Influence of vertical and horizontal whole-body vibration on heart rate of employees age 50+ (pilot study)

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Abstract. This paper presents the pilot study on influence of vertical and horizontal whole-body vibration on heart rate of employees at the age of 50+. Tests have been conducted in two series on special designed laboratory test bench for simulation of exposure to whole-body vibration. During the I series of tests, vertical vibration had acted on subjects and during II series horizontal lateral vibration had acted. Heart rate values obtained during I and II series indicates that there are slightly differences between reaction of subjects on vertical and horizontal vibration. It has been observed that exposure to vertical whole-body vibration causes the larger changes of heart rate value than exposure to horizontal vibration.

Keywords: whole-body vibration, heart rate, employees.

1. Introduction

Phenomena associated with the impact of whole-body vibration on the central circulatory system are important from safety and health point of view and still require research and analysis. Heart rate is one of the parameters used in its description. Studies have shown so far that exposure to whole-body vibration can cause changes of heart rate [1-4]. Vertical vibration in the range 2-20 Hz produce a cardiovascular response similar to that normally occurring during moderate exercise [1]. The heart rate increase latency is inversely related to vibration amplitude [4]. These and other effects are especially important in relation to the workers at the age +50 because in this age group the probability of disorders in the circulatory system is higher than in young people. The disorder can be hazardous to health and safety at work.

2. Aim of the study

The aim of this pilot studies was to recognize differences between influences of horizontal (lateral) and vertical whole-body vibration on heart rate of employees. In view of lengthening the time of professional activity, it was considered that the interest will be the results of studies in people at the age of +50. Presented study is a part of larger project on the impact of vibrations on the employee at this age.

3. Methodology

Objective, scope and methodology of the study have been presented to the Commission of ethics and bioethics, Cardinal Stefan Wyszyński University in Warsaw, which issued a favorable opinion (No. KEIB-14/2015) that represents the approval for their implementation.

All research carried out comply with the requirements of standard PN-EN ISO 13090-1:2002 [5]. Tests were conducted in laboratory at ambient temperature in the range of 22,1 °C to 23,1 °C and relative humidity in the range of 22 % to 57 %.

The study consists of the determination of heart rate (HR) in two measurement series. I series involved tests related to vertical whole-body vibration exposure and II series to horizontal (lateral) whole-body vibration exposure. Each series enrolled six measurement of heart rate value:

– measurement 1 – reference value,

– measurement 2 – HR value before exposure to vibration,
– measurement 3 – HR value obtained after 6 min of exposure,
– measurement 4 – HR value obtained after 12 min of exposure,
– measurement 5 – HR value obtained after 18 min of exposure,
– measurement 6 – HR value obtained after exposure.

In both series, the same group of examined persons was subjected to testing. They were subjected to exposure to vibration, in a sitting position two times (one-day exposure to vertical vibration and horizontal vibration another day). For each subject break between a series I and II of studies was at least 2 weeks. Vibration test signal was filtered white noise with frequency range: 1 Hz-30 Hz controlled with an accuracy of +/–2 dB. A single exposure of the subject lasted 20 min. The value of the frequency weighted vibration acceleration of the test signal was 0.9 m/s^2 controlled with a precision of +/–0.05 m/s^2. (In Poland it is 28 % of the limit value for short-term exposure whole-body vibrations in the working environment of 3.2 m/s^2 [6]).

The experimental tests carried out on developed test bench [7]. The main part of the bench was the system for generation of low-frequency vibrations based on shaker IMV J240 type, power amplifier IMV type SA4M J40 and control system Crystal Instruments Spider-81. The system allowed to simulate both horizontally and vertically whole-body vibration. The developed bench provides simulation exciting signal without disturbances in the entire range used in the research 1-30 Hz (resonance frequencies of bench elements > 120 Hz).

For heart rate (HR) measurement the Spacelabs Medical Model 90207 Ambulatory Blood Pressure (ABP) Monitor was used.

4. Subjects

The study enrolled 20 men at the age of +50 (10 men working at workplaces in vibration exposure for at least 10 years, and 10 men working for at least the last 10 years at work places without exposure to vibration). Qualification of the subjects was carried out on the basis of the medical assessment and preliminary psychomotor tests. In accordance with the requirements of PN-EN ISO 13090-1 within the scope of the study includes the following types of qualifying tests: survey (on the state of health of the subjects), medical examination, test resting ECG.

Age, mass and height of qualified subjects are shown in Table 1.

Table 1. Physical characteristics of subjects

	Age, year	Mass, kg	Height, cm
Mean value	54,5	93,9	178,4
Standard deviation σ	3,7	11,6	4,7
Median	53	95	179

5. Results

Heart rate was determined during six measurements for each subject. In Table 2 are presented mean HR values determined for each subject during the I series of tests (vertical vibration) and Table 3 shows the results obtained during the II series of tests (horizontal vibration). Fig. 1 illustrates a comparison of HR values obtained during the I and II series of tests.

For statistical evaluation of obtained results univariate analysis of variance has been used ($\alpha = 0{,}05$; result of univariate analysis of variance $F < 0{,}28$; significance level $p > 0{,}6$).

6. Discussion

In I series of tests, HR values have slightly decreased after 6 min exposure (measurement 3), increased after 12 min exposure (measurement 4) and decreased again after 18 min exposure (measurement 5). After exposure to vibration (vertical and horizontal), HR has been reached similar values to reference values (measurements 1). Comparison of average heart rate values shows that in II test series the values obtained before (measurement 1, 2), during (measurement 3, 4, 5) and after exposure to vibration (measurement 6) practically do not differ. However, the observed dependencies were not clearly confirmed in the statistical analysis (significance level $p > 0{,}6$).

Table 2. Heart rate values, in I series of tests (vertical vibration)

	Heart rate (HR), beat/min					
	Measurement 1	Measurement 2	Measurement 3	Measurement 4	Measurement 5	Measurement 6
Mean value	77,4	78,9	72,8	88,4	81,0	74,0
Standard deviation σ	14,2	13,8	16,4	20,6	18,6	10,2
Median	78	80	77	86	78	74

Table 3. Heart rate values, in II series of tests (horizontal vibration)

	Heart rate (HR), beat/min					
	Measurement 1	Measurement 2	Measurement 3	Measurement 4	Measurement 5	Measurement 6
Mean value	80,7	79,6	78,2	80,1	74,4	76,6
Standard deviation σ	11,2	11,6	11,6	11,2	10,3	11,9
Median	78	79	77	81,5	73	78

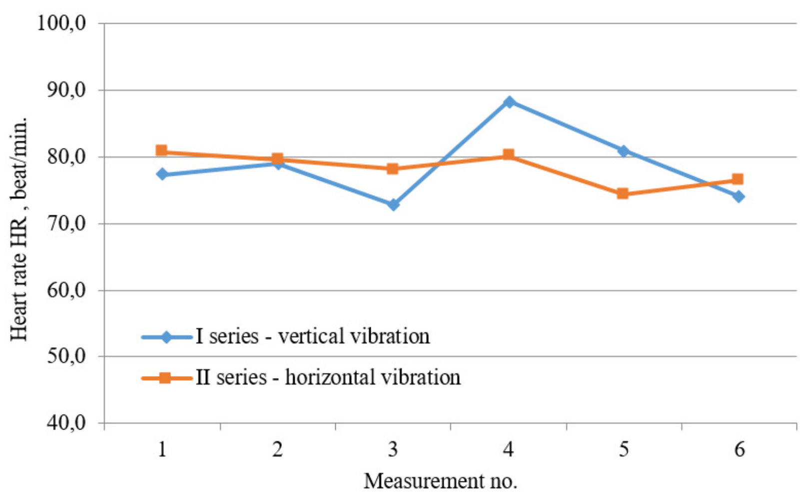

Fig. 1. Mean values of heart rate obtained in I and II series of tests

7. Conclusions

Heart rate values obtained during I and II series indicates that there are slightly differences between reaction of subjects on vertical and horizontal vibration. It has been observed that exposure to vertical whole-body vibration causes the larger changes of heart rate value than exposure to horizontal vibration.

In terms of employment of persons at the age of +50 changes in the central circulatory system raised the action of vibration are an important issue. Although, during carried out pilot studies, the observed phenomena have not been confirmed in statistical calculations, they can be justification to undertake research on the larger population of subjects.

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