

**THE VIBRATION RESPONSES OF
A HANDHELD WORKPIECE AND THE HAND-ARM SYSTEM**

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Introduction

Grinding and polishing of handheld workpieces are widely used in the fabrication or repair of some components of sports equipment, tools, furniture, and dentures. Such processes may generate significant vibrations that can be effectively transmitted to the fingers or hands of the workers holding the workpieces. The vibration exposure may cause vibration-induced white finger (VWF). The objective of this study was to characterize the vibration responses of the handheld workpiece and the hand-arm system. Such knowledge is required to enhance the understanding of their vibration response, to develop a model of the system, and to help explore more effective engineering methods for reducing the vibration exposure and health effects.

Methods

The experimental method used in this study is shown in Figure 1. A typical handheld workpiece (a golf club head) was used in the experiment. The two hands held the workpiece with the posture similar to that used in fine grinding.¹ The vibration was provided from a single-axis vibration test system (Unholtz-Dickie, TA250-S032-PB). The excitation spectrum (6.3 to 1,600 Hz) was an extension of that defined in the current ISO 10819 (2013).² It was delivered to the workpiece through an instrumented handle equipped with a tri-axial accelerometer (Endevco, 65-100) and two force sensors (Kistler 9212). Unlike a conventional instrumented handle with a cylindrical shape for the measurement of the biodynamic responses of the hand-arm system, the current handle has a flat interface. It was used to measure the input acceleration, interface feed force, and apparent mass of the workpiece-hand-arm system. The vibration of the workpiece was measured using a tri-axial accelerometer (PCB 356A11) installed on the club head. The vibration at each of the four locations (hand dorsum, wrist, forearm, and upper arm) was measured using adapters equipped with tri-axial accelerometers (Endevco, M35), which was secured in place using a cloth wrap, as also shown in Figure 1. Ten healthy adult subjects (5 males and 5 females) participated in this experimental study. The influencing factors considered in this study include two hand conditions (bare and gloved hands), two feed forces (15 and 30 N), and

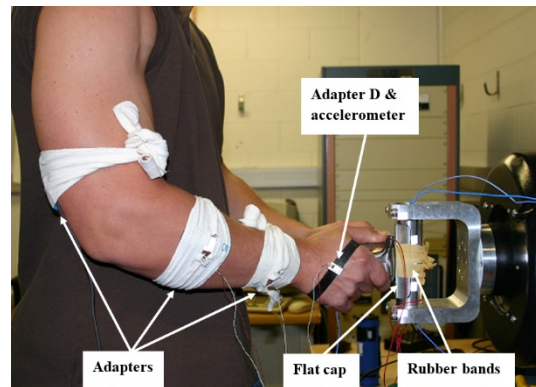


Figure 1: A pictorial view of experimental setup and hand-arm postures.

six simulated grinding interfaces represented by six synthetic rubber samples (R1, R2, R3, R45, R55, R65) with different stiffness values.

Results

Examples of the measured impedance and transmissibility spectra for 30 N feed force are shown in Figure 2.

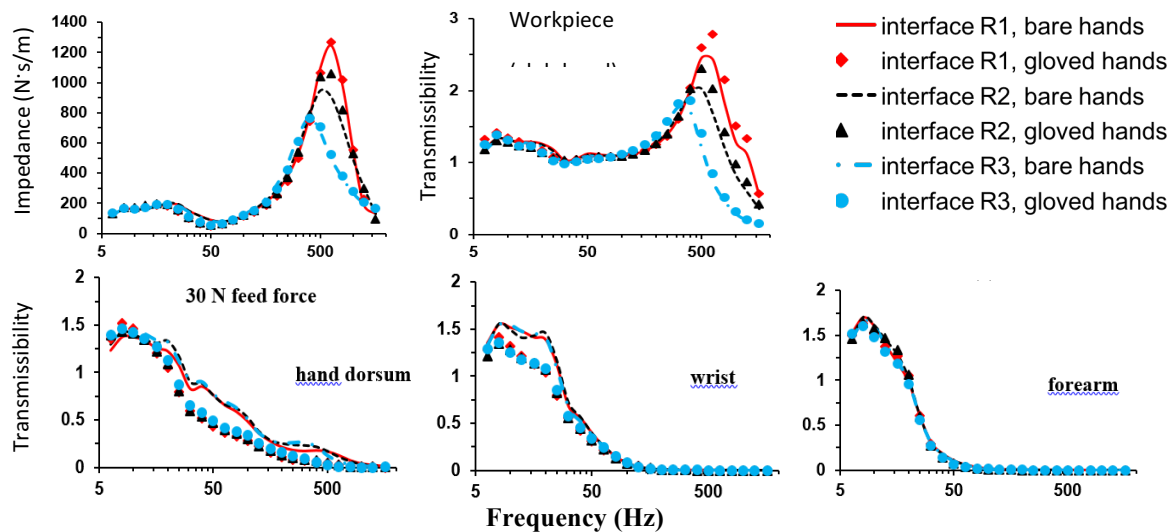


Figure 2. Examples of mechanical impedance of the entire workpiece-hand-arm system and the vibration transmissibility spectra measured on workpiece, hand dorsum, wrist, and forearm.

Discussion

The results of this study indicate that the vibration of the workpiece was significantly affected by the grinding interface stiffness, applied feed force, and gloves, especially in the major resonance of the workpiece. However, the vibration transmissibility on the hand-arm system was only significantly affected by the feed force and glove. While the use of vibration-reducing gloves marginally increased the resonance of the workpiece, the gloves significantly reduced the vibrations transmitted to the hand dorsum and wrist. This suggests that vibration-reducing gloves can be considered as one of the measures for reducing vibration exposures during the grinding of handheld workpieces.

References

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2. ISO 10819 (2013): Mechanical vibration and shock - hand-arm vibration - measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand. Geneva, Switzerland.

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