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Association between vibration exposure and hand-arm vibration symptoms in a Swedish mechanical industry

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ABSTRACT

Work with vibrating tools is common in many industries. Exposure to hand-arm vibrations is associated with a risk of hand injury in the form of: Vascular disorders, nerve malfunction, and effects on the musculoskeletal system. The aim of this study was to investigate the prevalence of hand-arm vibration symptoms among employees at a mechanical company, as well as to follow-up with patients presenting symptoms and evaluate the effects of certain proposed measures. We found that 21% of the employees were judged to have vibration-related problems even though the exposure to vibrations was judged to be relatively low. There seems to be an over-representation of Carpal tunnel syndrome among participants; this may suggest that ergonomic conditions at the investigated company, such as grinding with flexed wrists, are unfavorable.

Relevance to industry: Regular screening for early signs of vibration-related damage, even if workers are subject to only moderate vibration exposure, is an important part of preventing the aggravation of health problems.

1. Introduction

Work with vibrating tools is common in many industries, such as mechanical workshops, car repair shops, building and construction, foundries, and forestry. A Work Statistics Report from the Swedish Work Environment Authority (2014) stated that 14 percent of all employed men in Sweden are exposed to vibrations from hand-held machines for at least 25 percent of their working time (Swedish Work Environment Authority, 2014). The corresponding figure for women was three percent.

According to ISO (2001), the exposure level, or intensity, of vibrational power is measured as acceleration in m/s^2 (ISO, 2001). Exposure to hand-arm vibrations is associated with a risk of hand injury in the form of vascular disorders, nerve malfunction, and effects on the musculoskeletal system (Gemne and Lundström, 2000; Heaver et al., 2011).

Vascular symptoms usually manifest as suddenly pale and/or cold fingers, which are the result of a vibration-induced vascular spasm. The condition is sometimes called secondary Raynaud's syndrome, or vibration-induced Raynaud's. The risk of vibration-associated vascular spasms in the hands is related to both the intensity and duration of the vibration exposure (Gemne and Lundström, 2000; Bovenzi, 2010).

Once exposed, a spontaneous improvement is expected in about half of the workers who have experienced white fingers (Petersen et al., 1995; Ye et al., 2014). The symptoms are reversible, but some studies suggest that the symptoms become more persistent when they are more pronounced (Kurozawa et al., 2002). Therefore, early diagnosis is an important preventive measure.

Vascular symptoms from vibrations are classified according to the Stockholm Workshop Scale (Table 1) (Gemne et al., 1987). The vascular symptoms ($_V$) are graded from 0 to 4 depending on the gravity of the symptoms.

Early neurological symptoms of exposure to hand-arm vibrations are usually characterized by attacks of numbness in the hand or fingers, either with or without tingling. Prolonged exposure may cause the episodes to become more frequent, and also occur in combination with reduced tactile and fine motor skills (Gemne and Lundström, 2000). The neurological symptoms can affect different

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Table 1
Grading of vascular and neurological symptoms from vibrations according to the Stockholm Workshop Scale.

Vascular symptoms[a]	0_V	No attacks
	1_V	Attacks affecting only the tips of the distal phalanges of one or more fingers
	2_V	Occasional attacks of whiteness affecting the distal and middle (rarely also the proximal) phalanges of one or more fingers
	3_V	Frequent attacks of whiteness affecting all of the phalanges of most of the fingers
	4_V	As 3v, with additional trophic changes
Neurological symptoms	0_{SN}	Vibration exposure but NO symptoms
	1_{SN}	Intermittent numbness and/or tingling with a sensorineural loss
	2_{SN}	Intermittent or persistent numbness and/or tingling with reduced sensory perception
	3_{SN}	Persistent numbness and/or tingling with reduced manipulative dexterity.

[a] An extra grade, 0.5, is occasionally added for increased sensitivity to cold according to the modified Taylor Pelmear scale (Ekenvall, 1991).

sensory thresholds in the hands, such as those for touch, vibration, and temperature (Nilsson, 1998). However, there is no clear link between the vibration exposure intensity, frequency, or duration and which senses are affected.

Neurological symptoms ($_{SN}$) are also classified under the Stockholm Workshop Scale (Ekenvall, 1991) from Stage 0–3, as shown in Table 1:

Symptoms from the musculoskeletal system (muscle joints and connective tissue) seem to have a weak correlation with the actual vibration exposure. The degree of harmful effect is difficult to correlate to the intensity, frequency, or duration of vibration exposure; however, there is a strong correlation between working with vibrating tools and musculoskeletal symptoms. It is plausible that the overall work environment, including ergonomic factors, contributes to these symptoms (Hagberg, 2002). Muscle biopsies of people exposed to vibrations have revealed damage in the small muscles of the hand (Necking, 2003). Moreover, exposure to vibrations from hand-held tools can also cause musculoskeletal abnormalities, particularly osteoarthritis of the wrist and elbow (Necking, 2003).

Even though a high prevalence of Carpal tunnel syndrome (CTS) has been reported for vibration-exposed workers, the mechanism is not yet fully understood. Exposure to vibrations in combination with ergonomic factors, such as static load, power grip, and unfavorable hand posture, is believed to increase the risk of CTS (Aroori and Spence, 2008; Gemne and Lundström, 2000; van Rijn et al., 2009). Biopsies from people exposed to hand-arm vibrations have shown both damage to the myelin layer of nerves and signs of perineural fibrosis. The vibrations cause structural damage to nerves, and edema formation could explain why operating on vibration-caused CTS does not always provide good surgical results (Stromberg et al., 1997).

The damage caused by exposure to hand-arm vibrations is usually collectively referred to as hand-arm vibration syndrome, or HAVS. This usually includes damage to multiple areas, such as the vascular, nervous, and musculoskeletal systems.

The aim of this study was to investigate the prevalence of hand-arm vibration symptoms caused by hand-held vibrating tools among employees at a mechanical company. We also wanted to follow-up with the patients who had presented symptoms, and to evaluate whether proposed measures (information about the risks of vibration exposure and new tools) could reduce the exposure to hand-arm vibration.

2. Materials and methods

2.1. Study group

Full time employees (8 h day shift) at a mechanical industry where asked to answer a questionnaire about vibration related symptoms from the hands (n = 68). Employees who answered yes to at least one question about symptoms of white finger, neurological symptoms or hand pain in this questionnaire were offered a medical examination (Fig. 1).

Three years after the first examination, the participants who had shown symptoms of HAVS where offered a follow-up medical examination to evaluate if their symptoms had changed (regressed or increased). Seven people chose to participate. The high drop-out rate can likely be explained by a restructuring program that occurred at the company between surveys.

2.2. Questionnaire

A validated questionnaire available in the Swedish Work Environment Authority's book, Vibrations at work, was used in this study (Swedish Work Environment Authority, 2005). The participants answered 10 questions about hand symptoms by choosing from the following options: No; Negligible; Light to Moderate. The questions covered neurologic problems and CTS (numbness at night, often dropping objects, difficulty fastening buttons), white fingers (a cold feeling in the hands/fingers, fingers get white when moist and cold) and muscular disorders (pain in the wrist, pain in the fingers, shaking or trembling of the arms/hands, cramping sensations in the arms/hands).

2.3. Medical examination

The medical examination was carried out by occupational physicians and included both an evaluation of the participant's medical history, as well as the status and history of exposure to hand-arm vibrations. The presented study followed a standardized procedure described by Ekenvall, in which the examination includes an examination of the neck, shoulders, and elbows (Ekenvall, 1991). A more detailed examination on the hands, used to diagnose Carpal tunnel syndrome and identify signs of vascular damage at the wrist, implemented the Phalen-, Tinells- and Allen tests. All of the participants were classified according to the Stockholm Workshop

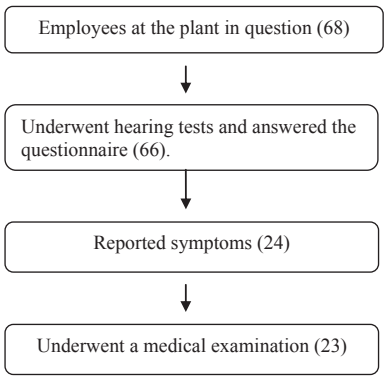

Fig. 1. Study group composition during different stages of the study (number of participants).

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