A PILOT STUDY OF GLOVE EFFECTS ON A FORCE MATCHING METHOD

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Introduction

Operating powered hand tools such as chipping hammers and rock drills frequently requires forceful and repeated push and grip actions to control the tools and achieve desired productivity. Many of these tools are also known to generate high magnitudes of hand-transmitted vibration. A tight hand-tool coupling imposes high stresses on the anatomical structure of the hand-arm system and impedes peripheral circulation; it also increases hand-arm vibration (HAV) transmissibility (Brammer, 1982; Hartung et al., 1993; Riedel, 1995). Although the importance of hand coupling force has been recognized, the current international HAV assessment standard (ISO-5349-1, 2001a) has not accounted for this factor. This is partially due to the lack of a practical method for quantifying the hand coupling force. Several approaches have been proposed to modify the assessment methodology to include the hand force effect (Riedel, 1995; Kaulbars, 1996). An international committee has drafted a working document in an effort to develop a generally acceptable method for quantifying hand coupling forces (ISO/WD 15230, 2001b). While it is technically feasible to accurately measure hand forces using instrumented handles or flexible force sensors (see Welcome et al., 2001), quantifying hand forces applied to tools in the workplace remains a formidable task.

As a convenient approach, a psychophysical technique called magnitude-reproduction or the force matching method has been used to quantify various hand and arm forces (e.g. Stevens, 1960; Gescheider, 1997). However, the use of this technique for measuring hand forces applied to vibrating tools has not been seriously studied. To examine and refine this technique, NIOSH researchers have planned a series of systematic studies. As part of this process, this study focused on glove use as an influencing factor on force matching accuracy.

Method

This study employed a simulated chipping hammer workstation. (See Figure 1.) The workstation was fabricated based on the design presented in the ISO chipping hammer test standard (ISO 8662-2, 1992). This design limits lateral tool movements; thus, the subject can monitor and accurately control the applied push force.

Six adult male subjects participated in the pilot study. During each trial, the test subject stood on a platform and applied a downward push force on the handle of an operating tool. The subject assumed an arm posture similar to that specified in the ISO standard. Four push force levels (50, 100, 150, and 200 N) were examined. A force plate was used to measure the applied push force. To provide feedback for the subject, the push force was displayed on a computer monitor. At the end of an 8-second tool operation period, the chipping hammer was turned off. Immediately after the tool stopped, the subject removed his hands from the tool handle and placed them on an instrumented handle mounted adjacent to the workstation platform. The subject then attempted to reproduce the push force he applied during the tool operation. Trials were performed with bare hands or with anti-vibration gloves. Two types of anti-vibration gloves (air bladder and visco-elastic) were examined. The data were analyzed with a mixed-model, two-way ANOVA.

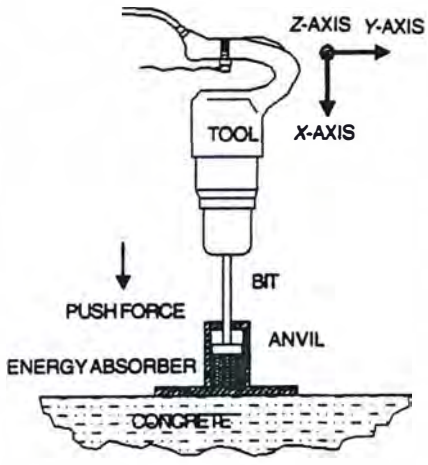

Figure 1 Simulated workstation.

Results

The variable of interest was the difference between the force matching attempt and the tool operation target force. First, the results of the trials with the two different gloves were compared with each other. No differences between gloves were found. Next, the glove trial results were compared with the bare-handed results. As can be seen in Figure 2, the match force mean values are well correlated with the target forces; subjects tended to overestimate the push force whether they were wearing gloves or not. However, the match force mean values were significantly higher during the bare-handed trials than when gloves were used ($p < 0.01$).

Discussion and Conclusions

A refined version of this force matching technique may prove to be a convenient and reliable method for quantifying hand forces used by workers in the field. However, there are many factors that need to be studied and accounted for before such a method can be appropriately applied. As a start, the effect of glove use was explored in this pilot study. The results indicate that glove use may increase the accuracy of this force matching technique.

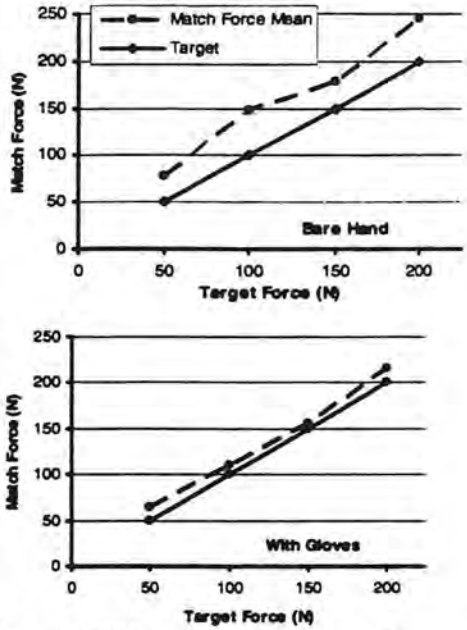

Figure 2 Mean force matching values compared with target forces with and without gloves.

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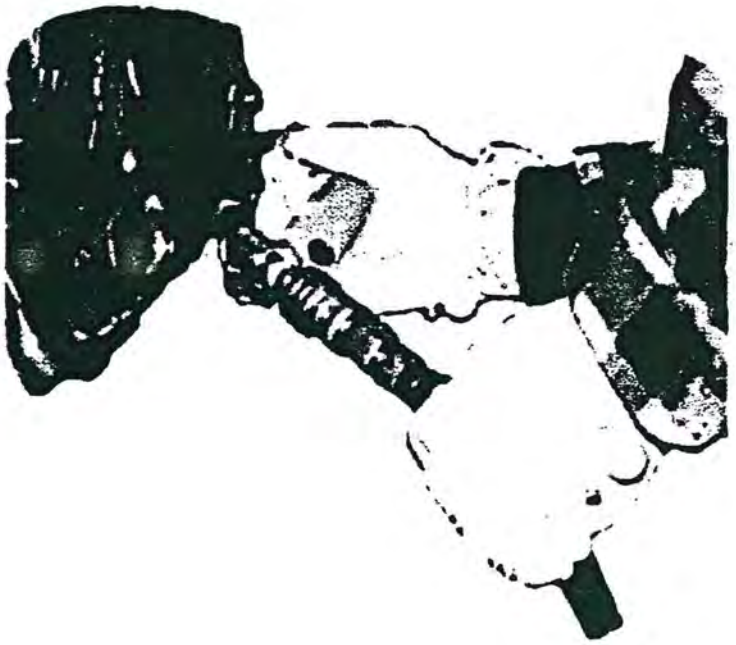

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