ACUTE VIBRATION EXPOSURE SHIFTS THE CURRENT PERCEPTION THRESHOLD OF Aβ FIBERS IN A RAT TAIL MODEL OF VIBRATION

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Introduction

Occupational exposure to hand-arm vibration through the use of powered hand tools can result in reductions in tactile sensitivity, grip strength and manual dexterity. In fact, even acute exposures to vibration cause shifts in vibrotactile thresholds in exposed fingers (2,4,5). Although reductions in tactile sensitivity after acute vibration exposures are transient, cellular changes associated with this shift in sensitivity could lead to the more permanent reductions in tactile sensitivity that are a common symptom of hand-arm vibration syndrome (HAVS).

Methods

Animals. Male Sprague Dawley rats (6 weeks of age) were used for all experiments. Animals were housed in AAALAC accredited facilities, and all procedures were approved by the NIOSH Animal Care and Use Committee and were in compliance with the CDC guideline for care and use of laboratory animals. Vibration exposures were performed by restraining rats in a Broome-style restrainer, and securing their tails to the vibration platform using 6 mm wide straps that were placed over the tail every 3 cm. Restraint control animals were treated in an identical manner except that the tail platform was set on isolation blocks instead of a shaker.

Tail temperature and current perception thresholds (CPTs). Rats were exposed to 4 h of tail vibration (125 Hz, 49 m/s2), or restraint. Tail temperature was collected prior to and immediately following the exposure using an infra-red camera. Sensory neuron function was assessed by measuring CPTs with a Neurometer (Neurotron, Baltimore, MD). Transcutaneous nerve stimulation was applied to the C10 region of the tail. Three frequencies were used to test specific fiber types (5 Hz – C, 250 Hz - Aδ, and 2000 Hz – Aβ). The intensity of the stimulus was automatically increased in small increments until the rat flicked its tail. Tests at each frequency were repeated until the animals displayed 2 responses that were within 2 CPT (or 0.02 mA) of each other (2-4 tests/animal). CPT tests were performed prior to the exposure, immediately following the exposure, and 24 h after the exposure.

Data Analyses. Temperatures were analyzed using a one-way ANOVA with animal as a random variable. ANCOVAS were used to analyze the CPTs at each frequency. Temperature at the time of the CPT test was used as a covariate, and animal was used as a random variable

Results

Tail temperatures declined between pre and post exposure ($F(1,25) = 62.85$, $p < 0.001$; mean ± sem pre 25.96°C ± 0.42, post 20.71°C ± 0.77), but were back to baseline levels by 24 h after the exposure in both groups of rats. The ANCOVAs demonstrated that exposure to a single bout of vibration did not alter sensitivity of C (5Hz) or Aδ (250 Hz) fibers to stimulation.

However, at 2000 Hz (Aβ fibers), restrained animals displayed an increased sensitivity to the stimulus following exposure (i.e., lower CPT value, $F(1, 28) = 23.71$, $p < 0.001$). In contrast, the CPT was significantly higher in vibrated rats immediately following the exposure, indicating that the Aβ fibers were less sensitive to stimulation. However, 24 h later, the CPT at 2000 Hz returned to pre-exposure values (Figure 1A-C). At 5 Hz, there were no group differences in pre to post CPT values. However, about one third of the animals did display a post exposure increase in CPT values. The increased CPT in this subset of animals accounts for the large variability in the post exposure measure at 5 Hz. None of the CPT values were affected by temperature. (Figures 1D-F).

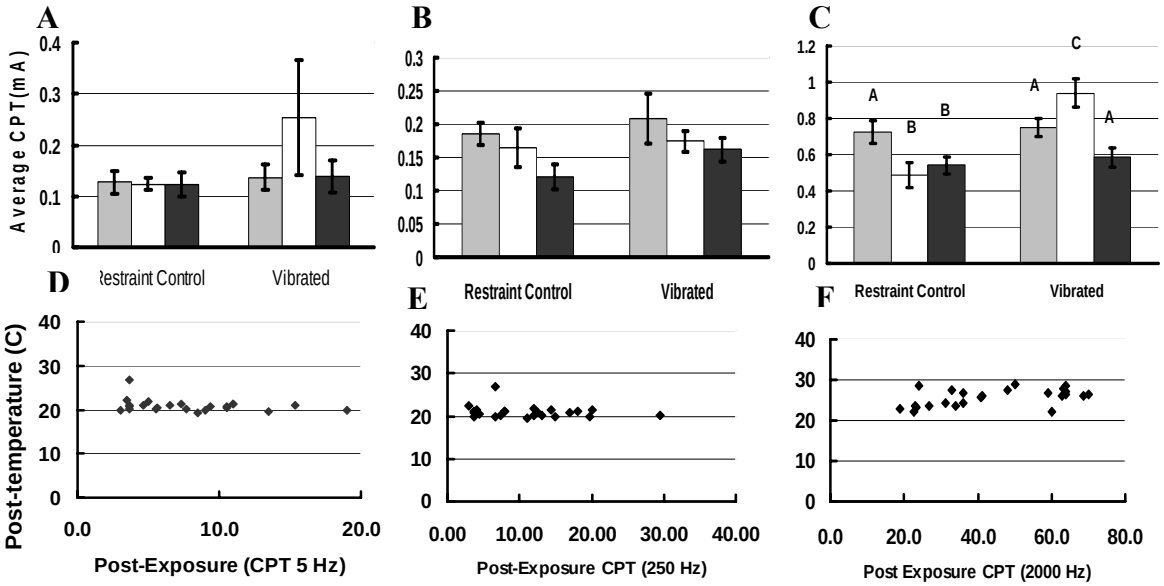

Figure 1. CPT measures (mA) at 5 (A), 250 (B) and 2000 Hz (C), and correlations between temperature and CPT values (D-F). Bars represent the means ± sem. Gray bars are pre-exposure, white immediately after exposure and black 24 h after exposure. In 1-C, different letters are significantly different from each other ($p < 0.05$). R^2 values for the correlation between temperature and CPT are 0.085 for 5 Hz, 0.042 for 250 Hz and 0.009 for 2000 Hz.

Discussion

- Exposure to a single bout of vibration results in a transient reduction in the sensitivity of the Aβ fibers to stimulation. This shift in sensitivity is comparable to the transient shift in vibrotactile thresholds seen in humans after an acute vibration exposure (2,4,5).
- The vibrotactile test is affected by the skin temperature of the subject (1,3). The results of this study demonstrate that the CPT is not affected by skin temperature. In addition, the CPT allows the tester to determine which nerve fiber subtype is affected. Thus, the CPT may serve as reasonable test for diagnosing vibration-induced changes in tactile sensitivity.

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