VIBRATION ALTERS SERUM MARKERS OF BONE TURNOVER IN RATS

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Introduction

Occupational exposure to whole body vibration (WBV) is associated with an increased risk of low back pain, disc compression and spinal degeneration [1]. Because exposure to WBV is often accompanied by exposure to lower frequency, higher magnitude mechanical shock, it is unclear if vibration, shock, or a combination of these two factors leads to spine degeneration and back pain [2] The goal of this study was to use a rat-tail model to determine how vibration exposure alone affects serum markers of bone mineralization and resportion. We hypothesized that exposure to vibration would increase serum markers of bone resportion and that this effect would be frequency dependent, with greater resorption occurring near the resonant frequency.

Methods

Male Sprague Dawley rats [Hla:(SD) CVF] rats (Hilltop Lab Animals, Inc, Scottdale, PA) arrived in the laboratory at 6 weeks of age. Rats were maintained in a colony room with a 12:12 reverse light:dark cycle (lights off 0700 h) and with Tekdad 2918 food and tap water available *ad libitum,* at the National Institute for Occupational Safety and Health (NIOSH) facility, which is accredited by the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC). Rats were acclimated to the facilities for 1 week before being used in experiments. 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.

For all exposures, rats were restrained in Broome Style restrainers. Rats were randomly assigned to a restraint group (control, n = 4), or to a vibration exposure group where the exposure frequency was 62.5 or 125 Hz (vertical sinusoidal vibration with a constant acceleration of 49 m/s squared r.m.s., n = 4/frequency). Previous work in our laboratory has demonstrated that the resonant frequency of the tail is between 125 and 250 Hz, depending upon the precise location of the measurement [3]. Rats were exposed to control or vibration conditions 4 h/day, 5 days/week for 8 weeks. After the last exposure, rats were anesthetized with pentobarbitol (100 mg/kg i.p.) and euthanized by exsanguination. Serum was isolated from blood. Serum was assayed for c-telopeptide fragments of collagen type-1 (CTX-1, rat LAPS Assay, Immunodiagnostics, Fountain Hills, AZ, USA), a marker of bone resportion, and osteocalcin, a marker of bone mineralization (Rat osteocalcin, Biomedical Technologies, Stoughten MA). Data were analyzed using one-way ANOVAs. Pairwise comparisons were made using Student's t-tests. Differences with $p < 0.05$ were considered significant.

Results

Circulating concentrations of osteocalcin were lower in control rats than in rats exposed to vibration at 125 Hz ($p < 0.05$; Figure 1A). Vibration exposure at both frequencies also resulted

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in an increase serum CTX-1 concentrations ($F(2, 11) = 7.55$, $p < 0.02$; Figure 1B). When we analyzed the ratio of mineralization to resorption (osteocalcin to CTX-1), we found this ratio was significantly reduced in rats exposed to vibration at both frequencies ($F(2, 11) = 5.44$, $p < 0.03$; Figure 1C).

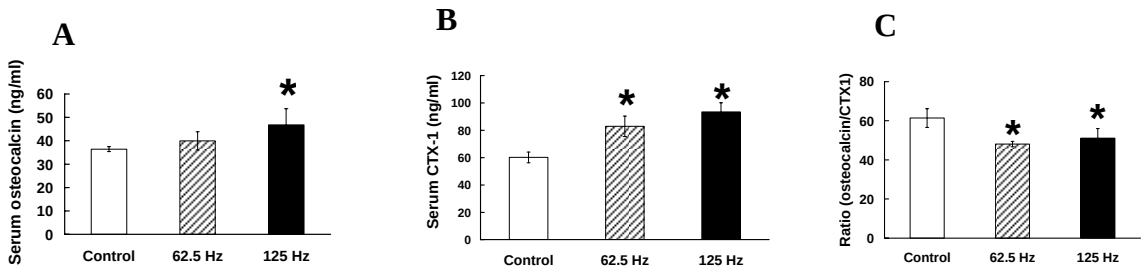

Fig. 1: Serum osteocalcin (A), CTX-1 (B) and the ratio of osteocalcin to CTX-1 in rats exposed to restraint (control) or tail vibration at 62.5 or 125 Hz for 8 weeks (different from controls, $p < 0.05$).*

Conclusions

After 8 weeks of vibration exposure, osteocalcin was slightly increased in rats exposed to vibration at 125 Hz, indicating that vibration at this frequency stimulated osteoblast activity and bone mineralization.

- Exposure to vibration at both frequencies also resulted in an increase in CTX-1, a serum marker of bone resorption, indicating that vibration also stimulated osteoclast activity and bone resorption

- The ratio of osteocalcin/CTX1 (an index of mineralization to resorption) was significantly lower in rats exposed to vibration than in control rats, suggesting that bone remodelling was altered to favour resorption instead of mineralization.

- These findings are consistent with *in vitro* studies demonstrating that vibration induces matrix degradation that can lead to disc degeneration and pain [4].

- Exposure to higher frequency, lower magnitude vibration is capable of inducing bone resorption in the absence of mechanical shock.

References

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