

## CASE REPORT

# Vibration-white foot: a case report

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<b>Background</b>	Hand–arm vibration syndrome (HAVS) refers to the neurological, vascular and musculoskeletal problems that may arise due to exposure to segmental vibration to the hands. An analogous syndrome may occur in the lower extremities of workers exposed to foot-transmitted vibration.
<b>Aims</b>	This report describes the case of a worker with a history of foot-transmitted vibration exposure presenting with cold intolerance in the feet and blanching in the toes.
<b>Case report</b>	A 54-year-old miner presented with a chief complaint of blanching and pain in his toes. The worker had a history of foot-transmitted vibration exposure over his 18 year career as a miner, primarily from the operation of vehicle-mounted bolting machines. Cold provocation digital plethysmography showed cold-induced vasospastic disease in the feet, but not in the hands.
<b>Conclusions</b>	This case illustrates a condition descriptively termed 'vibration-white foot': a disease analogous to HAVS arising after segmental vibration exposure to the feet. Further research is required to increase awareness of, and direct preventive efforts for, this potentially debilitating condition.
<b>Key words</b>	Feet; hand–arm vibration syndrome; occupational; Raynaud's phenomenon; vibration.

## Introduction

The acute and chronic effects of segmental vibration exposure to the hands are well documented [1]. Acutely, exposure to hand-transmitted vibration causes an increase in sympathetic tone in the heart and reduced blood flow in the fingers and toes [2]. Chronic exposure to hand-transmitted vibration results in hand–arm vibration syndrome (HAVS), a condition affecting the digital arteries, peripheral nerves and musculoskeletal system of the upper limbs [1]. That a condition analogous to HAVS might occur in the feet after lower extremity vibration exposure is biologically plausible, though not well studied. To our knowledge, the current evidence for this condition is limited to a single report in the literature [3].

## Case report

A 54-year-old miner presented with a 2–3 year history of cold intolerance and blanching in his toes. The worker denied symptoms of HAVS.

The worker had been employed in the mining industry for 35 years: initially as a furnace man for 17 years and then as an underground miner operating drills and roof bolters for 18 years. The worker retired 3 months prior to assess-

ment. Roof bolters are used to drill holes and place bolts to support the mine roof. These machines expose workers to foot-transmitted continuous vibration while drilling and bolting because the console is mounted on the machine and the platform upon which the worker stands vibrates when the machine is in operation. The worker estimated that he operated roof bolters 4 h/day, 3 days/week, during the 4 years immediately preceding assessment. The worker reported additional occupational exposure to foot-transmitted vibration from scissor lifts and load-haul-dump vehicles. History taking identified no non-occupational sources of foot-transmitted vibration exposure.

Past medical history included hypertension (not pharmacologically treated) and hypercholesterolemia. He was an ex-smoker (35-pack-year history), who had stopped smoking 6 years previously. He had a history of wrist fracture, but denied other trauma to the hands, fingers, feet or toes. There was no history of frostbite to the fingers or toes and he had no personal or family history of primary Raynaud's disease, connective tissue disease, diabetes mellitus, gout, arthritis, neurological problems or thyroid disease. His only medication at the time of assessment was rosuvastatin.

Physical examination showed a blood pressure of 160/90. Cardiac examination was normal. Adson's and Allen's tests were normal. There were no trophic

changes in the fingers or toes. Neurological and musculoskeletal examinations of both the upper and lower extremities were normal.

Blood tests for systemic causes of secondary Raynaud's phenomenon, including complete blood count, erythrocyte sedimentation rate, thyroid-stimulating hormone, cryoglobulins, rheumatoid factor, antinuclear antibody and serum immunoelectrophoresis, were normal.

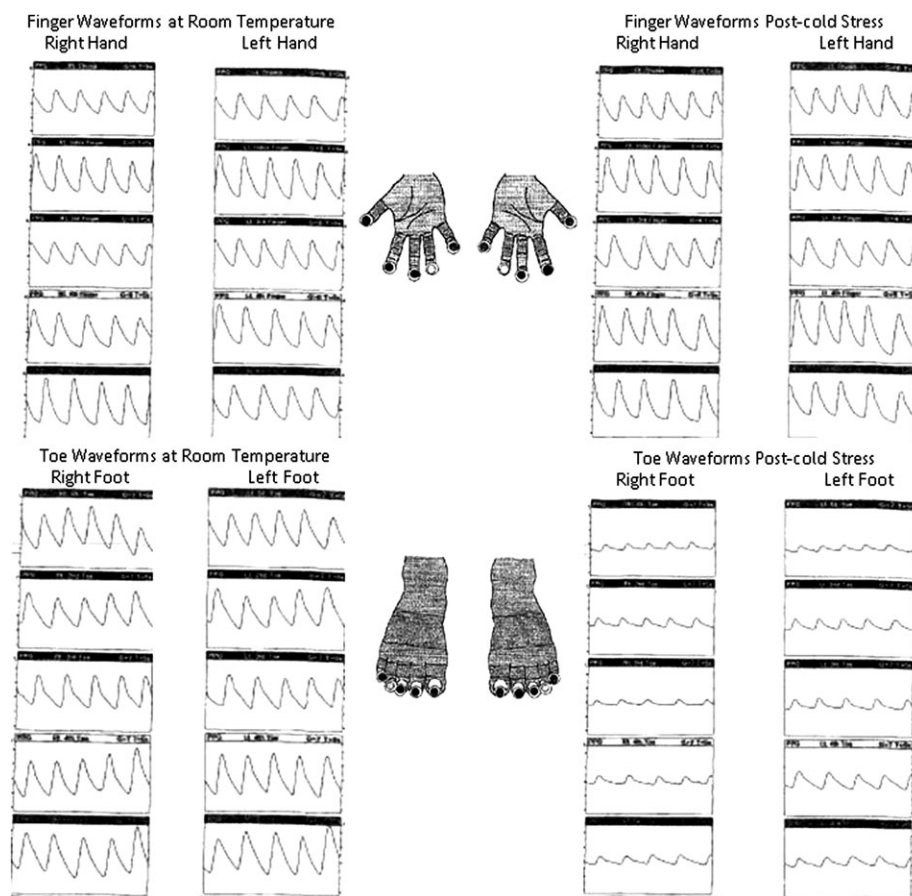
Doppler investigation was negative for peripheral vascular disease in the upper and lower extremities. Cold provocation plethysmography [4], nerve conduction studies and current perception threshold tests were all normal in the hands. Digital plethysmography for the toes showed normal toe waveforms at room temperature with moderate dampening of all toe waveforms post-cold stress (see Figure 1).

The worker was diagnosed with Raynaud's phenomenon of occupational origin in the feet. He was advised to avoid cold exposure as much as possible, to dress warmly whenever exposed to cold ambient conditions and to minimize vibration exposure to the feet. A trial with a calcium-blocking agent was suggested for treatment of his vasospastic symptoms. At 4 months follow-up, the worker had not yet tried pharmacological treatment and described no significant change in his condition.

## Discussion

This case demonstrates bilateral and symmetric vasospastic disease in the feet, but not in the hands, in a worker with a history of foot-transmitted vibration exposure. A diagnosis of vibration-induced Raynaud's phenomenon was determined based on exposure history, compatible symptoms, negative work-up for other secondary causes of Raynaud's phenomenon and plethysmographic findings. Unremarkable Doppler investigation with normal ankle-brachial indices argued against significant peripheral arterial insufficiency, while Buerger's disease was deemed unlikely given the worker's current non-smoking status, lack of findings in the hands and normal laboratory investigations and baseline plethysmography.

There is evidence to suggest that patients with HAVS may have concurrent, albeit usually less severe, vascular symptoms in the feet, with symptoms in the feet usually occurring after hand symptoms are already present [5]. This case demonstrates the inverse of the typical presentation; exposure to foot-transmitted vibration with primary symptoms in the feet. Most authors have considered the vascular symptoms in the feet of HAVS patients to be primarily due to autonomic dysfunction and sympathetic hyperactivity [6]. This case does not contradict this



**Figure 1.** Plethysmography results showing finger and toe waveforms at baseline (room temperature) and post-cold stress. Finger waveforms show no vasospasm post-cold stress. Toe waveforms show moderate dampening post-cold stress (immersion of the toes in water of 10 degrees centigrade for 2 min).

hypothesis, although it does suggest that local vascular pathology secondary to direct vibration exposure may be the principal pathophysiological mechanism in some cases.

Two reports in the literature document vibration measurements taken from the platforms of machines used in mining operations [7,8]. The reports use the International Organization for Standardization (ISO) 2631-1 guideline to interpret the measurements [9]. The measurements in these reports provide some insight into the most likely dominant frequency, which was 40 Hz in both studies [8] (T. Eger, personal communication). It should be noted that ISO 2631-1 may not be applicable to foot-specific effects because the frequency weighted acceleration values in the guideline focus on frequencies between 1 and 20 Hz. The relevant anatomic factors of the feet and toes would be expected to be analogous to the finger-hand-arm system, which is more susceptible to vibration at higher frequencies (40–100 Hz for the hand-arm system and >100 Hz for the fingers) [10]. As such, ISO 2631-1 may not be protective for vibration-induced pathology in the feet from drill and bolting platforms, which tend to have dominant frequencies of ~40 Hz.

In summary, this report describes a case of a worker with isolated cold-associated vasospastic disease in the toes after a history of vibration exposure to the feet. The case represents the inverse of the presentation of most HAVS patients. Recognition that foot-transmitted vibration can result in a HAVS-like syndrome in the feet should help to facilitate appropriate investigation, management and communication with other exposed workers.

### Key points

- Segmental vibration exposure to the feet may result in a condition termed 'vibration-white foot' that is similar to vibration-white finger but affecting the feet.
- Assessment of vibration-exposed workers should include a history of foot exposure and, if indicated, appropriate symptom history, physical examination and testing for vibration-associated pathology in the feet.
- Use of the current guidelines for vibration exposure for workers exposed to vibration in a standing position may not be protective for vibration effects in the feet.

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Disclaimer: the findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

## Conflicts of interest

None declared.

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