A NEW BIODYNAMIC APPROACH TO ASSESS THE EFFECTIVENESS OF ANTIVIBRATION GLOVES

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Introduction

Antivibration gloves have been increasingly used to help reduce hand-transmitted vibration exposure. A critical question is how much the gloves can help. Another important question is whether the effectiveness of the gloves can be further improved. The objectives of this study were to develop a new biodynamic approach to predict the vibration transmissibility of the glove at the palm and fingers of a human hand and to analyze the mechanisms of the gloves.

Method

The proposed method is based on the measurement and modeling of the driving-point biodynamic response of the hand-arm system. First, the mechanical impedances distributed at the fingers and the palm of the hand for a bare hand and a gloved hand were measured separately using a reported method [Dong et al. 2006]. The same postures and hand forces (30-N grip and 50-N push) as those specified in ISO 10819 (1996) and a broadband random vibration were used in the measurement. Six subjects participated in the experiments using two types of gloves (glove A: air bladder; glove B: gel-filled). Next, the experimental data measured with the bare hand were used to establish a five-degree-of-freedom mechanical-equivalent model of the hand-arm system (the part with nonfilled boxes and their connections in Figure 1) using a reported method [Dong et al. 2007]. Then, based on the assumption that the biodynamic properties of the hand-arm system remain unchanged when wearing a glove, we developed a mechanical equivalent model of the gloved hand-arm system (Figure 1) using the experimental data measured with the gloved hand. More specifically, the model parameters for the bare hand-arm system remain unchanged in the determinations of the elements for simulating the glove (the part with filled boxes and their connections in Figure 1) in the model. Finally, the glove transmissibility at the fingers is determined by taking the ratio (x_4/y) of the finger skin motion (x_4) in the gloved hand model and the handle motion (y). Similarly, the glove transmissibility at the palm is calculated by taking the ratio (x_3/y) of the palm skin motion (x_3) and the handle motion (y).

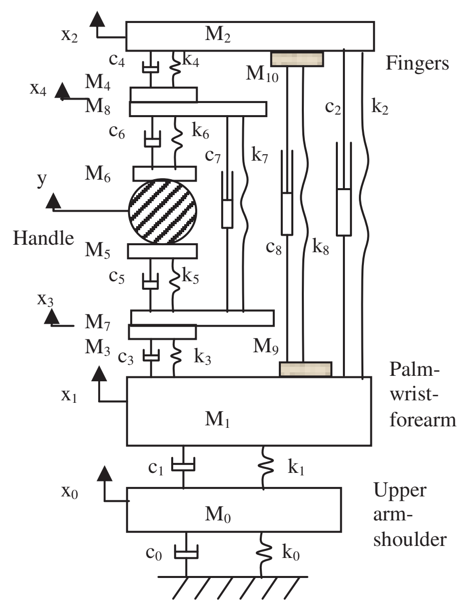

Figure 1.—A model of the gloved hand-arm system.

Results and Discussion

Figure 2 shows the predicted glove transmissibility values, together with those measured with the palm adapter method reported in our previous studies [Dong et al. 2003, 2004]. The basic trends of the measured and predicted transmissibility data at the palm are consistent, and their values are comparable below 200 Hz for glove A and 300 Hz for glove B. The isolation effectiveness of glove A is better than that of glove B. These observations suggest that both the proposed and the adapter method are acceptable, at least for glove-screening tests. The results also show that the gloves can provide some vibration reduction at the palm at frequencies higher than 30 Hz, but are not effective for reducing finger exposure if the vibration frequency of concern is below 250 Hz. Therefore, it is inappropriate to use the transmissibility measured at the palm to estimate the overall vibration reduction for the hand-arm system. Whereas the palm transmissibility may be used to help assess palm-wrist-arm system vibration exposure, the finger transmissibility may be applied to help assess finger vibration exposure.

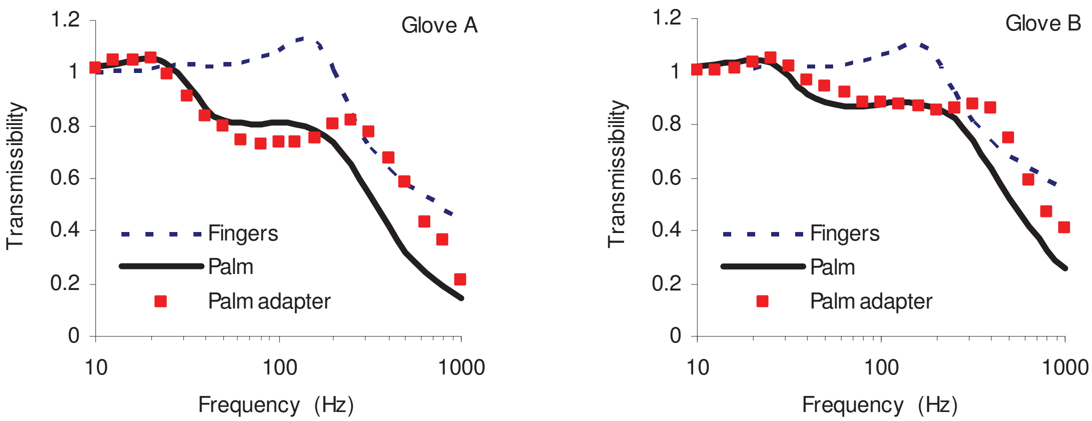

Figure 2.—Vibration transmissibility functions of an air-bladder glove (glove A) and gel-filled glove (glove B) predicted using the proposed method and measured with an adapter method [Dong et al. 2003, 2004].

In addition to the transmissibility of the gloves, the glove influences on the vibration power absorption distributed in the major substructures of the system can also be predicted using the model. Whereas it is unavoidable to impose some interference to the glove-hand-arm system in the glove test using an adapter method or an on-the-hand method, this new approach does not impose any such interference. The proposed model can be further used to identify the major factors that influence glove effectiveness and to help develop better antivibration devices.

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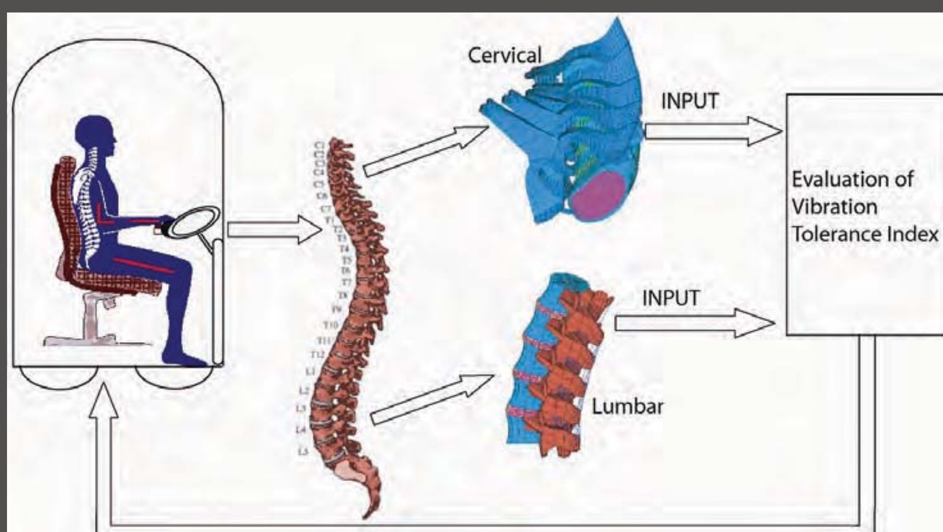

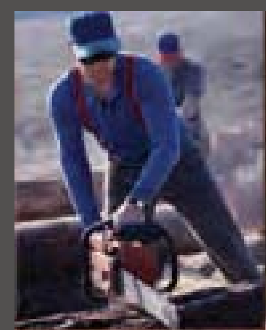

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