, scabblers, powered sanders, hammer drills and even powered lawnmowers and motorcycle handlebars (Fig. 1). Exposures are particularly common in the construction industry and in heavy engineering, but significant exposures can arise in many occupations, including builders, metalworking and maintenance fitters, welders, foresters, shipbuilders, foundry workers and labourers. In one survey, it was estimated that about 1.2 million men and 40,000 women in Britain had weekly exposures high enough to justify health surveillance [6,7].