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Title: Effects of Whole Body Vibration Exposure on Physiological Stresses in Mining Heavy Equipment Vehicle Operators

Organization: Oregon State University

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Focus Area: Musculoskeletal Disorders

Project Summary: Our objectives in this application are 1) to quantify the relative impacts of different types of WBV exposures (vertical dominant vs. multi-axial WBV) on physiological stress, and 2) to determine whether engineering controls designed to reduce WBV lower physiological stress. Our central hypothesis is that exposure to WBV causes muscle damage, oxidative stress, inflammation and other physiological stresses that can be detected by blood sampling. We also hypothesize that these physiologic stresses will be higher with multi-axial WBV exposure (common in mining vehicles) compared to vertical-dominant WBV exposure (common in on-road vehicles). These hypotheses were developed based on previous studies showing that repetitive muscle contraction and possible overuse increase muscle damage, oxidative stress, inflammation and physiologic stresses. As multi-axial WBV exposure may significantly increase spinal loading and associated muscle loads to counterbalance the inertia of the torso and head, multi-axial WBV exposures can cause the overuse and damage to the soft tissues, especially in the low back and neck regions, which can be objectively measured by validated biomarkers. To achieve our research objectives, we propose a repeated-measures laboratory study using 15 subjects to quantify the effects of WBV exposures on biological and physiological stress in the following specific aims:

Specific Aim 1: Determine the relative effects of the multi-axial WBV exposure on muscle damage, oxidative stress, inflammation, and physiological stress compared to vertical-dominant WBV exposure. In a laboratory setting where actual field-measured vibration profiles will be played into a motion platform, we will collect blood samples to assay circulating biomarkers for muscle damage, oxidative stress, inflammation and physiological stress from three different exposure conditions with an industrial standard vertical suspension seat: (a) vertical dominant WBV exposure, (b) multi-axial WBV exposure, and (d) no WBV exposure (control). In each condition, we will collect blood samples at pre-exposure (0 hour), during-exposure (2 and 4 hours), and in recovery two hours after exposure (6 hours).

Hypothesis 1.1: Exposure to the WBV will increase the level of muscle damage, oxidative stress, inflammation, and physiological stress indicated by the biomarkers.

Hypothesis 1.2: Markers of muscle damage, oxidative stress, inflammation, and physiological stress levels will be higher with mining vehicles' multi-axial WBV exposures compared to on-road vehicles' vertical dominant WBV exposures.

Specific Aim 2**: **Determine whether muscle damage, oxidative stress, inflammation, and physiological stress will be alleviated by a new engineering control (multi-axial active suspension seat). With the same research methods described in Aim 1, we will collect blood samples to compare the levels of muscle damage, oxidative stress, inflammation, and physiological stress between two different engineering controls: a single-axial suspension seat (industry standard) and a multi-axial active suspension seat (newly developed intervention).

Hypothesis 2: The use of a multi-axial active suspension seat will reduce the effects of multi-axial WBV exposures on markers of muscle damage, oxidative stress, inflammation, and physiological stress.

The primary outcome of this study is to identify underlying injury mechanisms and clarifying exposure- response relationships between WBV exposure and musculoskeletal stresses by measuring established markers of physiological stress. While some biomechanical studies have shown possible intervertebral disc degeneration and muscle fatigue, the injury pathology or underlying mechanisms are still not well understood. This is due, in part, to limitations of these studies including unrealistic sinusoidal vibration exposure, unidirectional (mainly vertical) vibration exposure, short WBV exposure duration, indirect fatigue assessment, and small sample sizes. Therefore, if we demonstrate that the exposure to WBV increase the level of muscle damage, oxidative stress, inflammation, and physiological stress after long (4-hour) exposure to real field-measured vibration profiles, we will advance the current knowledge on the underlying injury mechanisms associated with WBV exposures. Also, through varying the types of WBV exposures (vertical-axial dominant WBV and multi-axial WBV), we will be able to quantify relative impact of mining vehicle operators' WBV exposures (multi-axial WBV) on musculoskeletal injury risk as compared to on-road vehicle drivers (vertical-axial dominant). The long-term goal of this proposed study is to reduce work-related musculoskeletal disorders (MSDs) affecting mining vehicle operators in the United States.