CHALLENGES AND UNCERTAINTIES IN DESIGNING FIELD STUDIES TO MEASURE HAND VIBRATION

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Introduction

We encountered several areas of methodologic uncertainty during development of a data collection method for use with vibrating hand tools in metal assembly. A local manufacturer sought our assistance designing a data collection method for evaluating and predicting risks of upper extremity disorders associated with use of vibrating hand tools. Current methods of vibration measurement are described in ISO 5349 [2]. However, the complexity of measuring vibration along with other exposures such as force and posture has limited the number of workplace-based studies of upper extremity disorders that have included direct measurements of vibration. Data from this preliminary study was used to look at two issues: a comparison of vibration values between production and non-production workers when performing the same task, and a comparison of worker ratings of vibration comfort to direct measurement of tool vibration.

Methods

Eight experienced production workers used each of six metal fastening tools to install fasteners. Vibration was collected by 3 tri-axial accelerometers, one attached to the tool handle following ISO 5349 recommended locations, one attached to the hand dorsum on the 3rd knuckle and one to the thumb side of the wrist. Data sampling rate was 10,000 samples/second. Hand grip and feed forces were obtained using a Novel pressure sensing mat on the palm. Each trial consisted of installing 10 fasteners per tool for each of the 6 tools. The test set-up placed the wrist in the position typically used by the operator during production. Each worker documented subjective comfort and effort ratings on a seven point scale following each series of fastener installations. One series of testing was completed by three non-production workers inexperienced in fastener installation to simulate use of alternative employees for data gathering. Vibration data for each trial were acquired, digitized, and stored using LabView. The X, Y, & Z axes were used to calculate the vector sum response for each tri-axial accelerometer. The tool data were digitally filtered following ISO recommendations. Calculated data consisted of the mean RMS over the tool's on- time, the starting and breaking peak impulses, and the peak of the frequency response.

Results

Production workers (n=8) were right hand dominant males with a mean age of 55 years and normal hand strength (mean right grip = 106 lbs). Non-production workers (n=3) had similar characteristics.

We found large and statistically meaningful differences in hand force during tool use between production and non-production workers (mean production workers = 9.77 lbs, mean non-production workers = 43.30 lbs, $p = 0.0001$). Vibration values obtained from the hand also showed a statistically meaningful difference (mean in production workers = 0.67 Gs, mean in non-production workers = 1.48Gs, $p = 0.0014$, figure 1). Experienced worker ratings of comfort during tool use demonstrated a moderate correlation with measured vibration ($r=0.63$). Worker ratings trended with direct recordings from the tool handle as shown in figure 2.

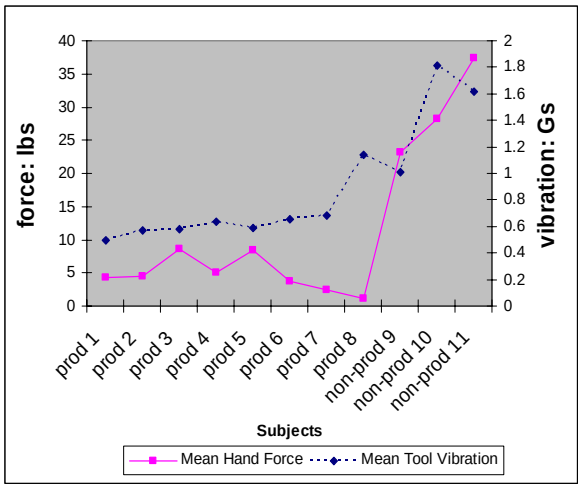

Figure 1. Comparison of hand force and vibration in production and non-production workers.

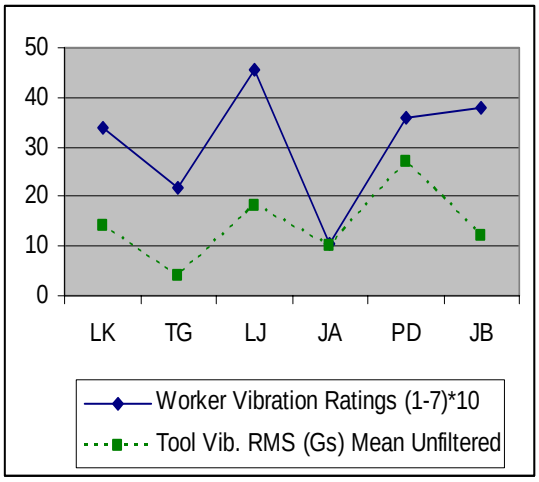

Figure 2. Comparison of worker ratings to vibration values produced for six different tools.

Discussion

This study highlights some of the issues that should be considered during vibration field studies. The striking differences in hand force and vibration between production and non-production workers suggest that vibration measures should be performed in the worker population actually using the tools. As workers become more adept at operating tools, they may use less hand force to perform a task, thus affecting vibration values. In our study, workers who were not experienced with daily use of the tools used higher hand force resulting in unreliable vibration values. The conditions of the field study should mimic real work conditions as much as is feasible, and deviations from normal work conditions should be considered when interpreting study results.

Our results also showed that worker ratings of tool vibration had reasonable correlation to measured vibration [1, 3]. This indicates that at least in a qualitative sense, experienced workers can estimate the magnitude of the vibration incurred during tool operation of familiar tools. Field studies may use worker rating data to identify problems or document the effectiveness of interventions. These data may supplement direct measures, particularly in large cohorts where direct measures on all subjects are impractical. Development of methods to estimate vibration under realistic work conditions will greatly enhance our ability to better understand the relationship between vibration and upper extremity disorders.

References

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