REDUCED SENSORY NERVE THRESHOLDS MAY BE INDICATIVE OF NERVE INJURY AFTER REPEATED EXPOSURE TO VIBRATION

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Introduction

Hand-arm vibration syndrome (HAVS) is characterized by the occurrence of cold-induced vasospasms and a reduction in tactile sensitivity. Although vascular dysfunction usually improves after workers stop using vibrating handtools, sensory symptoms are often maintained or degrade over time [Nasu and Ishida 1986]. If changes in nerve function could be detected earlier, it may be possible to intervene or treat workers and eliminate further damage to the sensory system. The goal of this study was to characterize changes in sensory nerve function during a 25-day exposure to vibration in a rat tail model of HAVS. Changes in sensory nerve function were assessed using the current perception threshold (CPT) test.

Methods

Animals. Male Sprague Dawley rats (6 weeks of age) were housed in AAALAC-accredited facilities. All procedures were approved by the NIOSH Animal Care and Use Committee and were in compliance with CDC guidelines for the 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. Restraint control animals were treated in an identical manner except that the tail platform was set on isolation blocks instead of a shaker. Rats were exposed to daily bouts of vibration (4 hr/day, 125 Hz, constant acceleration 49 m/s^2 root-mean-square) or restraint for 25 consecutive days. An additional group of animals served as cage control rats. These animals were tested at the same times as the other animals, but they were not exposed to restraint or vibration. All animals were euthanized with an overdose of pentobarbital (100 mg/kg), and tail nerves were collected for 2′-3′ cyclic nucleotide 3′ phosphodiesterase (CNPase) immunohistochemical analyses. CNPase levels are positively correlated with glia-axon contact in peripheral nerves [Toma et al. 2007]. CNPase staining was assessed in the right ventral nerve bundle (i.e., large nerve) and in smaller nerve bundles (i.e., small nerves less than 100 μm in diameter) found around the ventral artery. The labeled area of each nerve bundle was measured using densitometry (Scion Image).

CPT tests. Sensory neuron function was assessed by measuring CPTs with a Neurometer (Neurotron, Inc., 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 2,000 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 two responses that were within 2 CPT (or 0.02 mA) of each other (two to three tests per animal). CPT tests were performed after vibration exposure on the first day of each week.

Data analyses. Sensory nerve thresholds were analyzed using a mixed model three-way ANOVA where the independent variables were treatment, days of exposure, and pre/post exposure. Animal served as a random variable for each analysis. Biological data were analyzed using a one-way ANOVA where treatment was the independent variable. Differences with $p < 0.05$ were considered significant.

Results

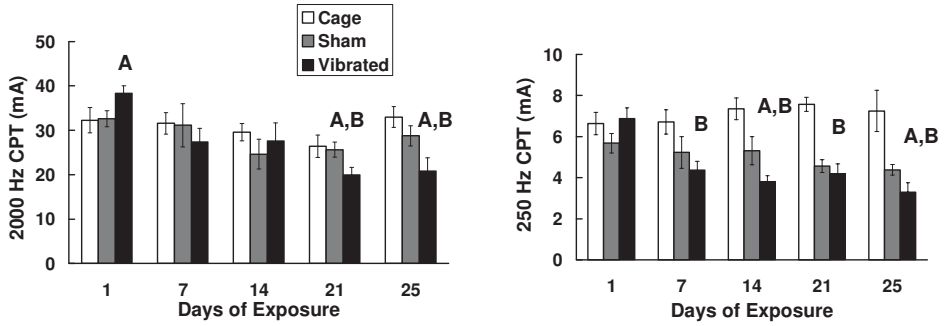

Figure 1.—Weekly CPTs in rat tails exposed to 25 days of vibration. Exposure to vibration resulted in a reduction in 2,000- and 250-Hz thresholds over time (A: different from cage controls; B: different from day 1 vibrated, p < 0.05). Restraint controls also displayed lower 250-Hz CPTs than cage controls after 21 and 25 days of exposure.

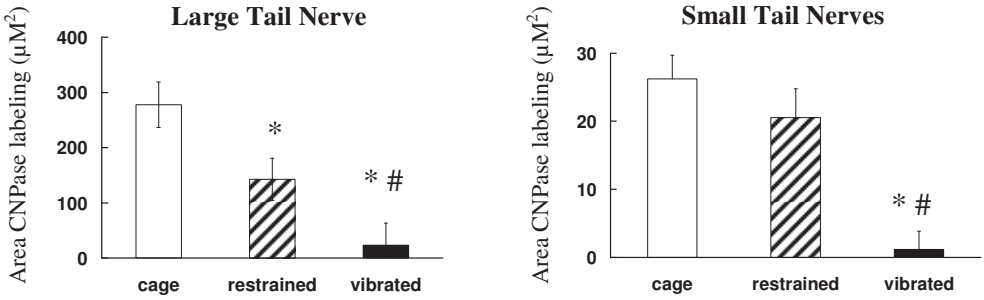

Figure 2.—The area of CNPase immunostaining in large and small tail nerves of rats. CNPase immunolabeling was lower in the large, but not small tail nerve bundles of rats exposed to restraint control conditions (* less than cage control, p < 0.05; # less than restraint control, p < 0.05).

Discussion

- CPTs in Aβ fibers (2,000 Hz) decline with repeated exposure to vibration. The reduced thresholds of Aβ fibers to stimulation could potentially lead to an increased sensitivity of rats to mechanical stimuli and serve as an early indicator of nerve injury.
- Vibrated and restraint control rats displayed reductions in the 250-Hz CPT, indicating that changes in Aδ fiber sensitivity are related to restraint and not necessarily due to vibration.
- Vibration-induced reductions in the 2,000-Hz thresholds were associated with a reduction in area labeled with CNPase in large and small nerve bundles. A reduction in the density of this enzyme shown is associated with reduced glia-axon contact in peripheral nerves and may indicate nerve dysfunction [Toma et al. 2007].

References

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June 4-6, 2008

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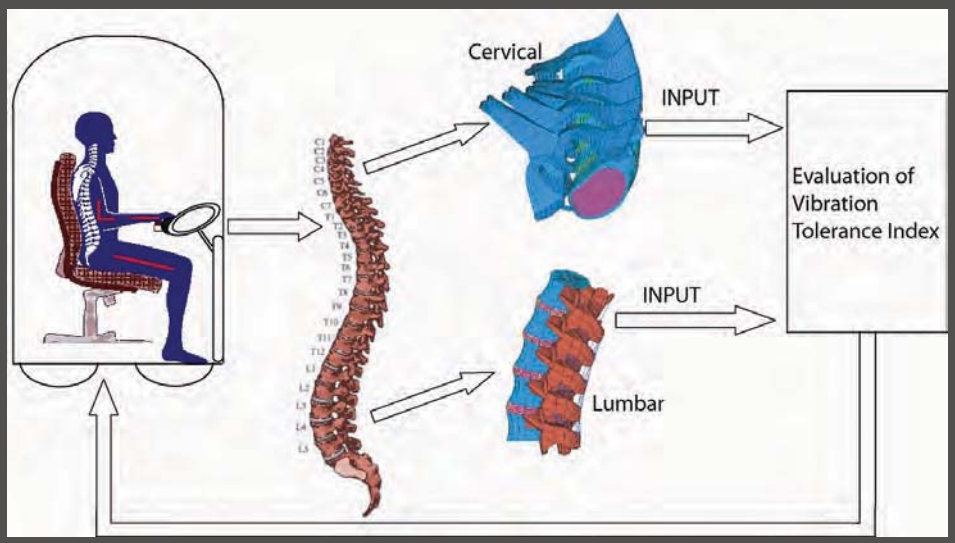

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Information Circular 9513

Proceedings of the Second American Conference on Human Vibration

Chicago, IL
June 4–6, 2008

Technical Editors: Farid Amirouche, Ph.D., and Alan G. Mayton, C.M.S.P., P.E.

Document Editor: Robert J. Tuchman

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Pittsburgh Research Laboratory
Pittsburgh, PA

June 2009

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DHHS (NIOSH) Publication No. 2009–145

June 2009

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