THE BIODYNAMIC AND PHYSIOLOGICAL RESPONSES OF THE RAT TAIL TO A SINGLE BOUT OF VIBRATION EXPOSURE

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INTRODUCTION

In humans, occupational use of vibrating hand tools leads to the development of neural and vascular damage. The goal of this study was to use the rat tail model to characterize the biodynamic response of the tail tissue to different vibration frequencies, and to determine what physiological changes occur in the vascular and neural systems of the tail after a single exposure to vibration.

METHODS

Male Sprague Dawley rats (6 weeks of age) were used for all experiments. Vibration exposures were performed by restraining rats in a Broome-style restrainer. Elastic straps (12 mm wide), located every 3 cm down the length of the tail, were used to hold the tail to a platform without compressing the tissue. The platform was attached to a shaker that produced a controlled, vertical vibration stimulus. The amplitudes of the tail and platform vibrations were measured down the length of the tail using a scanning laser vibrometer. The normalized magnitude (i.e., transmissibility) of the tail vibration was calculated by dividing the measured amplitude of the tissue vibration by the measured amplitude of the platform vibration. Measurements were made a number of frequencies (Figure 1).

The vascular and neural response of the tail to a single 4 h exposure to vibration (125 Hz, 49 m/sec^2 r.m.s.) was also measured to determine if the acute responses of the tail to vibration were similar to those of the human finger. The vascular responses assessed included tail temperature and luminal perimeter. The current perception threshold (CPT) procedure was used to assess the sensitivity of different nerve fiber types by measuring the response of the animals to electrical stimuli of different frequencies.

RESULTS AND DISCUSSION

The magnitude of the tail vibration was greater than the magnitude of the platform vibration at 125-250 Hz (Figure 1). However, the amplified response of the tissue to vibration at these frequencies only occurred in the unrestrained portions of the tail. At 63 Hz, the amplitude of the tail vibration was approximately equivalent to the platform vibration at all locations.

The vascular response of the rat tail to acute vibration was similar to the effects that have been reported in humans. Immediately following the exposure, the tail temperature of both control and vibration exposed rats was reduced (mean ± SEM, control pre 26.4 ± 0.52 and post 22.4 ± 0.33; vibrated pre 26.3 ± 0.51 and post 22.3 ± 0.02), suggesting that restraint caused a vasoconstriction in all rats. Tail temperatures in both groups of rats returned to pre-exposure levels 15 min following the end of the exposure. However, the internal perimeter of the ventral tail artery was significantly smaller in rats exposed to vibration than in control rats (546.93 ± 51.5 and 747.33 ± 55.7 μM). Therefore, even though skin temperatures recovered, there was a maintained constriction in the tail artery of rats exposed to vibration.

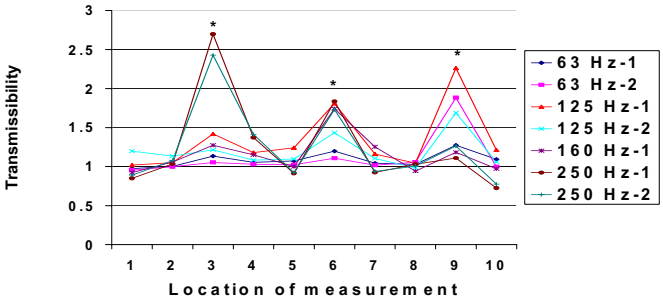

Figure 1: Normalized amplitude of the tail vibration vs. input frequency. The most proximal point on the tail is #1 on the x-axis and * represent un-restrained regions of the tail (N = 2).

CPT measurements demonstrated that the sensitivity of the Aβ fibers to 2000 Hz stimulation was significantly reduced (i.e. increased stimulus needed to induce a response) in rats exposed to vibration, but increased in the controls (Figure 2). The Aβ fibers carry vibrotactile information from sensory organs to the nervous system. All rats demonstrated slight increases in sensitivity to stimulations of 250 Hz (Aβ fibers) and 5 Hz (C fibers).

CONCLUSIONS

The acute biodynamic and physiological responses of the rat tail to vibration are similar to the responses seen in human fingers (1-3). Future studies will use this model to understand the effects of repeated vibration on soft tissue damage.

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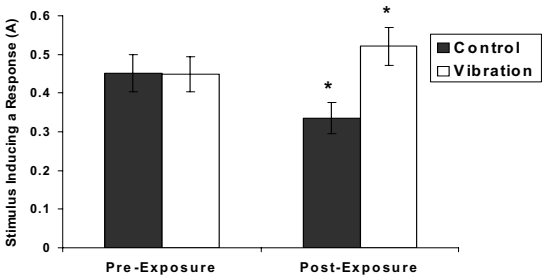

Figure 2. Responses of rats to 2000 Hz stimulation along the tail (data are mean ± SEM, * designates significantly different from pre-exposure test, N = 8/group).