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BIOMECHANICAL ASPECTS OF DEGENERATIVE DISEASES OF THE SPINE

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ABSTRACT

The influence of vehicle vibration on various degenerative diseases of the spine was studied in a group of 76 apparently healthy railway workers and in 45 control subjects. Although the results of vibration measurements in railway cars were generally within the permissible limits, a large number of various degenerative changes in the spine was found, the frequency being higher in railway workers than in control subjects.

Measurements of the vibration of railway vehicles and the effect of this vibration on the human body have been the subject of many investigations. In 1974 the International Organization for Standardization (ISO) published a document entitled: "Guide for the evaluation of human exposure to whole body vibration"[1]. ISO Standard provides a procedure for evaluating vibration within a frequency range from 1 to 80 Hz as a function of the exposure periods giving limits for longitudinal and transversal whole body vibration. The levels of these limits for 1 minute to 24 hours are shown in Figure 1. It is also known that ISO Standard does not apply to the effects of rotational vibration. Our study was not made to research such effects, but to establish typical conditions on Yugoslav railways using different coaches at typical speeds. Although the present ISO Standard has served a purpose, it probably does not cover all factors which indicate how vibration frequency and intensity interact to produce conditions for pathological diseases of the human spine.

The present paper reports on the authors' preliminary investigations of the influence of vehicle vibrations on different degenerative diseases of the cervical spine in railway workers.

SUBJECTS AND METHODS

Our preliminary tests were made with two different vehicles in everyday use. Two coaches of Yugoslav production were studied on a section of a main line approximately 120 km long. One was a four-axle, the other a two-axle car.

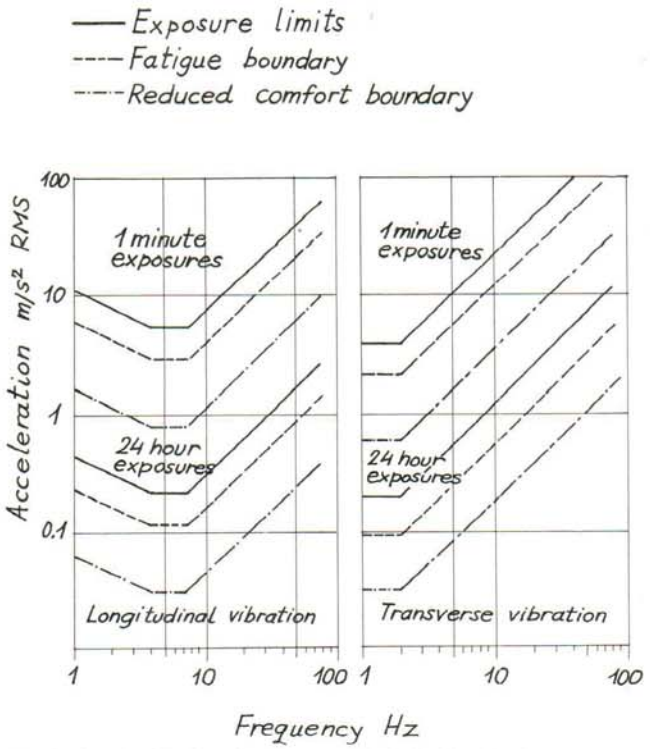

FIG. 1 – Limits for longitudinal and transverse whole-body vibrations proposed by ISO.

The accelerations at one point in the floor were measured in three directions by means of a KD21 piezometric accelerometer with what is known as "crossaxis sensitivity". The accelerations were shown by an oscilloscope. The measuring points for both cars are shown in Figure 2. The measurements of vibration were carried out by means of a three-channel measuring apparatus SM232, VEB – – RFT, Dresden (D.R. Germany).

The connection between vibration and acceptable human exposure to whole body vibration we tried to find out by X-ray analysis of the workers who had worked on the respective cars for a long time.

We analysed the X-rays of the cervical and lumbal spines of 76 railway workers (apparently healthy brakers, conductors and drivers) aged 20–40. As a comparative group we used workers employed in a different kind of standing job, who were not exposed to vibration during their work.

The morphologic shape of the vertebra is responsible for the complex way in which the spine elements are loaded. The loading forces, according to our investigations are transmitted over three points arranged in a triangle formed by six interdependent surfaces: two surface of the vertebral bodies with the center of

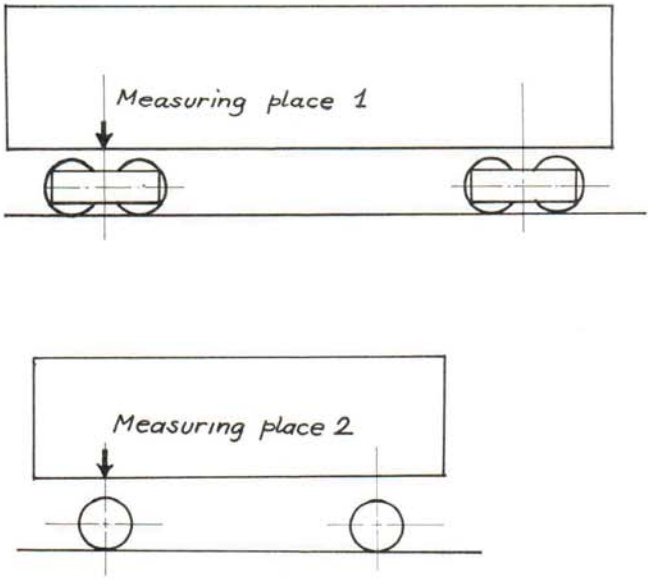

FIG. 2 – Positions of the places of measurement in investigated different railway cars.

loading in the region of the nucleus pulposus, and four forces of the system of small vertebral articulations. Each of these reactive forces in these places may be divided into three components. All vertical components are in equilibrium with the horizontal components forming couples of forces. Any change of the direction or intensity of any force causes a change of the forces on other surfaces. Although we analysed anisotropic material, experimental strain analysis by means of strain gauges showed us that the vertebral bodies in a mechanical meaning are weaker than the region of small articulations. This is due to the fact that the strength of a compact bone can be even a hundred times greater than that of a spongy bone.

RESULTS AND DISCUSSION

From the vibrograms we found that lateral accelerations of the car at the beginning of a curved part of the railroad exceed 1.5 m/s^2, which is much higher than the allowed accelerations of 0.65 to 0.85 m/s^2. The frequency of these vibrations is about 40 Hz, varying with varying train speed.

Lateral and vertical vibrations (intensity and frequency) in the rest part of the curvature are within the range of allowed quantities but at the upper limit.

The results of the analysis of the appearance of degenerative changes in the human spine we divided into two groups: frequency of processes in terms of disease as a function of age, and in terms of disease as a function of the number of vertebrae.

The results of our investigation of railway workers and a control group are shown in Tables 1 and 2.

TABLE 1
Degenerative processes in the spine of railway workers and control subjects.

Pathological changes of the spine	Railway workers (N = 76)						Control subjects (N = 45)					
	All		Cervical		Lumbal		All		Cervical		Lumbal	
	n	%	n	%	n	%	n	%	n	%	n	%
Spondylosis	45	59	29	38	16	21	11	24	6	13	5	11
Discopathia	31	41	2	3	29	38	22	49	0	–	22	49
Spondyloarthrosis	19	25	7	9	12	16	3	7	0	–	3	7
Osteochondrosis	27	36	15	20	12	16	30	67	15	33	15	33

The vibrations of railway cars were found to be generally within permissible limits. However, among the examined "healthy" railway workers certain degenerative changes in the spine were established.

TABLE 2
Frequency of pathological changes in the cervical spine.

Vertebrum	Spondylosis	Spondyloarthrosis	Unkarthrosis	Osteochondrosis
C 1	0	0	0	0
C 2	0	0	0	0
C 3	1	1	0	1
C 4	8	3	3	6
C 5	19	9	5	11
C 6	12	8	4	9
C 7	4	4	1	3

From our results it appears that the changes in the spine are mostly of a degenerative character, and that some of them (spondylosis) appear more often in the cervical than in the lumbosacral spine. Changes in the cervical spine were more frequent in the examined railway workers than in the control group.

It was established that vibration levels may sometimes exceed those recommended by standards, and thus our investigations pointed to some of the problems which arise when comparing measured vibration with the current standard. Therefore, in working out Yugoslav standards, it is necessary to revise some of the ISO Standard formulations.

REFERENCE

1. *International Organization for Standardisation.* Guide for the evaluation of human exposure to whole-body vibration. ISO, 1974, p. 2631.