

VIBRATION EXPOSURE REDUCES NITRIC OXIDE CONCENTRATIONS IN THE VENTRAL ARTERY OF THE RAT TAIL

Claud Johnson and Kristine M. Krajnak

National Institute for Occupational Safety and Health, Morgantown, WV 26501

Introduction

Vibration transmitted to the upper limb by the chronic use of hand tools can result in cold-induced vasospasms finger blanching and cyanosis, similar to that seen with Raynaud's phenomenon (4). These vasospasms, commonly referred to as vibration white finger (VWF), are in part the result of an increased sensitivity of peripheral arteries to the vasoconstricting effects of norepinephrine (e.g., (1-3)). However, alterations in vasodilating factors could also contribute to vasospasms. The goal of these studies was to determine if exposure to a single bout of vibration alters concentrations of the vasodilator, nitric oxide (NO), in a rat tail model of vibration. To determine if vibration exposure alters NO, we exposed animals to a single bout of vibration and measured concentrations of the synthetic enzymes, nitric oxide synthetase (NOS)-1 and NOS-3 in the ventral tail artery. We also directly assessed arterial concentrations of NO using a nitrate/nitrite assay.

Methods

General apparatus. Animals were placed in Broome-style restrainers, and their tail was secured to a vibrating or stable platform. Rats were exposed to a single 4 h bout of tail vibration (125 Hz, acceleration of 49 m/sec² r.m.s.) or restraint control. Animals were euthanized with an overdose of pentobarbital (100 mg/kg) and the ventral tail artery was dissected and frozen.

Experiment 1: Male Sprague Dawley rats (6 weeks old, n = 32) were used for all exposures. All animals were maintained in AAALAC accredited facilities, and all procedures were approved by the NIOSH Animal Care and Use Committee, and were in compliance with the CDC Regulations for the Care and Use of Laboratory Animals. Animals were euthanized 1 or 24 h after the completion of the exposure. Western analyses were performed on total proteins (80 µg/lane) isolated from the C16-18 artery segments. Band densities were detected by chemiluminescence and quantified using Scion Image, and analyzed using 2-way ANOVAs.

Experiment 2. Nitrate/nitrite concentrations.. Male Sprague Dawley rats (n = 24, 6 weeks of age) were maintained and exposed as described above. All animals were euthanized 24 h after the exposure and the ventral artery was collected. Nitrate/nitrite concentrations were measured in ventral artery tissue homogenates using the nitrate/nitrite colormetric Assay Kit (Caymen).

Results

Analyses of band densities revealed that there was an effect of time ($F(1, 17) = 6.03$, $p < 0.03$) on NOS-1 protein in arteries exposed to vibration, with NOS levels being lower in arteries collected 24 h after the exposure than arteries collected 1 h after the exposure. Although NOS-1 proteins concentrations were slightly lower in control arteries collected 24 h after an exposure than arteries collected 1 h after exposure, post-hoc contrasts indicated they were not significantly different than 1 h controls. In contrast, NOS-1 band densities from arteries collected 24 h after the exposure were lower than those collected 1 h after the exposure ($p < 0.01$; Figure 1). NOS-3

protein concentrations in the ventral artery were not affected by vibration exposure. Exposure to vibration also resulted in a significant decrease in nitrate/nitrite concentrations (an estimate of NO concentrations) in the ventral tail arteries of rats when compared to cage controls ($F(1, 17) = 5.07$, $p < 0.03$; Figure 2).

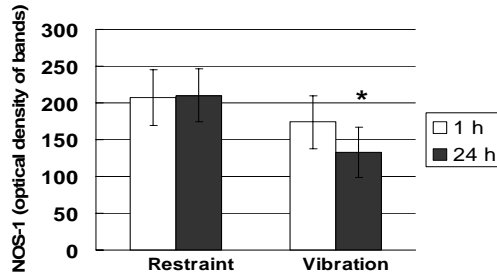


Figure 1. NOS-1 concentrations in the ventral tail artery (mean \pm sem). * represents less than 24 h restraint control and 1 h vibration exposed.

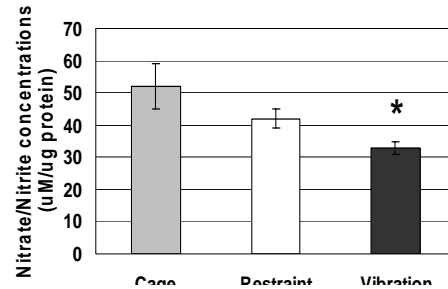


Figure 2. Nitrate/Nitrite concentrations in the ventral tail artery (mean \pm sem). * is less than cage control, $p < 0.03$.

Discussion

- NOS-1, the neuronal form of the enzyme, stimulates NO production by nerve and smooth muscle cells. NOS-1 was reduced in ventral artery homogenates collected 24 h after a vibration exposure. This suggests that NO production by nerves and/or smooth muscle may be reduced in vibration exposed animals.
- The reduction in NOS-1 protein concentrations was associated with a reduction in NO concentrations in the ventral artery. Reductions in NO may prevent or delay re-dilation of the ventral artery after a vibration-induced constriction.
- NOS-3, the endothelial form of the enzyme, was not altered by vibration exposure, suggesting that endothelial mediated vasodilation may be unchanged after a single exposure to vibration.

References

1. Curry BD, Govindaraju SR, Bain JL, Zhang LL, Yan JG, Matloub HS and Riley DA. Nifedipine pretreatment reduces vibration-induced vascular damage. *Muscle Nerve*, 2005.
2. Krajnak K, Dong RG, Flavahan S, Welcome DE and Flavahan NA. Acute vibration increases α_{2c} -adrenergic smooth muscle constriction and alters thermosensitivity of cutaneous arteries. *Journal of Applied Physiology*, in press.
3. Lindblad LE and Ekenvall L. Alpha 2-adrenoceptor inhibition in patients with vibration white fingers. *Kurume Med J* 37 Suppl: S95-99, 1990.
4. Stoyneva Z, Lyapina M, Tzvetkov D and Vodenicharov E. Current pathophysiological views on vibration-induced Raynaud's phenomenon. *Cardiovasc Res* 57: 615-624, 2003.

Proceedings of the
First American Conference on Human Vibration

June 5-7, 2006

Waterfront Place Hotel
Morgantown, West Virginia, U.S.A.

Ren Dong, Ph.D.
Kristine Krajnak, Ph.D.
Oliver Wirth, Ph.D.
John Wu, Ph.D.

Engineering and Control Technology Branch
Health Effects Laboratory Division
Morgantown, West Virginia, U.S.A.

Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Disclaimer

Mention of any company or product does not constitute endorsement by 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. The findings and conclusions in this report have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

This document is in the public domain and may be freely copied or reprinted.

ORDERING INFORMATION

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

NIOSH – Publications Dissemination
4676 Columbia Parkway
Cincinnati, OH 45226-1998

Telephone: 1-800-35-NIOSH (1-800-356-4674)

Fax: 513-533-8573

E-mail: pubstaft@cdc.gov

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

DHHS (NIOSH) Publication No. 2006-140
June, 2006