VIBRATION TRANSMITTED FROM AN IMPACT WRENCH TO THE HUMAN WRIST AND ELBOW

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Introduction

Extensive use of impact wrenches could expose operators to prolonged, intensive vibration. Such exposure could result in hand-arm vibration syndrome. The effects of vibration exposure in a structure of the hand-arm system are likely to be more closely related to the actual vibration power absorption at that specific structure [Dong et al. 2008]. The objective of this study was to characterize the vibration transmitted to the wrist of the operators of impact wrenches.

Methods

Six experienced male operators of impact wrenches participated in the experiment. Each of them used 15 impact wrenches on a simulated work station (Figure 1). For each trial, the subject seated 10 nuts onto plate-mounted bolts in a 30-sec period. Five trials were performed for each tool. Triaxial accelerations at three locations (tool handle, wrist, and elbow) were measured. In an effort to better simulate actual work situations in the field, postures were not controlled, and the subject could use a posture judged to be most comfortable. The six subjects generally adopted one of three postures wherein the tool handle was oriented vertically, horizontally, or at a 45° angle. Figure 1 shows the 45° working posture.

In addition, a vibration transmissibility test was performed on a one-dimensional (1-D) vibration system using a broadband random vibration as the excitation (Figure 2). Operators were instructed to keep the same posture and apply the same grip and push forces to the shaker's instrumented handle as they perceived in the tool test. Whereas the instrumented handle provided the measurement of the input vibration, the accelerometers fixed on the subject's wrist and elbow were used to measure the transmitted vibrations. For each subject, six trials were performed lasting 30 sec each.

Figure 1.—Operation of an impact wrench.

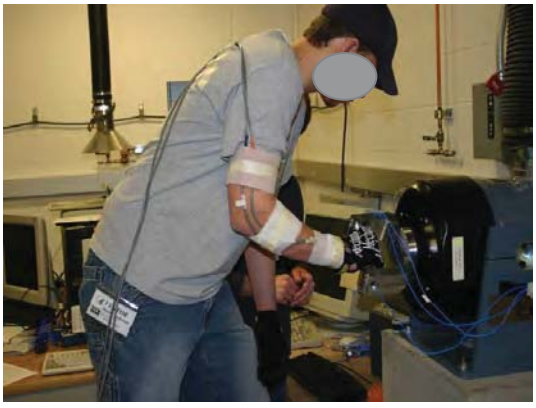

Figure 2.—Measurement of the transmissibility on a 1-D test system.

Results and Discussion

Even though the vibration magnitudes measured at the three locations are statistically significantly different across 6 subjects × 15 tools × 5 trials = 450 trials (ISO-weighted tool handle acceleration: 6.26 ± 2.08 m/s^2; wrist: 7.49 ± 2.54 m/s^2; elbow: 4.05 ± 1.32 m/s^2), they are reliably correlated with each other ($p < 0.001$). The correlation between ISO-weighted tool acceleration and wrist acceleration is shown in Figure 3. Figure 4 shows the transmissibility measured with the six subjects on the 1-D test system, together with ISO frequency weighting (ISOwt), the transmissibility-derived weighting ($W_{Tr\text{-}Wrist}$), and the weighting derived from palm vibration power absorption (VPAwt) [Dong et al. 2008]. The vibration transmissibility shows a resonant peak at 31.5 Hz. A similar trend is observed in the VPA weighting. However, this resonance is not reflected in the ISO weighting.

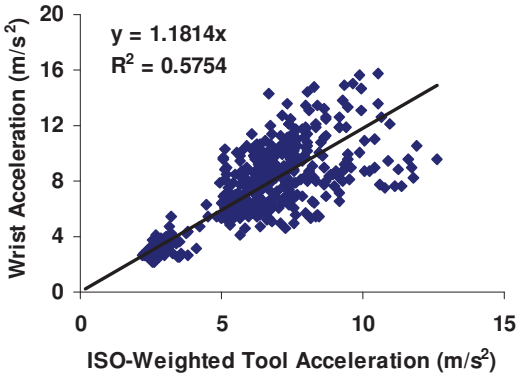

Figure 3.—A correlation relationship.

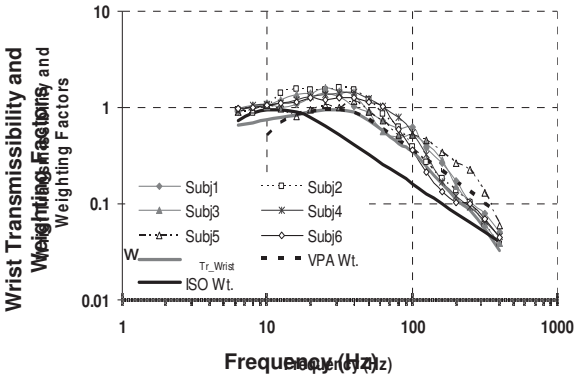

Figure 4.—Vibration transmissibility and frequency weighting.

The reliable correlation between ISO frequency-weighted tool acceleration and the wrist and elbow accelerations suggests that the ISO weighting partially reflects the characteristics of the vibrations transmitted to the wrist and elbow. The results, however, also suggest that the ISO weighting may underestimate the effect of the resonance of the hand-arm system. It is feasible to develop a wrist vibrometer for continuously measuring the vibration transmitted to the wrist. The exposure duration of the vibration can also be accurately quantified with a wrist vibrometer. A method based on wrist vibration measurement may be developed to monitor the exposure and to assess the risk of the exposure at least in the wrist-arm subsystem.

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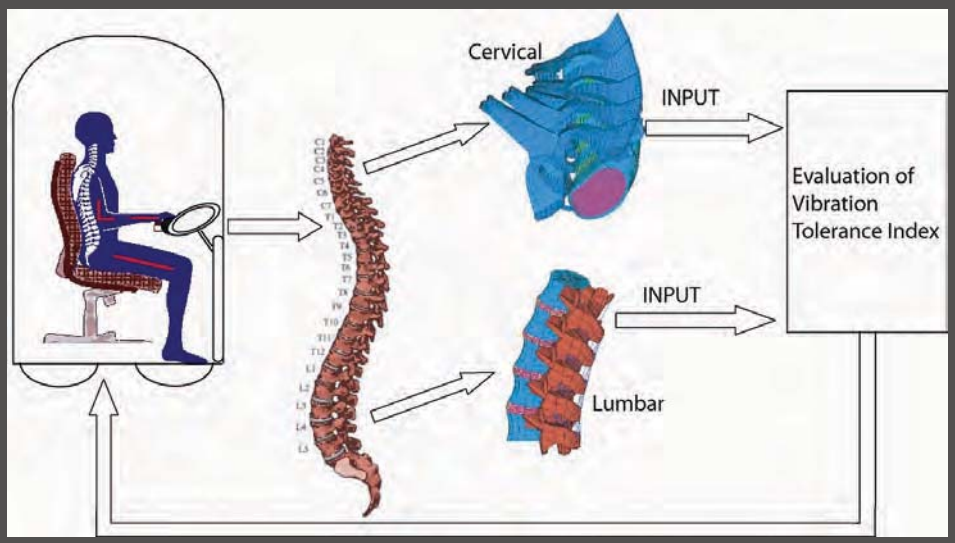

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