EFFECT OF HAND-ARM VIBRATION AND PROXIMAL NEUROPATHY ON CURRENT PERCEPTION THRESHOLD MEASUREMENT IN THE FINGERS

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1. INTRODUCTION

Hand-arm vibration exposure is associated with sensorineural abnormalities in the exposed fingers and these abnormalities may be measured by quantitative sensory tests such as current perception threshold (CPT) (Kurozawa et al, 2010). This quantitative sensory test allows all of the main sensory nerve fibres to be measured in a simple, non-invasive manner. However CPT measurements may also be affected by proximal neuropathies such as carpal tunnel syndrome (Nishimura et al, 2004) which are common in workers with HAVS, and may confound the demonstration of an effect of vibration exposure on sensorineural dysfunction in the fingers (Pelmear and Taylor, 1994). Therefore, this study was carried out to determine if hand-arm vibration exposure is associated with current perception threshold (CPT) measurement in the fingers after controlling for neuropathy proximal to the hand measured by nerve conduction testing.

2. METHODS

The study was carried out at the Occupational Health Clinic, St. Michael's Hospital and all of the 165 participants were men. They included 117 participants who had been exposed occupationally to hand-arm vibration and were being assessed for possible Hand-Arm Vibration Syndrome (HAVS), and 48 controls with no significant exposure to hand-arm vibration. All of the participants had a detailed occupational and medical history and physical examination to ensure that no other conditions were present that might affect sensation in the hands. In the workers exposed to vibration, the occupational histories were reviewed by a team of industrial hygienists to determine the intensity of daily vibration exposure and the following ordered categories of exposure were determined: miners > non-miners > controls.

All of the participants had nerve conduction tests and measurement of CPT in each hand. The nerve conduction tests were carried out in the hospital's electromyography department using standard methods and conventional electrode placement. The hand temperature was measured continuously and was at least 32°C during testing. This test identified the presence of median and/or ulnar sensory neuropathy proximal to the hand with the results being defined categorically (yes/no) for the purposes of this study. The CPT measurements were carried out using a Neurometer CTP/R (Neurotron Incorporated) with measurement at frequencies of 2000, 250 and 5 Hz corresponding to large myelinated (Abeta), small myelinated (Adelta) and unmyelinated (C) sensory fibres respectively. The measurements were done on the volar surface of the tips of the index finger for the median nerve and the little finger for the ulnar nerve. Therefore, there were 12 CPT measurements (2 hands × 2 nerves × 3 frequencies) on each participant. The nerve conduction and CPT measurements were carried out in a blinded fashion.

The analysis was carried out using SAS 9.2 (SAS Institute, Cary, NC). The principal analysis involved a set of 12 multiple linear regressions, one for each CPT dependent variable to determine key predictors. The independent variables examined in each regression included duration of vibration exposure (years), age (years), daily vibration exposure intensity (categorical variable: miners, non-miners, controls), median neuropathy (yes/no) and ulnar neuropathy (yes/no). In the regressions, the median and ulnar neuropathies were used from the same side on which the CPT testing had been done. In each case a saturated model was initially created which included all of the independent variables, and backwards elimination was then carried out to include only those variables that were statistically significant ($P<0.05$) in the final model.

3. RESULTS

The 165 participants had a mean (SD) age of 45.3 (11.2) and included 34 vibration exposed miners, 83 vibration exposed non-miners and 48 non-exposed controls. In the vibration exposed participants, the mean (SD) duration of exposure was 23.8 (11.3) years overall, 23.3 (9.5) years for the miners and 24.1 (12.0) for the non-miners. Forty-eight participants had median neuropathy on the right upper extremity and 30 on the left; 10 had ulnar neuropathy on the right side and 8 on the left. The prevalence of each of these proximal neuropathies was higher in the vibration exposed participants than in the controls on each side, and the differences were statistically significant ($p<0.05$) in all instances except for ulnar neuropathy on the left side.

In the multiple linear regression analysis, the only statistically significant variable included in the six regression models in the right upper extremity, after backwards stepwise elimination, was the variable for daily vibration exposure intensity. In all instances, the effect estimate for miners (with higher daily vibration exposure intensity) was greater than for non-miners. In the left upper extremity, the daily vibration exposure intensity variable was also included in all six regression models and was the key predictor variable. However, on this side, several proximal neuropathy variables were also found to be statistically significant – median neuropathy for the 5 Hz median CPT outcome and ulnar neuropathy for the 2000 Hz and 250 Hz ulnar CPT outcomes. Table 1 summarizes the R^2 values for the 12 CPT regression models which indicated that the vibration effect on CPT was greatest at 2000 Hz.

Table 1. R^2 Values for Regression Models for CPT Dependent Variables

Side	CPT	R^2
Right	Median 2000 Hz	0.408
	Median 250 Hz	0.207
	Median 5 Hz	0.236
	Ulnar 2000 Hz	0.356
	Ulnar 250 Hz	0.231
	Ulnar 5 Hz	0.188
Left	Median 2000 Hz	0.351
	Median 250 Hz	0.197
	Median 5 Hz *	0.208
	Ulnar 2000 Hz **	0.420
	Ulnar 250 Hz **	0.212
	Ulnar 5 Hz	0.170

All backwards stepwise models included daily vibration exposure intensity variable (categorical: mining>non-mining>control).
* Also included left median neuropathy variable.
** Also included left ulnar neuropathy variable.

4. DISCUSSION AND CONCLUSIONS

In this study, the main factor affecting CPT in the fingers was vibration exposure. In all of the 12 CPT regression models, the backwards stepwise elimination procedure resulted in the inclusion of the daily vibration intensity variable as the key predictive factor. If this daily vibration intensity variable was excluded and the regression modeling was repeated, the key predictor became the duration of vibration exposure.

In some of the models, in the left hand where vibration exposure is often less than in the right, proximal neuropathy variables were also found to be statistically significant. In these instances, median or ulnar CPT abnormalities were predicted by the corresponding median or ulnar proximal neuropathies. Proximal neuropathies, in particular median neuropathy at the wrist associated with carpal tunnel syndrome (CTS), commonly occur in workers exposed to hand-arm vibration (Pelmear and Taylor, 1994). As well, proximal neuropathy may be associated with CPT abnormalities in the fingers (Nishimura et al, 2004). However our findings indicated that the sensory abnormalities measured by CPT in workers exposed to vibration were not due to confounding by proximal neuropathy.

All of the fibre types measured by CPT were found to be affected by vibration exposure. The R^2 values were highest for the CPT 2000 Hz dependent variable regression models, indicating that vibration had the greatest effect on large myelinated fibres, although all fibre types were affected. This is consistent with previous CPT studies that have shown that CPT thresholds at 2000 Hz are most predictive of the Stockholm sensorineural scale in workers exposed to hand-arm vibration (Kurozawa et al, 2001; House et al, 2009). The results are also consistent with animal studies which have shown that acute high exposure of the rat tail to vibration is associated with an increase in CPT thresholds at 2000 Hz. (Krajnak et al, 2007). As well, chronic exposure of the rat tail to vibration has been found to be associated with ultrastructural changes in the myelin sheaths of large myelinated fibres (Chang et al, 1994), and biopsies of workers with HAVS have shown similar lesions (Takeuchi et al, 1988).

In conclusion, despite the high prevalence of proximal neuropathy in workers exposed to hand-arm vibration, there is an effect on nerve fibre damage in the fingers due to hand-arm vibration that cannot be explained by common median or ulnar neuropathies proximal to the hand.

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