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OCCUPATIONAL DISEASES INDUCED BY VIBRATIONS

Abstract: *Vibration is physical noxiousness which is present in different branches of industry. Vibration disease is the disease caused by professional vibrations. The disorders caused by acute and chronic, local or general exposure are numerous and very nonspecific. Vibration disease signs are expressed late during natural course of disease, and diagnosis is made with significant delay. The occupational disorders caused by vibration represents important segment in occupational medicine and occupational protection. Pathogenetic factors are microtrauma, spasm of arterial blood vessels and ischemia. The vibration damages all tissues but the cardiovascular, muscular, nervous system and bones are specially damaged. High frequent vibration damages cardiovascular system and low frequent vibration damages bones. Vibrations may represent contributing factor in development of occupational accidents. In the estimation of working ability the demands of workplaces, noxiousness, health state, functional state, motivation, length of working must be examined. The preventive steps include technical, organisational, and medical procedures as well as using of personal protective means. The vibrational disease has great impact on workers' health and demand further research and permanent labor regulation adjustment in this field.*

Key words: Occupational disease, Vibrations, Health, Hazard

INTRODUCTION

Occupational use of vibrating tools and exposure to vibration results in vibration disease. The patient is not only afflicted with peripheral disorders, but also with a systemic disorders and manifested laboratory and clinical finding [1]. The pathophysiology of vibration induced disorders is not fully clarified and proposed models are not fully evaluated [2]. Vibrational disease still represents medical issue without effective treatment [3].

The main problem in preventive approach to vibration disease is its slow and long progression. Many workers do not think that their exposure to vibration could be a health hazard because they do not have clinical manifestation in early phases of disease. Moreover, in the later stages, vibration disease could be presented with many non-specific symptoms that workers do not connect with the disease. As disease progress workers can suffer from serious health problems such as vascular and neurological disorders, spinal syndrome and back pain, carpal tunnel syndrome and other clinical manifestation [4, 5].

The exposure to vibration could be by whole-body and by hand an arm. These two types of vibration have different sources, affect different areas of the body, and produce different symptoms. Hand-transmitted vibration is limited to the hands and arms and is usually the consequence of the use of power hand tools. In this case vibration enters the body through the hands, e.g. in various work processes where rotating or percussive

power tools are held by the workers' hands [6]. Whole-body vibration occurs when mechanical vibration enters by seat or feet, or both, often through driving or riding in motor vehicles and when working near some industrial machinery with frequencies of concern ranging from 0.5 to 80 Hz [7].

Male workers are mainly exposed, especially hand-tool workers, operators of a variety of vehicle categories such as cars, buses, forklifts, tractors, trucks, and heavy machinery, drivers of mobile machines, locomotives or people working in the vicinity of stationary machines. [8]. There is great variation in proportion of workers occupationally exposed to vibrations. This proportion varies widely between countries, from 14-34%, and is concentrated in the sectors of construction (63%), manufacture and mining (44%) and fishing (38 %) [9].

A great number of workers in different occupations exceeded limits to whole-body vibration (WBV) established by the European directive. This is more often observed in operators of most off-road machinery and heavy machines in agricultural forestry industry. In the case of fork-lift trucks, the action level is likely to be exceeded if they are driven for longer than three to four hours and in the case of trucks and lorries if they are driven all day long. However, the limit value is likely to be reached only rarely, except in the case of scrapers and some finishers [10]. The greatest concern involving WBV exposure is low back pain [4].

Regarding hand-arm vibration (HAV), the action level is likely to be exceeded by operators of most main

percussive and roto-percussive tools (such as chipping hammer, demolition hammer, rock drill, breaker, impact drill, scabbler, rammer, vibratory rammer), of main rotative tools (e.g. grinder, impact wrench, sander) and main alternative tools (e.g. jig-saw, file). The limit value for exposure to vibration may be exceeded if percussive and roto-percussive tools are used for more than one to two hours a day, or in the case of some rotative tools if used for more than four hours [9, 10].

Many novel tools and technological innovation are used in modern industry, mining, forestry and other branches of industry. This comprises different hand, pneumatic, electric and vibrating tools and devices. Although their manufacturing satisfied many rigorous standards for environment and health protection there are still hazardous effects on human health, especially by vibration induced disturbances [11]. Working with these devices is commonly associated with broader spectrum of symptoms and signs of vibration disorders. This leads to development of vibration disease. The intention is replacement of old pneumatic devices with devices engined by electric power aimed to reduce vibration but health issues still remain under question [10].

PHYSICAL CHARACTERISTICS OF VIBRATIONS

Vibrations imply any oscillatory motion of solid particles or bodies where material points periodically pass through the equilibrium position. This motion is continuous or steady periodic movement that can be simple, harmonic and very complex.

Apart from specific sources of oscillations, vibrations can be caused by noise of certain frequencies as well. Audio-frequency vibrations between 18 Hz and 20 000 Hz may cause noise. This type of noise shares the same physical characteristics of the noise arising from other sources. The only difference is that due to the possibility of propagation of vibrations through constructions noise can be transferred to other facilities as well.

The direction of the spread of vibrations can be vertical (in mechanical pneumatic hammers) and horizontal (in some types of hammer with horizontal beats). However, some advanced machines may have both directions including any direction between horizontal and vertical one. In practice, machine vibrations are mostly vertical while in pneumatic piston tools (air guns, hammers) they are parallel to the axis of the tool [12].

Vibrations cover a wide field of oscillations starting from the lowest values of Hz (Hertz) up to 20,000 Hz and over. The frequency area of few up to few thousands Hz. is in the focus of medicine. Frequency intensity ranging from 25 Hz and 8192 Hz is referred to as vibration velocity. It is in this range of orbital speed that a human body is most sensitive and this aspect of

vibration velocity is especially important for consideration and research.

Occupational groups exposed mostly to local vibrations.

This group includes workers who work with vibrating hand tools such as diggers, miners, moulders, power cutters, forestry workers, workers in the footwear industry, workers in construction and road construction. Tools that generate these vibrations are pneumatic and electric drills, rotary hammers, grinders, chain saws, air guns, hammers, rams and the like [12].

Occupational groups exposed mostly to general vibrations

This group includes workers who work with transport services: drivers, conductors, drivers of agricultural machinery (tractor, combiners), workers in construction machinery (bulldozers, excavators, tippers), textile, tobacco and timber industry [9,13]. The most important finding for these mainly seating occupations is that the transmission of vibration through a seat depends on the impedance of the seat and the apparent mass of the seat occupant [14].

THE EFFECT OF VIBRATIONS ON THE ORGANISM OF EXPOSED WORKERS

The human body receives vibration via skin receptors, and proprioceptors and interoreceptors of otolithic apparatus. Received vibrations spread all over the body of workers and can damage all their organs and systems. All tissues and organs are good transmitters of vibrations throughout the body. The most effective vibration dampers are joint cavities. The effects of vibration may result in irritation of central nervous system and vegetative nervous system thus having detrimental effect on cardiovascular, musculoskeletal, auditory-vestibular, and endocrine system as well [15].

Vascular disorders

Vascular disorders are detected primarily in the capillary and precapillary circulation and are present in high frequency vibration effects and in sudden shock effects which cause microtrauma of the nervous apparatus in skin. Tendency of capillary towards spasm is registered. Due to capillary spasm and small blood vessels subjective symptoms occur including paresthesia, attacks of white fingers, livid skin, cold hands. At first these spasms are functional and transient but gradually over time due to chronic effects of vibration some serious disorders may occur such as: hypertrophy of muscle walls of blood vessels, fibrous changes and constriction of lumen of blood vessels with signs of atherosclerotic changes in arterial blood vessels. Reduction of venous tone is observed in vibration disease. Veins are dilated which leads to slow venous circulation and venous routes. Venous pressure increases which leads to acrocianosis, local oedema of hands and difficulty of hand mobility [16].

Disorders of periphery and central nervous system

Disorders of peripheral nerves are prominent, manifested as the form of polyneuritis syndrome, followed by a variety of sensitive, trophic and vascular disorders [17].

Sensibility disorders

High frequency vibrations lead to damage of vibration sensibility, sensitivity to pain and sensitivity to thermal stimuli and touch. Reduced sensitivity to pain (hypoesthesia) on hands is determined by the type of gloves and reduced sensitivity to pain on feet is determined by the type of socks. The more advanced stages of disease are marked by disturbance of sensibility of segmental type usually involving innervation's area C4 - L5 or lower determined by the type of short coat-jacket (pseudosiringomieloid form) [18].

Biochemical changes in body of exposed workers

The effect of vibrations leads to disorder of metabolism of carbohydrates, fats, proteins, minerals and vitamins. Disturbance in terms of reduction of serum concentrations of vitamin C, B1, B2 and B6 caused by the effects of vibration has been observed.

Reduction of serum concentrations of albumin and globulin increase with the decrease in albumin globulin coefficient in workers exposed to vibration has been determined. Workers exposed to vibration are more prone to develop hypophosphataemia and hypocalcemia with decreased calcium phosphorus ratio [19].

Muscular changes

The following changes occur in muscular system [13, 19]:

- presence of painful infiltrative changes such as myofascikulitis and cellulitis on muscles of the upper arms,
- tendovaginitis of m. biceps brachi and hand extensors,
- contractures of Dupuytren type,
- disorders of muscle metabolism with destruction of muscular fibres and their nuclei as well as reduction in RNA content in cytoplasm of muscular fibres and DNA in nuclei,
- disorders of structure of motor planes with disorder of localisation of cholinesterase in cross striated muscles.

Skeletal changes

Vibration, counter strikes and static wrist strain of joints and bones lead to following disorders:

- radiological examinations of the shoulder joint reveals spur-like deformed osteoarthritis.
- clinical picture shows limited and painful mobility of shoulder joint.

Due to proliferation of periosteum and deposition of calcium salts on the attachment points of periosteum and joint capsule on elbow joints pinnacles are formed

and osteoarthritis is observed radiologically manifested as elbow spur or a parrot's beak (ossified attachments of m. triceps with olekranon). Due to pathological fractures free joint bodies (joint mice) are created making joint movements limited and very painful [20].

The wrist joint may be affected by vibrogenic cysts, osteoporosis, enostosis, egzostosis, vibrogenic fractures and aseptic vibrogenic necrosis as a result of compromised circulation and nutrition of bone tissue.

The spinal cord may be affected by osteoporosis of vertebral body, spondylosis, osteochondrosis, stem growths, deformation of vertebral bodies and intravertebral disc hernia (Schmorl hernia) [21].

Disorders of other organs functions

- Disorders of cardiovascular system are present in the form of tachycardia, rhythm disturbances, and increased arterial blood pressure.
- Gastrointestinal system dysfunction is reflected in terms of hypersecretion or hiposecretion, intestinal dyskinesia, peptic ulcer and duodenal ulcer.
- Disruption of coronary and cerebral circulation is manifested as coronary heart disease or stroke.
- Disturbance of the sense of sight is manifested in the form of diplopia, the appearance of the net and poor vision and is the result of a spasm of central retina.
- Disorders of the sense of hearing are the result of a spasm of a. auditive and poor nutrition of cells of organ of Corti under the influence of noise and vibration as well as direct effects of vibrations that are transmitted from bones to inner ear.
- Disorders of the vestibular apparatus are manifested as vertigo, disturbed coordination of movement and disturbed maintenance of body position [15, 22].

Clinical presentation of vibration disease

High-frequency vibrations usually cause vasospastic changes in blood vessels. If the low frequency vibrations are accompanied by static tension of the limbs and joints neuromuscular and articular changes will be dominant in clinical picture. Clinical picture mainly develops through four stages [23].

The initial stage is manifested by mild pain and hand paraesthesia, light sensitivity disorders and moderate spasm of capillaries with rare tropic changes of shoulder muscles. These changes are completely reversible and disappear after the cessation of exposure to vibration [24].

The second stage is characterized by more prominent pain and paraesthesia, reduced skin temperature, cyanosis and increased sweating of hands. The reduced sensitivity affects fingers and entire hand, and capillaroscopy procedure shows capillary spasm. Painful infiltrations in the area of upper arm and forearm are palpable. The changes are reversible, if exposure to vibration stops immediately [13].

The third stage is characterized by marked vascular spasm and attacks of white fingers (Raunayd's syndrome), the appearance of cyanosis, swelling of the hands [25]. Sensitivity of either periphery or segment type is significantly reduced. Painful infiltrations are palpable in muscles and there occur disorders of the central nervous system. The function of cardiovascular and endocrine systems with strong neurotic reactions is disturbed. These changes are largely irreversible.

The fourth stage is characterized by a generalization of vascular disorders that affect peripheral blood vessels, coronary and cerebral circulation. Disturbed sensitivity is prominent giving a picture similar to syringomyelia. Changes are irreversible [13, 24, 25].

Clinical presentation of vibration disease induced by effects of general vibrations

The effects of general vibrations are described as cerebrovascular and spinal syndrome.

Cerebrovascular syndrome

Problems include attacks of headache, followed by nausea, vomiting, vertigo, loss of balance, dizziness and loss of consciousness. Patients are complaining of stenocardiac problems. Clinical examination shows arterial hypertension, arterial tension asymmetry with a difference of 10-15 mm Hg, and pulse asymmetry. The ECG registers signs of coronary insufficiency. Vascular changes are accompanied by signs of polyneuritis, sensitivity disorder and insufficient peripheral circulation. More prominent clinical picture shows increased tendon reflexes, tremor of fingers and nystagmus, endocrine disorders (thyrotoxicosis) with reduced sexual function [26].

Spinal syndrome

This syndrome is characterized by an organic disorder of the spinal cord and is divided into two forms

Syringomieloid form is characterized by widespread disturbances of sensitivity in the arms, shoulders and whole chest cavity, with the loss of sensitivity to pain and temperature.

Amyotrophic form is very rarely found. Along with vegetative sensitive disorders of hands signs of progressive muscular atrophy of upper extremities, shoulder region and sometimes lower extremities gradually develop. Deep reflexes weaken and disappear and pareses occur without pronounced pyramidal signs [27, 28].

CONCLUSION

Vibrations represent one of the most common physical agents present in the workplace and have a major impact on the function of many organ systems. Disorders that occur in conditions of acute and chronic exposure are numerous and many of them are very non-specific so that diseases that result from their actions are diagnosed very late. Therefore, occupational

diseases induced by vibrations are very important segment in the activities of occupational medicine specialists and other medical professionals responsible for the implementation of preventive measures in the workplace. This segment of occupational exposure requires additional research and harmonization of law regulation in this area.

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BIOGRAPHY

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PROFESIONALNE BOLESTI IZAZVANE VIBRACIJAMA

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Abstrakt: *Vibracije u radnom okruženju su fizička profesionalna noksa koja je prisutna u raznim granama industrije. Vibracije mogu delovati lokalno i opšte i mogu biti visokofrekventne i niskofrekventne. Vibraciona bolest predstavlja skup poremećaja i simptoma nastalih pod uticajem proizvodnih vibracija. Poremećaji su vrlo nespecifični te se bolesti koje nastaju kao posledica njihovog delovanja vrlo kasno dijagnostikuju. Zbog toga profesionalna oštećenja izazvana vibracijama predstavljaju važan segment u aktivnostima lekara medicine rada i osoba zaduženih za primenu mera zaštite na radnom mestu. U patogenezi ove bolesti glavnu ulogu igra mikrotrauma, spazam krvnih sudova, nedovoljna ishrana i ishemija tkiva i organa. Štetni efekti vibracija se ogledaju na skoro svim sistemima i organima ali su posebno ugroženi kardiovaskularni, mišićni, nervni i koštano zglobovi. Vibracije mogu biti faktor koji doprinosi češćoj pojavi povreda na radu. U ocenjivanju radne sposobnosti stoga treba uzeti u obzir zahteve radnog mesta, prisutne nokse, zdravstveno stanje, funkcionalno stanje organa i sistema, godine starosti, radni staž i motivaciju radnika. Preventivne mere mogu biti tehničke, medicinske, organizacione i primena ličnih zaštitnih sredstava. Ovaj segment profesionalne izloženosti zbog svog značaja zahteva dodatna istraživanja i stalno uskladjivanje zakonske regulative u ovoj oblasti.*

Ključne reči: profesionalne bolesti, vibracije, zdravlje, opasnosti.