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# EXAMINATION OF VIBRATION CHARACTERISTICS FOR WORKERS EXPOSED TO VIBRATION VIA THE FEET

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## Introduction

Prolonged exposure to hand-transmitted vibration has been shown to cause debilitating vascular, neurological, and musculoskeletal problems to the hand-arm<sup>1</sup>. Workers who are exposed to vibration via the feet could also be at risk for similar health problems<sup>2</sup>; however, limited research has examined the characteristics (frequency content, acceleration, amplitude) of vibration (from occupational sources) entering the body via the feet. In mining applications, vibration that enters the body via the feet has often been initiated with vibration from a hand-tool that has caused a working platform (that a worker is standing on) to vibrate. Therefore, the purpose of this study was to document the characteristics of vibration experienced at the feet under typical mining equipment operation.

## Methods

Four types of underground mining equipment (locomotive; jumbo drill; raise platform wood; raise platform metal) that expose workers to vibration through the feet were tested. Equipment types were split into two categories, primary and secondary, depending on the origin of vibration. Transmitted vibration from a primary source originated from a motor responsible for moving a vehicle (locomotive). The vibration exposure at the feet was classified as a secondary source exposure if the vibration was originally generated by a "powered-tool" that was attached or supported on the surface the worker stood on (jumbo drill; raise platform wood; raise platform metal). Vibration measurements were collected at the location where the worker stood to complete the required job task. Background information and a musculoskeletal disorder questionnaire were also collected for each equipment operator.

## Results

Vibration exposure resulting from a primary source exposure had a dominant frequency below 6.3 Hz. However, the dominant frequency recorded from secondary source exposures were predominantly in the 31.5 and 40 Hz range (Table 1). Two workers indicated they have been diagnosed with white feet and all other workers reported discomfort in their lower limbs. The wooden raise platform and the metal raise platform exposed the workers to vibration levels at the feet that placed them above the ISO 2631-1 health guidance caution zone, when the 8-hour frequency-weighted r.m.s acceleration exposure levels were considered (ISO, 1997).

Table 1: Vibration characteristics recorded at the feet during the operation of underground mining equipment. Musculoskeletal discomfort reported by the workers is also summarized.

Machine	Source	DF <sub>z</sub> (Hz)	a <sub>wz</sub> (m/s/s)	Reported Musculoskeletal Discomfort 1=mild discomfort; 4 = severe discomfort
Locomotive-1	Primary	6.3	0.43	Neck:1, Lower Back:2, R.Wrist:1, L.Wrist:1, L.Knee:1, R.Knee:1
Locomotive-2	Primary	3.15	0.36	L.Knee:1, R.Knee:1, L.Ankle:3, R.Ankle:1
Jumbo Drill (1 drill boom)	Secondary	31.5	0.16	R.Shoulder, R.Wrist 2, L.Wrist:2, L.Feet:1, R.Feet:1 <b>Diagnosed with white hands and feet</b>
Wooden Raise Platform (1 drill operating)	Secondary	40	1.1	L.Shoulder:2, R.Shoulder:2, L.Elbow:2, R.Elbow:2, Upper Back:2, Lower Back:2, L.Wrist:2, R.Wrist:2, Hips&Thighs:2, L.Knee:2, R.Knee:2, L.Ankle:2, R.Ankle:2 <b>Diagnosed with white hands and feet</b>
Metal Raise Platform (1 drill operating)	Secondary	40	1.08	<i>Worker 1:</i> L.Ankle:1, R.Ankle:1, L.Knee:3, R.Knee:3, Hips&Thighs:1, L.Wrist/Hand:2, R.Wrist/Hand:3, Lower back:3, L.Elbow:1, R.Elbow:1, Upper back:1, L.Shoulder:2, R.Shoulder:2, Neck:3
Metal Raise Platform (1-drill with “anti-vibration” leg)	Secondary	40	0.8	<i>Worker 2:</i> L.Ankle:2, R.Ankle:2, L.Knee:2, R.Knee:2, L.Wrist:3, R.Wrist:3, Lower back:1, Upper back:1

### Discussion

Workers standing on the jumbo drill and raise platforms experienced dominant frequency vibration known to be associated with hand-arm vibration syndrome. The jumbo drill operator and one of the raise workers confirmed they have already been diagnosed with white feet. The dominant frequency recorded at the feet of the locomotive operators was in the range associated with “whole-body” health effects. Interestingly, one of the locomotive workers reported greater discomfort in the neck and lower back. Further investigation is warranted to determine long-term health effects resulting from vibration exposure via the feet.

### References

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