Vibration Injury Network

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

Report on ISPESL – NIWL joint experimental studies on whole-body vibration

Appendix W3B to Final Report
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EC Biomed II concerted action BMH4-CT98-3251

1. Collaborative study on power absorbed during exposure to whole-body vibration

ISPESL : Paolo Lenzuni, Pietro Nataletti

NIWL: Patrick Holmlund, Ronnie Lundström

Introduction – Collaborative experiments between ISPESL and NIWL have been performed from January 29 to February 9. All experiments were run in the whole-body vibration laboratory of the Department of Technical Risk Factors at NIWL, Umeå

Methods– The amount of energy per unit time (power) absorbed was measured for twelve healthy individuals, with no previous record of professional exposure to hand-transmitted vibration. All subjects were adult males, age 33 – 50.

The experiment was designed to investigate functional dependence of absorbed power on the frequency and magnitude of vibration, as well as on the muscle tension of the exposed subjects, and on the spectral shape of the stimulus. The experiment was accordingly divided into three sections.

In section one the subjects have been tested three times at each of three vibration magnitudes (0.5 ms^{-2}, 1.0 ms^{-2}, 1.5 ms^{-2} rms). The posture was erect but relaxed. The vibration spectrum was flat from 2 to 20 Hz.

In section two the subjects have been tested once at each of three vibration magnitudes. The subjects were asked to provide the maximum muscle tension. The vibration spectrum was again flat from 2 to 20 Hz.

In section three the subjects have been tested once with each one of three input vibration signals, one at low frequencies (2 - 7 Hz), one at high frequencies (7 - 20 Hz), the third with a sinusoidal wave around 12 Hz superimposed on a low magnitude 2 - 20 Hz signal. The posture was erect but relaxed, as it was in section one.

During each exposure force and velocity signals were measured, and from cross correlation of these quantities absorbed power was calculated.

Results – The following is the outcome of a very preliminary analysis. A more thorough investigation will be needed for a complete exploration of the data collected.

The general trend of absorbed power with frequency is in good agreement with the existing studies on this topic (Lundström and Holmlund 1998, Mansfield and Griffin 1998). Data for the relaxed posture show a peak in the 5 ÷ 6 Hz region. The peak frequency is shifted to lower values if the tense posture is adopted. This is possibly explained by the larger transmissibility of stiff muscles, which allows more mass to be put into motion. This in turn results in a decrease of the resonant frequency. Higher peak values in the tense posture are also consistent with this picture.

Measurements at different magnitudes confirm the existence of a nonlinear behaviour described in the literature (Mansfield and Griffin 1998). Departures from linearity are smaller in the tense posture, vanishing completely for a few subjects.

The effect of different stimuli is currently (March 2001) being investigated.

2. Collaborative study according to the experimental design described in Appendix W3A carried out at NIWL

ISPESL : Paolo Lenzuni, Pietro Nataletti

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Methods - Six healthy male subjects were exposed to nine vibration stimuli. Subjects had weights between 69 and 77 kg (5/6 between 70 and 80 kg) and had statures between 173 and 186 cm (4/6 between 170 and 180 cm). Anthropometric measurements were made as required in WP3W. Subjects were exposed to each of three stimuli three times. The stimuli were three 60 second random vertical acceleration with an additional 1 second taper at each end of the stimulus. The magnitude of the stimuli were 0.5, 1.0 and 1.5 ms^{-2} r.m.s. Data were acquired at 200 samples per second at the following locations:

Seat	NIWL seat plate	x, y, z force	x, y, z acceleration
L3	skin mounted accelerometer	x, y, z acceleration	
Head	BITE-BAR	x, y, z, roll pitch, yaw acceleration	

Results - Vertical impedance data (i.e. apparent mass and absorbed power) showed results comparable to those in the literature. Peaks occurred at about 5 Hz and the frequency of the peaks reduced with increasing vibration magnitude. For the vertical transmissibilities to L3 a peak was observed at about 5 Hz that also reduced in frequency with increasing vibration magnitude. Vertical seat to fore-and-aft L3 transmissibilities had a modulus of less than 1 at frequencies below 20 Hz. There was some variability between subjects, but all showed a peak between 5 and 7 Hz. Vertical seat to lateral L3 transmissibilities showed a modulus of less than 0.3 at frequencies above 5 Hz. Data correction was applied to all measures of vibration on the surface of the skin at L3 using Kitazaki's method. In the vertical direction the effect of the correction was to reduce the modulus of the transmissibility above 10 Hz but the frequency of the peaks in the transfer functions were not affected. Data correction had little effect on the seat vertical to L3 fore-and-aft transmissibilities. For the lateral direction the mounting of the accelerometer was the least well coupled. However, the effect of the mounting was greatest in the frequency range where the modulus of the transmissibility was low and so the absolute change from the data correction was small.