Occupational Exposure to Vibration and Ischemic Heart Disease

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Abstract: Occupational Exposure to Vibration and Ischemic Heart Disease: Luciana-Daniela TAMAIA, *et al.* Pneumoconiosis Lab., Mining Institute, Cluj-Napoca—150 miners working in an ore mining area were investigated to evaluate the prevalence of ischemic heart disease. They were assigned to three groups: 50 subjects exposed to vibration with signs of Raynaud phenomenon, 50 with similar exposure without Raynaud phenomenon, and the other 50, who were not exposed, representing the control group. The three groups were matched in terms of age, food habits, and hereditary risk factors for ischemic heart disease, smoking habits, lipemia, and blood cholesterol levels. In the group exposed to vibration, the prevalence of ischemic heart disease was 11% and in controls 6% ($p=0.35$). The presence or absence of Raynaud phenomenon did not significantly influence the prevalence of ischemic heart disease in the group of subjects exposed to vibration.

(*J Occup Health* 1998; 40: 73–76)

Key words: Raynaud phenomenon, Ischemic heart disease, Vibration and Ischemic heart disease

In countries in a social and economic transitional period, a large number of workers are exposed to vibration. Under conditions of insufficient protection, the impact on the health status can be considerable.

The variety of functional disorders and clinical manifestations caused by vibration with frequencies ranging between 20 and 200 Hz, outlines the state of vibration disease¹⁾, of which neurovascular syndrome is a characteristic manifestation. In addition to peripheral circulation disorders, well known as a result of many studies, a series of other clinic-functional disorders of the cardiovascular system may occur²⁾. It has been proven in a few studies

dealing with this problem³⁾ that exposure to vibration is related to a higher rate of ischemic heart disease. Thus, Tsvetkov and Tsacheva⁴⁾ have been related considerably high hypertension disease and ischemic heart disease incidences in vibration-related professions. Idzior-Wallus⁵⁾ also have been shown that vibration and noise may be factors which increase the risk of coronary heart disease. This paper aims at evaluating the prevalence of ischemic heart disease in a group of young miners exposed to vibration with a frequency spectrum between 20 and 200 Hz.

Methods

The study included 150 miners working in an ore mining area from the north of Romania. All of them come from a geographical area around the mine basin, with identical climatic conditions and food habits. Of these, 50 subjects were exposed to vibration and showed signs of Raynaud phenomenon—group A; 50 were exposed to vibration, but did not show Raynaud phenomenon—group B; 50 subjects included in group C (control group) were not exposed to vibration as they performed maintenance duties in the galleries.

Vibration are produced by the pneumatic drill T 90 with a frequency of 30 percussions per second and the miners are usually exposed for 2–6 hr per shift in a cold and wet climate, without any individual protection. The noise level was 96–98 dB, exceeding by 1.06 and 1.08 respectively the permissible levels, and the vibration level was 150 m/s²–100 m/s² respectively, in the frequency band 31.5–125 Hz, exceeding by 8.3 and 5.5 times respectively the permissible levels. Data were collected on the basis of a questionnaire in which the following were mentioned: duration of professional activity (years), heredo-collateral history of ischemic heart disease, smoking habits and presence or absence of psychological stress related to the profession. Raynaud phenomenon was evaluated on the basis of

Received March 28, 1997; Accepted Aug 12, 1997

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history, physical examination, skin thermometry and cold test. In each of the 150 workers, a lipid concentration was dosed by the Kunkel method, plasma cholesterol by the Watson method (both methods reported by Manta *et al.*⁶⁾) and electrocardiograph tracing was recorded. After 5 min rest, while the heart rate became stable, an electrocardiograph was performed. We selected the subjects which described typical effort pain associated with EKG repose modifications: horizontal or descendent depression of the ST segment, at least 1 mm at 0.08 sec from the J point and/or symmetrical negative T wave in at least two adjacent derivations. The clinical diagnosis could not be confirmed by an effort test or/and coronarography, because we did not have the properly medical equipment in the workplace⁷⁾. The relationships expressed as prevalence were examined by the χ^2 test and differences between means by the Student's t-test.

Results

Table 1 shows the main characteristic elements of the three groups of miners. The differences in age and duration of exposure to vibration are statistically insignificant ($p > 0.10$), which emphasizes the homogeneity and comparability of the three groups. Total lipids and cholesterol were within the limits considered normal for our geographical zone and the differences between groups are statistically insignificant. Individually, the higher normal limit was found to be slightly excessive in 15% in group A subjects, 10% in group B and 12% in group C, but these frequency differences are not significant (A/B, $p = 0.29$; A/C, $p = 0.29$; B/C, $p = 0.20$). Slight hyperlipemia was found in 14% of group A subjects, 10% of group B and 10% of group C, but these frequency differences did not reach a threshold of significance (A/B, $p = 0.29$; A/C, $p = 0.29$; B/C, $p = 0.20$).

These findings are important because the possible frequency differences of ischemic heart disease in

the three groups are unlikely to be a consequence of metabolic risk factors. Heredity of ischemic heart disease was reduced and frequency differences were insignificant ($p > 0.10$): 4% in group A, 2% in group B and 4% in group C. All subjects reported the same work-related stress factors, including noise, vibration, heavy work, accident risk and the smoking habit, recognized in 36% of the subjects exposed to vibration and 38% of the miners in the control group ($p = 0.65$).

Table 1 also shows the prevalence of ischemic heart disease in the three groups: 8, 14 and 6% in groups A, B and C respectively. The prevalence differences were not statistically supported on application of the χ^2 test (A/C, $p = 0.70$; B/C, $p = 0.20$), but comparing the A and B groups together, both exposed to vibration, with the C group, unexposed to vibration, we found 11% prevalence of ischemic heart disease in groups A and B and 6% prevalence to group C (control group). In spite of this, the frequency difference does not reach the threshold of statistical significance ($p = 0.35$).

Discussion

Functional disorders and morphological lesions of arterial vessels have been found in classical and current studies. Takeuchi *et al.*⁸⁾ reported that the prolonged use of vibratory tools produces important morphological arterial obstructive changes as a consequence of vascular wall hypertrophy and subintimal fibrosis. These studies were carried out on finger biopsies in patients exposed to vibration with Raynaud phenomenon. Whether these disorders and lesions remain strictly local or can also manifest themselves at a distance from the area exposed to vibration is a question we cannot answer yet. Tsvetkov *et al.*⁹⁾, studying the specific and non-specific indices for exposure to vibration, created some models which could be used to predict the presence or absence of concomitant diseases, such as hypertension, coronary heart disease and arthritic

Table 1. Mean age, duration of exposure to vibration, total lipids, plasma cholesterol and prevalence of ischemic heart disease in 150 miners

Groups	Groups exposed to vibration		Group unexposed to vibration (C)
	With Raynaud phenomenon (A)	Without Raynaud phenomenon (B)	
Mean age	45.3 ± 9.5	47.1 ± 9.0	45.7 ± 9.3
Duration of activity (yr.)	15.2 ± 6.3	14.4 ± 6.0	16.0 ± 5.3
Total lipids	663.2 ± 110.8	641.2 ± 97.4	614.0 ± 112.2
Cholesterol	169.4 ± 41.5	161.9 ± 42.5	174.6 ± 45.1
Prevalence of IHD	8%	14%	6%

lesions in persons exposed to vibration. In the case of strictly local effects, a higher incidence of ischemic heart disease in workers exposed to vibration could not be confirmed. Over the last 15 years, many observations have supported the existence of more complex mechanisms, which can determine vascular responses on a larger scale. Thus, by their action on peripheral receptors, vibration are considered to disturb the balance of the autonomous nervous system, causing an increase in the sympathetic system tonus, which is a serious disorder in the mechanism of Raynaud phenomenon^{3, 10}. This supposition is supported by Hesaki's¹¹ research, which revealed the increase in urinary catecholamines in patients with vibration disease. The increased tonus of the autonomous sympathetic system might be the consequence of a parasympathetic depression^{3, 12, 13}. According to Matoba *et al.*¹⁴, a series of stress factors, including noise, exposure to cold, vibration, psychological pressure and posture during work, have an effect on the limbic system and cerebral cortex, causing at the same time permanent chronic functional and/or anatomic injuries in the vascular walls. A possible mechanism of small blood vessel deterioration could be an immunological one, as the McHugh's *et al.*¹⁵ studies show. This authors have found a persistent increase in IgG anticardiolipin antibodies in the serum of males exposed to vibration daily at work, and they have considered them to be a marker of endothelial damage associated with vibration-white-fingers. Studying the effect of vibration on the production of hormones and neurotransmitters (ACTH, cortisone, adrenaline, noradrenaline and dopamine), the author provides very convincing arguments for putting vascular disorders within the more general category of responses coordinated by the hypothalamus and the limbic system. Serotonin release is the consequence of platelet aggregation caused by exposure to cold against the injured vascular background, and this has an effect on the 5 HT vessel receptors, triggering vasoconstriction¹⁶. Many workers have described abnormal blood rheology in hand arm vibration syndrome including abnormalities of platelet function¹⁷, blood viscosity¹⁸ and plasma fibrinogen¹⁹. Palmer and Moson²⁰ have shown that the large relative rise in serum Endothelin₁₋₂₁ (a naturally vasoconstrictor produced by the endothelium) may contribute directly or indirectly to vasospasm.

We consider that in the context of these neuroendocrine disorders, which have been currently elicited, this may imply responses on a larger biological level, possibly a vascular involvement of the coronary area. For this, the almost two-fold preva-

lence of ischemic heart disease in the miners exposed to vibration compared to the control group, which is close to the threshold of statistical significance without reaching it, opens a new research prospective. As we know from classical physiology, catecholamines have vasodilating effects on the coronary area and on this basis the problem of ischemic heart disease in vibration disease could be considered as closed. But we should bear in mind that the possible coronary dilating effects, by prolonged action, can produce silent ischemic heart disease in which the coronary arteries are dilated under the influence of vibrations, react by rebound spasms after the interruption of exposure, a phenomenon similar to that known in workers exposed to nitroglycerine in the explosives industry. It is premature to draw conclusions, but our observations suggest that a relation between exposure to vibration and ischemic heart disease unconditioned by the concomitant presence of Raynaud phenomenon is possible. A subsequent study of a larger group of miners could clarify this.

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