SENSORY NERVE RESPONSES TO ACUTE VIBRATION ARE FREQUENCY-DEPENDENT IN A RAT TAIL MODEL OF HAND-ARM VIBRATION SYNDROME

Kristine Krajnak,[1] Stacey Waugh,[1] G. Roger Miller,[1] and Michael L. Kashon[2]

[1]Engineering and Control Technology Branch, Health Effects Laboratory Division
[2]Biostatistics and Epidemiology Branch, Health Effects Laboratory Division

National Institute for Occupational Safety and Health (NIOSH), Morgantown, WV

Introduction

Occupational exposure to hand-arm vibration through the use of powered handtools can result in reductions in tactile sensitivity. Acute exposures to vibration cause shifts in vibrotactile thresholds in exposed fingers that are affected by the frequency of the exposure, with exposure to midrange vibration frequencies (i.e., around 125 Hz) producing the greatest shifts [Maeda and Griffin 1994]. We have demonstrated that acute vibration exposure at 125 Hz results in a transient increase in sensory nerve thresholds to a 2,000-Hz transcutaneous stimulus in a rat tail model of hand-arm vibration syndrome [Krajnak et al. 2007]. The goal of this study was to determine how repeated exposures to vibration at frequencies that produce different biodynamic responses affect sensory nerve function in our rat tail model.

Methods

Animals. Male Sprague Dawley rats (8 weeks of age, n = 5 per group) 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 a 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. Rats were exposed to 4-hr bouts of vibration or restraint for 10 consecutive days at 0, 62.5, 125, or 250 Hz with a constant acceleration of 49 m/s^2 root-mean-square. Previous work in our laboratory has shown that vibration exposure at these frequencies and acceleration produce different magnitudes of transmissibility to the tail [Welcome et al. 2006]. An additional group of animals served as cage control rats.

Current perception thresholds (CPTs) and mechanoreceptor sensitivity. Sensory nerve function was assessed by measuring CPTs with a Neurometer (Neurotron, Inc., Baltimore, MD). Transcutaneous nerve stimulation at 2,000 Hz was applied to the C10 region of the tail to determine the effects of vibration on Aβ nerve fiber sensitivity. The intensity of the stimulus was automatically increased in small increments until the rat flicked its tail. Aβ-nerve fibers are large-diameter, myelinated nerve fibers that carry information from mechanoreceptors to the central nervous system. Tests 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). To determine if changes in sensory nerve responsiveness were accompanied by changes in mechanoreceptor sensitivity, the response to pressure induced by the application of 1- and 10-g von Frey filament was assessed. If animals flicked their tail, they were responsive; if not, they were nonresponsive. CPT and mechanoreceptor sensitivity tests were performed before (pretest) and immediately after (posttest) the vibration exposure on days 1 and 9 of the exposure.

Data analyses. CPT data were analyzed using a mixed model three-way (condition × days of exposure × pre/post exposure) ANOVA where animal served as a random variable. The number of animals responding to stimulation with the von Frey filaments was analyzed using contingency table chi-square tests. Differences with $p < 0.05$ were considered significant.

Results

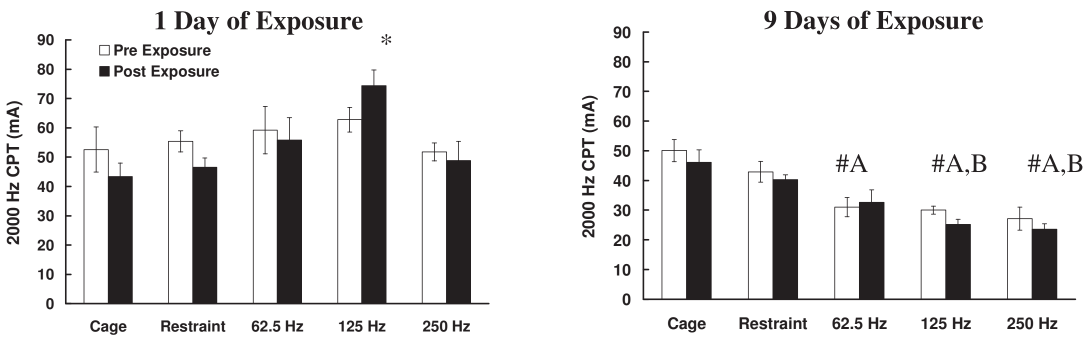


Figure 1.—CPTs after vibration exposure. After 1 day of exposure, vibration at 125 Hz resulted in an increase in the 2,000-Hz CPT threshold (*greater than preexposure, $p < 0.05$). After 9 days of exposure, CPTs were reduced in all rats exposed to vibration (# less than day 1, $p < 0.05$). In addition, vibrated animals displayed lower thresholds than control animals after 9 days of exposure (A: different from cage controls; B: different from restraint controls, $p < 0.05$).

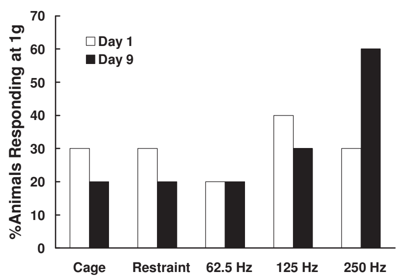


Figure 2.—Percentage of animals responding to mechanoreceptor stimulation with a 1-g von Frey filament after 1 or 9 days of vibration. The percentage of animals responding to stimulation with the filament was higher after 9 days of vibration exposure at 250 Hz than after 1 day (χ^2, $p < 0.04$). No changes were seen with 10-g stimulation.

Discussion

- As previously shown [Krajnak et al. 2007], a single exposure to vibration at 125 Hz results in an increase in the 2,000-Hz CPT. Similar responses to acute vibration are also seen in humans [Maeda and Griffin 1994].
- After 9 days of vibration exposure, 2,000-Hz thresholds were lower in vibrated than in control or restrained rats. In contrast, changes in mechanoreceptor sensitivity were seen only in rats exposed to 250 Hz, which is the frequency that generates the greatest biodynamic response in the tail [Welcome et al. 2006].
- Increased sensitivity to mechanical stimuli may serve as an early indicator of vibration-induced nerve damage.

References

Krajnak K, Waugh S, Wirth O, Kashon ML [2007]. Acute vibration reduces Abeta nerve fiber sensitivity and alters gene expression in the ventral tail nerves of rats. Muscle Nerve *36*(2): 197–205.

Maeda S, Griffin MJ [1994]. Temporary threshold shifts in fingertip vibratory sensation from hand-transmitted vibration and repetitive shock. Nagoya J Med Sci *57*(Suppl):185–198.

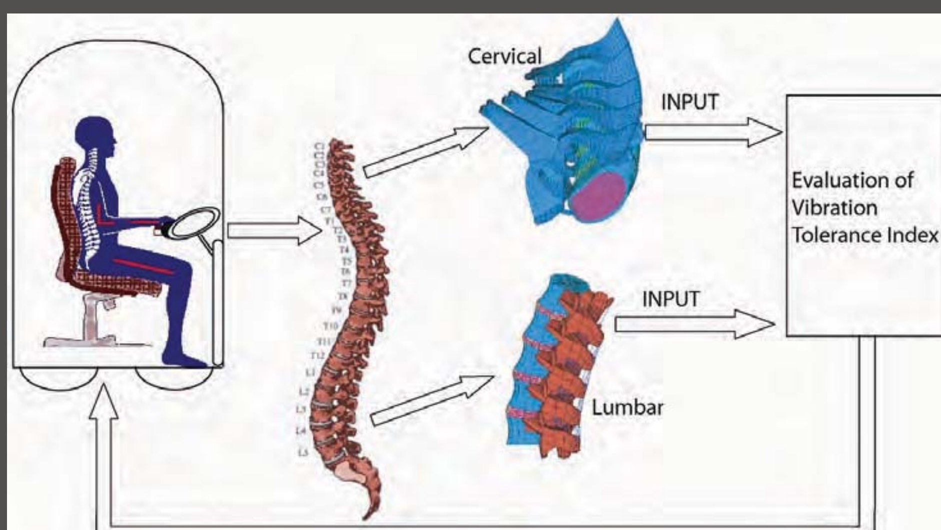
Welcome D, Dong RG, Krajnak KM [2006]. A pilot study of the transmissibility of the rat tail compared to that of the human finger. In: Proceedings of the First American Conference on Human Vibration (June 5–7, 2006). Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2006–140, pp. 101–102.

IC 9513
INFORMATION CIRCULAR/2009

2nd AMERICAN CONFERENCE ON HUMAN VIBRATION

June 4-6, 2008

Proceedings



Organized by:

UIC UNIVERSITY OF ILLINOIS AT CHICAGO Department of Mechanical and Industrial Engineering
COLLEGE OF ENGINEERING

CDC Workplace Safety and Health

NIOSH National Institute for Occupational Safety and Health

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

Disclaimer

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to Web sites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these Web sites. All web addresses referenced in this document were accessible as of the publication date.

The views expressed by non-NIOSH authors in these proceedings are not necessarily those of NIOSH.

Ordering Information

To receive documents or other information about occupational safety and health topics, contact NIOSH at

Telephone: 1–800–CDC–INFO (1–800–232–4636)
TTY: 1–888–232–6348
e-mail: cdcinfo@cdc.gov

or visit the NIOSH Web site at www.cdc.gov/niosh.

For a monthly update on news at NIOSH, subscribe to NIOSH *eNews* by visiting **www.cdc.gov/niosh/eNews**.

DHHS (NIOSH) Publication No. 2009–145

June 2009

SAFER • HEALTHIER • PEOPLE™