Energy Absorption in the Hand and Arm System Exposed to Impact Vibration with High Frequency Contents

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In the following study, ten subjects were exposed to four different authentic vibrations with impact and high frequency contents. The purpose was to investigate the energy absorbed in the hand and arm system from hand-held vibrating tools. The tools studied were a chipping hammer, an impact drill, an impact wrench and a breaker. The frequency range chosen was 20 to 5000 Hz. The influence of two frequency-weighted acceleration levels, 3 and 6 m/s^2, and two different grip and feed forces, 20 and 40 N, were also investigated. The study shows that there were differences in the amount of vibration energy between the four types of hand-held vibrating tools. The impact wrench and the impact drill contributed to higher absorbed energy in the hand than the chipping hammer and the breaker. The energy absorbed in the hand and arm increased with the vibration level. No clear relationship was found between the hand forces and the energy absorption. Furthermore, the results show a relationship between the rise time of the tools and the amount of energy absorbed in the hand and arm. A conclusion from this study is that tools which generate impacts with a short rise time increase the risk of vibration injuries.

1. INTRODUCTION

Vibrating tools generate different kinds of vibration, i.e. sinusoidal, random and impact. Tools like chipping hammers, impact drills, impact wrenches and breakers generate vibration with impact and high-frequency contents. This vibration often typically contains repetitive impacts, usually with low levels of acceleration at low frequencies, between 20 to 100 Hz, and high levels of acceleration at higher frequencies. Each stroke generates an initial transient with very high peak acceleration.

There has been discussion as to whether vibration-containing impacts has stronger effects on the hand-arm system in comparison with vibration not containing impacts. Some studies in the international literature indicate that impact vibration has contributed effects to vibration injury, for example vascular disorders;[1-7] and effects on the locomotor apparatus of the hand-arm system, especially located at the wrist and elbow.[5,8] Acute effects, such as decreased vibrotactile thresholds due to impact-type vibration, have also been shown to differ from non-impact vibration exposures.[9-11] There are also studies where no differences have been found between impact and non-impact vibration.[12-14]

The current standard, ISO 5349,[15] states that measurements of vibration should be taken for a period of four hours within the frequency range 5 to 1500 Hz and presented as a frequency-weighted acceleration. The standard applies to periodic, non-periodic or random vibration and can only be used temporarily for the risk assessment of high-frequency and impact vibration. Our knowledge of the effects of shock-type excitation is, however, limited.

An alternative measurement method for considering vibration with high-frequency and impact contents could be to determine the energy absorption instead of the acceleration magnitude in the hand and arm system.[16,17] The assumption is that a higher quantity of absorbed energy per unit of time (power) represents an increased risk of vibration injuries or a reduction in comfort.[17] Studies show a correlation between energy absorption and the prevalence of vibration disorders for frequencies below 1250 Hz.[18-20]

The aim of the present study was to investigate the absorption of vibration energy in the hand and arm while the subject was exposed to four common, authentic vibrations with impact and high-frequency contents. A further aim was to study the influence of the grip and feed forces on energy absorption.

2. METHODS

2.1. Apparatus

The authentic vibration which affected the subjects through the handle was measured with an accelerometer (Rion PV90B) and recorded by a DAT recorder (Sony 204 A). The signals were measured on four common types of hand-held vibrating tools that generate strong impacts with a high-frequency content (a chipping hammer, an impact drill, an impact wrench and a breaker). The impact frequency was 50 Hz for all the tools, and the measurements of the signals were taken under practical working conditions. Tools that generate impacts have a higher frequency content compared with other vibrating tools.[21]

The recorded signals were then displayed on an oscilloscope (Hewlett & Packard 54601 B). One typical stroke was chosen and then transferred to a computer. Using a computer program (Hewlett & Packard 34820 A), the signal could be adjusted and then stored as a time signal (Fig. 1) in a function waveform generator (Hewlett & Packard 33120 A). The frequency range studied was 20 to 5000 Hz. The limitations of the frequency range studied are dependent on the technical equipment.