

## AN INVESTIGATION OF THE RELATIONSHIP BETWEEN VIBRATION-INDUCED WHITE FINGER AND POWER ABSORPTION

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### Introduction

About 30 years ago, it was proposed that vibration energy/power absorption might be a significant etiological factor in vibration-induced disorders (Lidström, 1973; 1977). It was also suggested that the energy dissipation in the hand would provide a better indication of vibration damage than would a measure of the vibration acceleration spectrum. Since then, the energy method has been used in many studies. However, some doubts on the energy method have been raised (Griffin, 1990). Our review (Dong et al., 2001) indicated that the validity of this method has been far from sufficiently established. The total energy method that has been used almost exclusively in the past has several fundamental deficiencies; and the method is thus questionable for studying vibration-induced white finger (VWF) (Dong et al., 2003). The specific aim of this study is to find whether the total vibration power absorption (VPA) has a stronger association with VWF than the acceleration measured on a power hand tool.

### Method

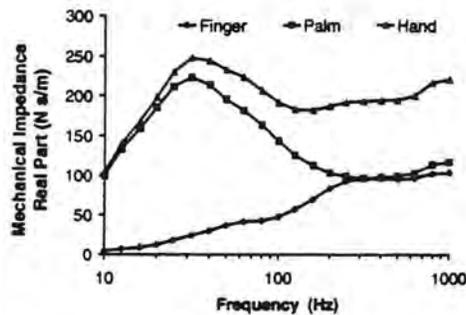
The medical examination data reported in the epidemiological study (Lidström, 1977) that was originally used to support the energy method were used in the current study. The vibration acceleration spectra of three types of tools (rock drill, chipper, and grinder) were reconstructed based on previously reported experimental data (Griffin, 1998). The reconstruction was carried out by matching the calculated VPA values using the mechanical impedance (MI) of hand-arm system measured in the present study with the VPA data reported in Lidström's epidemiological study. The MI was measured using the method developed by NIOSH investigators (Dong et al., 2003). After obtaining the tool vibration spectra and MI data, the VPA values for the fingers, the palm, and the entire hand-arm system were calculated ( $VPA = \text{Real}(MI) * \%V^2$ ). The unweighted acceleration and the weighted acceleration according to ISO 5349-1 (2001) were also calculated. These results were compared to determine the better measure for risk assessment.

### Results

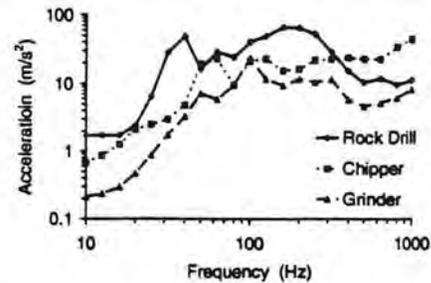
Fig. 1 shows the real part of the MI values measured at the fingers and the palm, together with their summation that forms the total MI of the entire hand-arm system. As the results indicate, the MI at the palm has an obvious resonant range from 25 to 63 Hz. At frequencies below 100 Hz, the palm MI accounts for the majority of the total hand MI. At the low frequencies, the palm MI is substantially greater than the finger MI. Fig. 2 shows the vibration spectrum of the three types of tools used in this study. Table 1 lists the prevalence of the disorder among the workers using these three types of tools and their corresponding VPA values, as well as the weighted and unweighted accelerations. The correlation between the unweighted acceleration and the disorder prevalence shows the strongest relationship ( $r = 0.986$ ,  $p = 0.108$ ).

### Discussion and Conclusions

The results of this study suggest that the VPA may be responsible for a portion of vibration-induced injuries or disorders, but the VPA of the entire hand-arm system is not a good measure of the energy absorption for the study of VWF. This is because the total energy method ignores the energy concentration effect, the distribution characteristics at different locations and frequencies, and the differences between different tissues' resistances to injury. The VPA at low frequencies is mostly transmitted from the palm and distributed through the entire hand-arm system. It is not reasonable to associate such VPA directly with finger disorders. The measurement of local finger VPA can partially overcome these deficiencies. Hence,



**Figure 1** Mechanical impedance (real part) of the fingers, the palm, and the entire hand-arm system.



**Figure 2** Vibration spectra of three types of tools (based on the data reported by Griffin (1998))

it showed a better relationship with VWF. The best measure of the energy absorption is probably VPA density (VPA per unit volume or tissue mass), which requires further studies.

**Table 1** Relationships between the prevalence of vibration-induced finger disorders and the vibration measures (VPA in watts, and root-mean-square acceleration in  $m/s^2$ .)

Worker Category	*Prevalence of VWF(%) /Norm. Ratio***	*Reported hand VPA(W) /Norm. Ratio	Hand VPA(W) /Norm. Ratio	Finger VPA(W) /Norm. Ratio	Palm VPA(W) /Norm. Ratio	Weighted Acc.( $m/s^2$ ) /Norm. Ratio	Unweighted Acc.( $m/s^2$ ) /Norm. Ratio
Rock drilling	72 / 3.43	21.0 / 30.0	21.00/30.0	3.28/20.71	17.72/32.72	30.86/5.24	150.84/3.77
Chiseling	53 / 2.52	2.7 / 3.86	2.70/ 3.86	0.54/3.39	2.16/3.99	11.25/1.91	93.19/2.33
Grinding	21 / 1.00	**0.7/ 1.00	0.70 / 1.00	0.16/ 1.00	0.54/ 1.00	5.89/ 1.00	39.98/ 1.00

\* Data from Lidström (1977).

\*\* 0.07 Watt was reported in the reference Lidström (1977), which was likely either an editorial or measurement error. 0.7 Watt is much more reasonable.

\*\*\* Normalized Ratio = The value for a specific worker category / The value for the reference category (grinding).

The results suggest that the unweighted acceleration is far better than any energy absorption measure. The unweighted acceleration is also better than the frequency-weighted acceleration recommended in the current ISO 5349-1 (2001). This conclusion is consistent with those of a recently published epidemiological study (Griffin et al., 2003) and several earlier studies (e.g. Pelmeur et al., 1989). This also further supports the NIOSH-published position on this issue (NIOSH, 1989).

In summary, this study indicates that the association between the total VPA and VWF is very weak. The VPA distributed at the fingers has a better relationship with VWF than the total VPA. The palm VPA is unlikely associated with VWF, but it may have some association with disorders in the palm-wrist-arm-shoulder-neck-head system. Of the measures studied, the unweighted acceleration measured on a tool is the best gauge for assessing risk of VWF.

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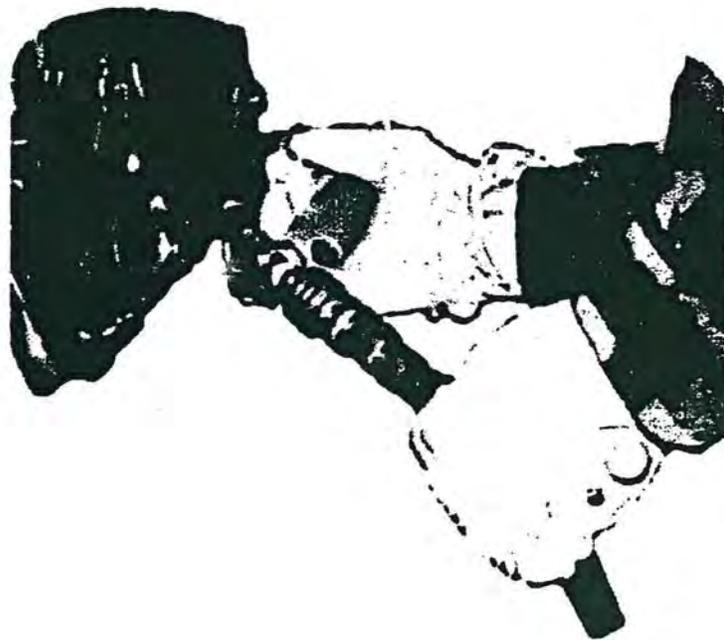
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