HIGH FREQUENCY VIBRATION TRANSMITTED TO THE HUMAN FINGERS WITH AND WITHOUT WEARING GLOVES

*Daniel E. Welcome, Xueyan S. Xu, Thomas W. McDowell, Christopher M. Warren, John Z. Wu, and Ren G. Dong

Health Effects Laboratory Division, National Institute for Occupational Safety and Health
Morgantown, WV 26505, USA

Introduction

Vibration at frequencies above 100 Hz may not be effectively transmitted to arms but it can be transmitted to the hands, especially to the fingers and palms of the hands. This may partially explain why vibration-induced white finger can be found among workers using tools such as grinders, chipping hammers, and rivet hammers, which mainly generate high-frequency vibrations. While the vibrations transmitted to the fingers in three orthogonal directions for frequencies up to 500 Hz have been investigated in our previous study[1], the vibration transmissions on the fingers at higher frequencies in the three directions have not been sufficiently studied. The objectives of this study are to verify the reported results and to investigate the finger vibration transmission at high frequencies. The effect of vibration-reducing gloves on the finger vibration transmissibility is also examined in this study.

Method

The transmissibility spectra at the fingertips and the proximal area of the fingers in each of the three orthogonal directions were measured in separate tests on a uniaxial shaker (Unholtz-Dickie) for six subjects using a 3D Scanning Laser Vibrometer (PSV-500, Polytec). Figure 1 shows the placements of the hand and fingers on the instrumented handle for each of the three orthogonal directions (X, Y, and Z), along with the locations of the retro-reflective tapes used to assure good optical signal in each case. As shown in the Figure, the left or right hands were used depending on the best sight lines for the laser. The Z direction is along the axis of the arm, Y is in axial shear and X is orthogonal to both. The subjects maintained a combined 30 N grip, 50 N push for the tests in the Z direction and gripped only at 30 N for the tests in the X and Y directions. The handle was instrumented with force sensors (9212, Kistler) and an accelerometer (356A12, PCB) for feedback to shaker; and a low pass filter with a cutoff at 5 Hz was used to display the forces. The subjects were tested barehanded, with a neoprene glove (Glove 1), and an air bladder glove (Glove 2), as in previous experiments[1]. A random vibration spectrum in a frequency range of 10 - 1600 Hz was used as the excitation for the X and Z directions, which was similar to that for the standardized glove test[2]. Due to the lower resonance of the instrumented handle used for the Y-direction tests, the excitation spectrum was limited to 700 Hz.

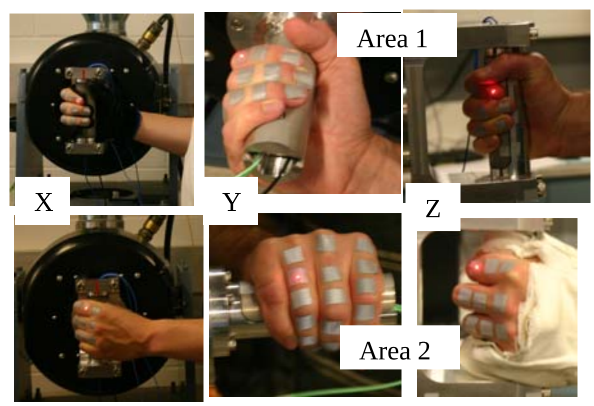


Fig. 1: The measurement of finger vibration

Results and Discussion

As examples, Fig. 2 shows the vibration transmissibility spectra measured at the top surface of the distal part of fingers (Area 1 in Fig. 1) of a subject exposed to the random vibration in each of the three directions. Consistent with the spectra reported before[1], the transmissibility of the bare fingers in each direction was close to 1.0 in the low frequency range (f < 25 Hz). It gradually increased with the increase in frequency, reached the peak at the major resonant frequency, and decreased with further increase in frequency. With a grip force of 30 N, the major resonant frequency was in a range from 80 to 160 Hz, depending on the vibration direction and subject. The transmissibility remained greater than 1.0 for f < 500 Hz in the X and Z directions, and for f < 250 Hz in the Y direction.

As also shown in Fig. 2, the major resonant frequency was reduced when the gloves were used. This is because each glove basically serves as a cushion between the fingers and the handle and it reduces the contact stiffness of the fingers. As a result, the overall transmissibility of the gloved fingers became greater than that of the bare fingers in a large part of the middle frequency range. This means that the gloves are likely to increase the frequency-weighted vibration transmitted to the fingers and it is not beneficial to wear the gloves if the vibration-reducing effectiveness of the gloves is judged based on the current standard for assessing the risk of the vibration exposure[3]. However, the gloves, especially the neoprene glove (Glove 1), substantially reduced the fingers-transmitted vibration for f > 150 Hz. This means that the gloves are likely to reduce the unweighted vibration if the vibration spectra of a hand tool or handheld workpiece contain substantial high-frequency components. In such cases, the effectiveness of the gloves may be underestimated when judged based on the standard method.

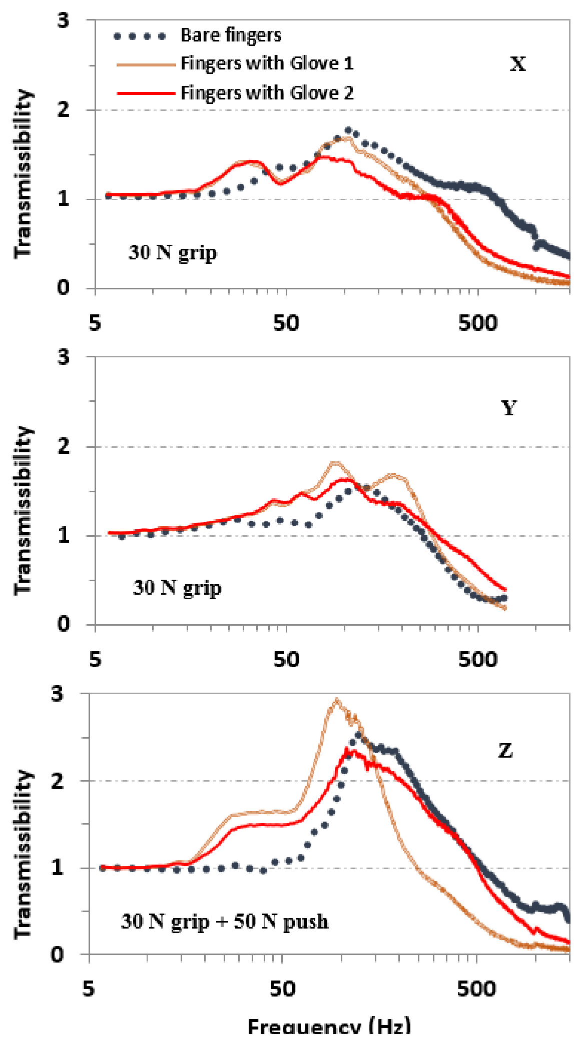


Fig. 2: The transmissibility spectra of the fingers with and without wearing gloves.

References

1. Welcome DE, Dong RG, Xu XS, Warren C, and McDowell TW (2014). The effects of vibration-reducing gloves on finger vibration. International Journal of Industrial Ergonomics. 44: 45-59
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. International Organization for Standardization, Geneva, Switzerland.
3. ISO 5349-1, 2001: Mechanical vibration - Measurement and evaluation of human exposure to hand-transmitted vibration - Part 1: General requirements. International Organization for Standardization, Geneva, Switzerland.

MEDICAL COLLEGE OF WISCONSIN

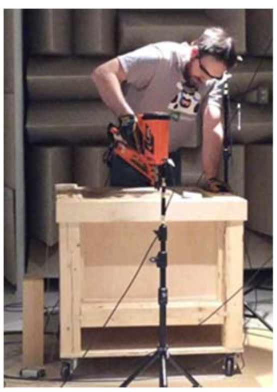
Program & Proceedings
6th American Conference on Human Vibration

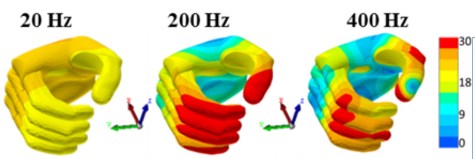
MARQUETTE UNIVERSITY
BE THE DIFFERENCE.

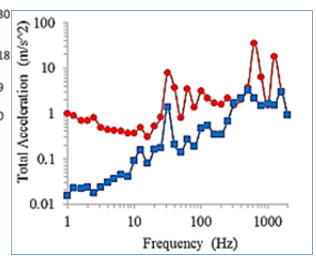
Venue: Marquette University Alumni Memorial Union

Teaming physicians / health professionals, engineers and research scientists in academia, government and industry to understand and prevent vibration disease and engage the next generation of students

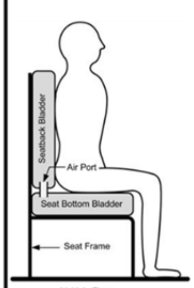
Distinguished Keynote Speaker: Massimo Bovenzi, MD

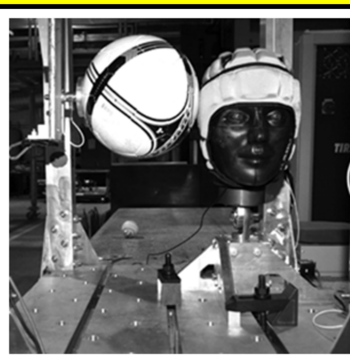


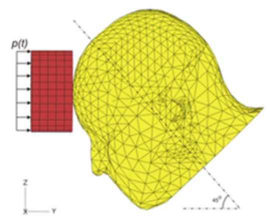


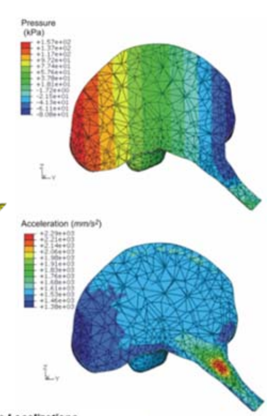


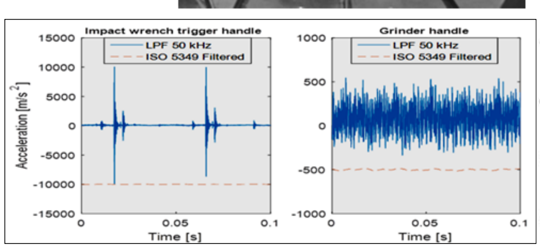
Samples of the Hand Arm, Whole Body and Impact Vibration Research Studies

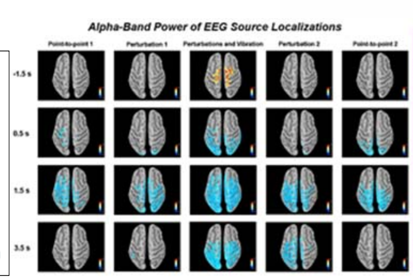


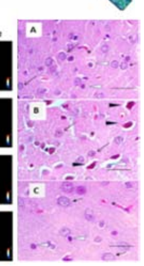












Proceedings of the

Sixth American Conference on Human Vibration

June 8 – 10, 2016

Jointly hosted by the

Medical College of Wisconsin

and

Marquette University

Venue
Marquette Alumni Memorial Union
Milwaukee, Wisconsin, U.S.A

Co-chaired by

Danny A. Riley, PhD
Department of Cell Biology, Neurobiology & Anatomy
and Physical Medicine & Rehabilitation
Medical College of Wisconsin

and

Brian D. Schmit, PhD
Department of Biomedical Engineering
Marquette University
Medical College of Wisconsin

http://www.mcw.edu/American-Conference-on-Human-Vibration-ACHV.htm