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VASCULAR RESPONSES TO VIBRATION ARE FREQUENCY DEPENDENT

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Introduction

The current frequency weighting used in the ISO-5349 standard assigns greater weight to lower frequency vibration (i.e., less than 16 Hz), and significantly less weight to exposure frequencies greater than 100 Hz. However, recent experimental and epidemiological studies suggest that this weighting may underestimate the risk of injury associated with exposure to higher frequency vibration (1, 2). The goal of this study was to use a rat-tail model to determine how exposure to higher frequency vibration (i.e., 62.5 – 250 Hz) affects peripheral nerves and arteries. We chose to use this model because previous work from our lab has demonstrated that the biodynamic response of the rat tail and human finger are similar within this frequency range (3), and thus, we expect that the frequency dependent changes we see in this study will be representative of the changes seen in human fingers.

Methods

Animals. Male Sprague-Dawley [Hla:(SD) CVF rats; 6 weeks of age at arrival; Hilltop Lab Animals, Inc, Scottdale, PA)] were used in this study. Rats were maintained in a colony room with a 12:12 reversed light:dark cycle (lights off 0700 h) with food and tap water available *ad libitum,* at the NIOSH facility, which is accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC). All procedures were approved by the NIOSH Animal Care and Use Committee and were in compliance with the Public Health Service Policy on Humane Care and Use of Laboratory Animals and the NIH Guide for the Care and Use of Laboratory Animals.

Exposure. Rats were restrained in Broome style restrainers, and their tails were secured to a platform attached to a shaker. Groups of rats (n = 5 – 8/group) were exposed to vibration at 62.5, 125 or 250 Hz at a constant unweighted acceleration of 49 m/s^2 rms for 4 h/day for 10 days. Restraint control rats were restrained and had their tails secured to stationary platforms. Cage control rats were maintained in their home cages throughout the study.

Procedures. All rats were euthanized 60 min following the last exposure. Ventral tail arteries from the C9-10 region of the tails were dissected and frozen. Gene transcription in these tissues was assessed using total rat genome arrays and/or quantitative RT-PCR. Arteries from the C15-18 section of the tail were frozen or fixed and used for immunohistochemical or morphological analyses.

Results

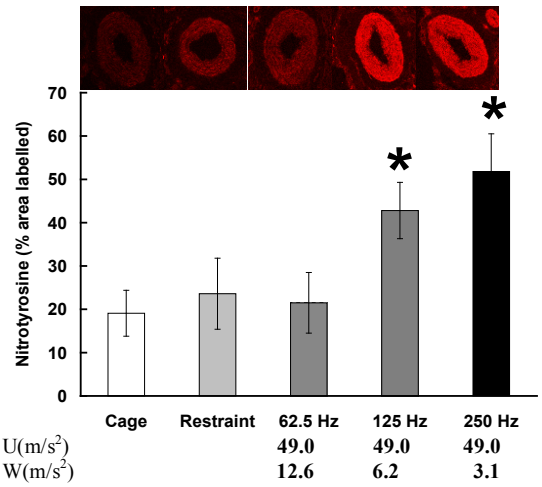

Figure 1. Nitrotyrosine staining, a marker of oxidative stress and damage, was assessed in response to vibration using unweighted (U) and ISO-weighted frequencies (W). Staining was significantly greater in arteries from rats exposed to vibration at 125 and 250 Hz than in arteries from rats in other conditions (* greater than other groups, $p < 0.05$)

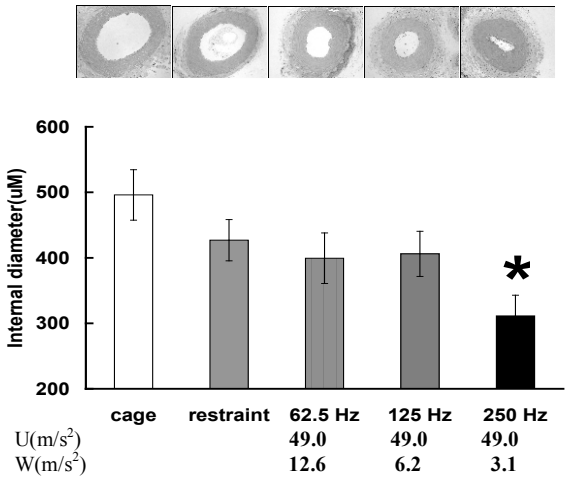

Figure 2. Luminal diameter was assessed in response to vibration using unweighted (U) and ISO-weighted frequencies (W).Exposure to vibration resulted in a reduction in the luminal diameter of the tail artery. However, this reduction was only significant in rats exposed to vibration at 250 Hz (* less than cage or restraint controls, $p < 0.05$).

Discussion

- Exposure to higher frequency vibration (i.e.,≥ 62.5 Hz) results in changes in vascular biology and morphology that are indicative of dysfunction.
- Vascular responses to vibration were frequency dependent. Vibration-induced increases in markers of oxidative stress and inflammation (data not shown) were greatest in rats exposed to vibration at 250 Hz. This is the frequency with the lowest ISO-weighted acceleration.
- Vibration transmissibility to the tail is greatest at 250 Hz (3). The fact that markers of injury and dysfunction were also greatest with exposure to vibration at 250 Hz suggests that the additional stress and strain on the soft tissue generated by exposure to this frequency may pose the greatest risk of injury.
- These findings are consistent with the results of other studies suggesting that IS0-5349 underestimates the risk associated with exposure to higher frequency vibration.

References

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