ACUTE CHANGES IN VASCULAR FUNCTION INDUCED BY VIBRATION MAY BE ELIMINATED BY THE USE OF ANTI-VIBRATION MATERIALS

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Introduction

Occupational exposure to hand-arm vibration through the use of powered hand tools may result in cold-induced reductions in peripheral blood flow that result in vasospasms, along with finger and hand blanching. In humans and rat models, exposure to single bouts of vibration can induce a transient vasoconstriction. Animal studies have demonstrated that this constriction is associated with a short-term increase in the sensitivity of peripheral arteries to vasoconstricting factors (i.e., α2C-adrenoreceptor-mediated), and a delayed reduction in sensitivity to acetylcholine (ACh)-induced re-dilation (1, 2) . Recent evidence suggests that the reduction in the ability of ACh to induce vasodilation may be maintained for as long as 7 days following a single exposure to vibration. Therefore, protecting workers against the negative health effects of vibration is critical.

One method that has been used to protect workers against vibration-induced injuries is to have them wear anti-vibration gloves. However, a number of studies have found that anti-vibration gloves may not protect the hands of workers. In fact, the resonant frequency of some anti-vibration materials used in gloves is in the same range as the resonant frequency of human fingers (3). Because the risk of developing vascular disorders seems to be greatest at frequencies that induce the greatest bending and shear stress on the tissues of the fingers (4), it is possible that using anti-vibration (AV) gloves may actually increase the risk of developing vibration-induced disorders.

We have developed a rat-tail model of vibration-induced vascular injury that shows similar biodynamic properties to the human finger. In this study, we used this model to test the hypothesis that vibration-induced changes occurring after a single exposure to vibration may actually be worse when AV materials are used to buffer the transmission of vibration to the tail.

Methods

Animals. Male Sprague Dawley rats (8 weeks of age, n = 8/grp) were housed in AAALAC accredited facilities. All procedures were approved by the NIOSH Animal Care and Use Committee and were in compliance with the Guide for 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 Soft tape (Neurotron, Baltimore MD) which does not stick to the skin. Restraint control animals were treated in an identical manner except that the tail platform was set on isolation blocks instead of a shaker. Air bubble materials from gloves were placed on one control and one vibrating platform. Thus the study was a 2(glove vs no glove) x 2 (control vs vibration) completely crossed design. Rats were exposed to a 4 h bout of vibration or restraint at 125 Hz with a constant acceleration of 49 m/s^2 rms. Previous work in our lab has demonstrated that vibration exposure at this frequency and acceleration increase transmissibility to the tail (5). After the exposure, rats were returned to their home cages for 24 h and then euthanized by pentobarbital injection (100 mg/kg, i.p.) followed by exsanguination.

Vibration transmissibility: A laser vibrometer was used to measure vibration amplitude on the bare platform and on a platform with the air bubble AV material attached. Transmissibility was also measured at the surface of the tail during vibration on a bare platform and on a platform covered with AV material. Four rats were used to assess transmissibility to the tail.

Microvessel: Ventral tail arteries were dissected from the C15-20 region of the tail, mounted on cannulas in a microvessel chamber, and maintained in HEPES buffer containing sodium bicarbonate kept at 37°C. Vasoconstriction in response to the α2C-adrenoreceptor agonist, UK14304 was assessed. In a more distal segment, acetylcholine (ACh)-induced re-dilation after phenylephrine vasoconstriction was measured.

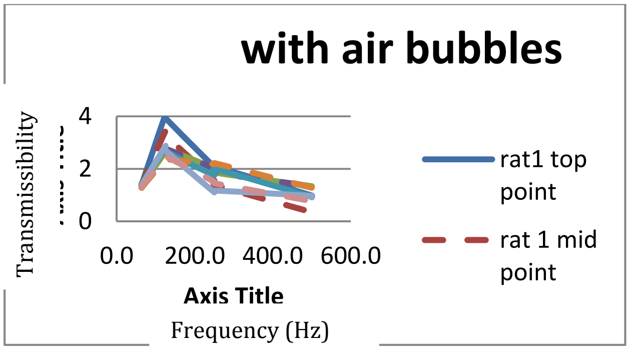

Figure 1: Vibration transmissibility to the tail when the platform was covered with AV air bubble materials. Vibration transmissibility in all tails was greatest at approximately 125 Hz. Transmissibility was defined as the amplitude of vibration measured at the tail/amplitude of vibration measured on the platform or air bubbles)

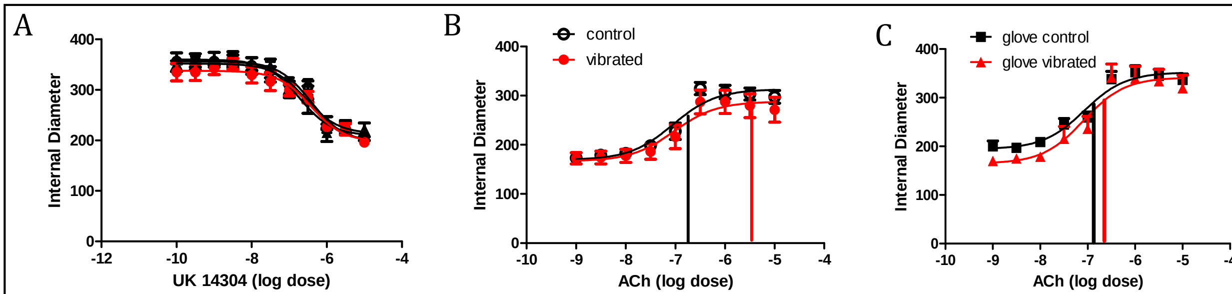

Figure 2: **A:** Dose-response curves to UK14304. Vibration did not alter the α2C-adrenoreceptor-mediated vasoconstriction in any of the groups. **B:** ACh-dependent re-dilation from arteries exposed to vibration without anti-vibration materials. The dose of ACh needed to induce a 50% re-dilation (effective dose or ED50) of the arteries was greater in vibrated than control arteries (lines designating ED50: black is control, red is vibrated). **C:** ACh-dependent re-dilation from arteries exposed to vibration AV materials. Use of AV material blocked the vibration-associated shift in the dose of ACh needed to produce a 50% increase in diameter.

Conclusions

- Although the resonant frequency of the air bubble AV materials and the tail are in the same range, use of air bubbles did prevent the vibration-induced reduction in sensitivity to ACh-induced re-dilation in vibration exposed rats.
- Arteries from control rats did not display changes in vascular responsiveness to α2C-mediated constriction or ACh-mediated re-dilation, suggesting that the changes we saw in vibrated rats were the result of protection from vibration and not from the prevention of heat loss.
- Our findings did not support the hypothesis. Instead, these findings suggest that the use of AV gloves may reduce the adverse effects of vibration exposure on vascular function. However, additional studies with repetitive exposures should be performed.

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This activity is an Accredited Group Learning Activity (Section 1) as defined by the Maintenance of Certification program of The Royal College of Physicians and Surgeons of Canada and approved by Occupational Medicine Specialists of Canada (OMSOC). The activity has been approved for up to 13 hours for the 3 day course (1 credit per hour).

Forward – Welcome Address

On behalf of my conference co-chairs, I am pleased to welcome you to Guelph, Ontario, Canada for the 5th American Conference on Human Vibration. The 5th ACHV is being co-hosted by the University of Guelph, Laurentian University, Western University and the University of Toronto. We are honored to be hosting this biennial conference on the University of Guelph campus. As the premier North American conference for human exposure to vibration, the conference provides a unique and convenient opportunity for researchers, engineers, medical professionals and industry representatives to exchange information on all aspects of vibration control and human responses to hand-transmitted vibration and whole-body vibration. The theme for this year's meeting is "Human Vibration - From Theory to Industrial and Clinical Applications".

Founded in 1827, Guelph was named after the British Monarch King George IV, who was from the House of Hanover. Selected as the headquarters of a British development firm called "The Canada Company", Guelph was designed by John Galt, who was a Scottish Novelist. The town was designed to resemble a European city center comprised of squares, wide main streets and narrow side streets. Guelph was home to Lieutenant Colonel John McCrae, the author of "In Flanders Fields". Its references to the red poppies that grew over the graves of fallen soldiers resulted in the remembrance poppy becoming one of the world's most recognized memorial symbols for fallen soldiers. Guelph was also the home of North America's first cable TV system. Fredrick T. Metcalf created MacLean Hunter Television (now part of Rogers Communications) and their first broadcast was of current monarch Queen Elizabeth II's Coronation in 1953. With a population of over 120,000, Guelph is part of a technology triangle which is comprised of the cities of Guelph, Kitchener, Cambridge and Waterloo. Guelph is consistently rated as one of Canada's best places to live because of its low crime rate, clean environment, high standard of living and low unemployment rate. Almost one quarter of Guelph employment is provided through the manufacturing sector with over 10% provided through Educational services. The City of Guelph has identified life science, agri-food and biotechnology, environmental management and technology companies as industries on which to focus future economic development activities.

Many thanks to Elyse Dubé from Conference Services at the University of Guelph for all of her hard work in helping to plan and sort through the conference logistics. We'd also like to thank Guelph Engineering students Gregor Scott and Dan Leto as well as School of Engineering technician Carly Fennell for their help in setting up the laboratory tours. We hope that your visit to the 5th ACHV and Guelph will be both educational and enjoyable.

Sincerely,

Michele Oliver, Jim Dickey, Tammy Eger and Aaron Thompson