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Multiple Influence of Vibration on Biochemical Brain Indicators

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Abstract: Dysfunction of the nervous system is one of the main manifestations caused by vibration. With repeated exposure to vibration, significant changes in the activity of enzymes and the content of the studied substrates in the brain tissue of experimental animals are observed. The observed changes in the activity of enzymes and the content of the studied substrates of brain tissue and the associated disturbances in the basic biochemical metabolic processes may be the direct cause of serious disorders of the functions of the nervous system. According to research results, it was revealed that exposure to general vibration leads to disturbances in the process of transamination of alanine-, aspartic-amino acids, cholinesterase, the activity of enzymes of the tricarboxylic acid cycle (GDH, SDH and MDH), alkaline phosphatase, ribonuclease and lactate dehydrogenase, as well as the content of total protein, serotonin, histamine and acetylcholine in the brain of experimental animals.

Key words: *vibration, brain, nervous system, transamination, experimental animals, enzymes, biochemical processes.*

1. Relevance

Vibration is a fairly common environmental factor [11, 12]. Man experiences vibration while using all vehicles, but vibration, from a chariot to a rocket, and using various states, is generally inherent in the movements of this [3, 13].

On the other hand, the widespread use of mechanized tools in the production of labor, increased load-carrying capacity and high-speed means of transport causes an undesirable increase in the number of people exposed to vibration, thereby creating the preconditions for the spread of vibration pathology in the structure of chronic diseases of professional etiology [4, 15].

The effect of vibration on a person depends both on the physical characteristics of the oscillatory process and on the duration of body contact with vibrating surfaces [14]. It can lead to persistent adverse changes in physiological and biochemical functions in the body and even be accompanied by morphological changes in the body [1, 16].

Vibration is a mechanical operating factor of the external environment, and the human body is essentially a mechanical oscillatory system, if we do not take into account the irritants of biochemical and bioelectric

processes that arise in the body. A large number of works are devoted to the study of the patterns of vibrations of various human organs and the whole body as a whole [2, 17]. High-frequency vibration is widespread in industry (all types of pneumatic tools, sharpening and grinding wheels, etc.). These instruments are strong irritants for the nervous system and cause significant disturbances in the autonomic innervation of the trophism of various tissues [18, 21]. Vibration is associated with a complex of pathological changes observed in individuals systematically exposed to vibration. The latter affects mainly the nervous system [5, 19, 20].

Aim of the research. Experimental study of the influence of high-frequency vibration on the biochemical processes of the brain of white rats.

2. Materials and research methods.

Experiments were carried out on white male rats weighing 150-170 grams in two series of experiments. The 1st series of animals was control. 2nd series - animals were exposed to high-frequency vibration at a level of 110-130 Hz. Exposure to vibration on animals daily was 4 hours for 15, 30, 60, 90, 120 days.

After the end of the studies, after 15, 30, 60, 90 and 120 days of exposure to high-frequency vibration, the animals were decapitated, the cerebral hemispheres were removed in cold conditions (cold room at a temperature of 0-4^{0}C), homogenates were prepared in 0.85% NaCl and biochemical studies were carried out. Indicators [6]

Study of biochemical parameters: activity of the enzymes alanine, asparagine transferase, cholinesterase, lactate dehydrogenase (LDH), glutamate dehydrogenase (GDH), succinate dehydrogenase (SDH), malate dehydrogenase (MDH) [7, 8], alkaline phosphatase, ribonuclease, as well as the content of biogenic amines - determination the content of serotonin, histamine, acetylcholine was carried out using the fluorometric method and total protein in brain tissue [9]. Determination of acetylcholine and biogenic amines - serotonin and histamine - by spectrophotometric method [10]

3. Research results.

When exposed to general vibration, changes in the body are associated primarily with large vibrations experienced by the body as a whole and its individual organs. When the frequencies coincide - affecting the body with the natural vibration frequencies of the head, shoulders or other parts of the body, they begin to move 1.5-2.0 times more than the vibrating object affecting the body.

Vibration can be periodic, jolting, regular, irregular and aperiodic. The nature of the parts and amplitude of vibrations influence the disruption of biochemical processes in the central nervous system. In this regard, it is of interest to study the state of biochemical parameters in brain tissue. We studied the activity of dehydrogenase enzymes (LDH, GDH, SDH, MDH and alkaline phosphatase), transamination of alanine and asparagine amino acids between α-ketoglutaric acid, cholinesterase, ribonuclease, the content of total protein, biogenic amines (serotonin, histamine) and also acetylcholine in brain tissue upon repeated exposure to vibration.

Conducted studies on the content of total protein in the brain of laboratory animals under the influence of vibration made it possible to establish changes in the functional state of cellular proteins (Table 1).

Table 1 The state of total protein, acetylcholine and biogenic amines in the brain tissue of laboratory animals exposed to vibration

№	Duration of the study	Groups	Statistical indicators	Total protein (mg/g)	Serotonin (mcg/g)	Histamine (μg/g)	Acetylcholine (μg/g)
1		Control	M±м	7,81±0,09	0,40±0,04	0,72±0,02	1,46±0,05
2	15 day	Experience	M±м %	6,59±0,07*** 84,4	0,54±0,02** 135,0	0,92±0,01*** 127,8	1,78±0,04** 122,0
3	30 day	Experience	M±м %	6,31±0,13** 80,8	0,64±0,02*** 160	0,86±0,10 119,4	1,89±0,03*** 129,4
4	60 day	Experience	M±м %	6,20±0,06*** 79,4	0,61±0,04*** 152,5	0,98±0,04*** 136,1	1,76±0,04* 120,5
5	90 day	Experience	M±м %	6,30±0,09** 80,7	0,73±0,01*** 175,0	0,95±0,05** 132,0	1,95±0,05*** 133,5
6	120 day	Experience	M±м %	6,30±0,08*** 72,4	0,65±0,05*** 162,5	0,96±0,03*** 133,3	1,97±0,05*** 135,0

Note. Reliability in relation to control: *p<0,05; **p<0,01; ***p<0,001

Exposure of white rats to vibration at a level of 110-130 Hz has a significant effect on the level of protein and biogenic amines in the brain.

Table 1 shows data on the content of protein, serotonin, histamines and acetylcholine in the brain. The table shows that in rats of the control group the level of total protein was 7.81±0.079 mg/g. When exposed to vibration in animals of the experimental group (2nd series of animals), the protein content in the brain decreased during all periods of the experiment (15, 30, 60, 90 and 120 days), respectively 84.4; 80.8; 79.4; 80.7; 72.4%. At the same time, when exposed to vibration, the synthesis and breakdown of protein in the brain is disrupted.

When studying serotonin and histamine, the decarboxylation of amino acids - tryptophan and histidine in brain tissue increases. At the same time, the serotonin content during all periods of the study increases to 135-175%. Histamine levels also increased during all periods of the study. These changes are more pronounced on days 60-120 of exposure to vibration.

Studies of acetylcholine in brain tissue with repeated exposure to vibration showed an accumulation of 122 to 135%, which indicates an increase in the transmission of the excitation impulse of the nervous system.

So, with repeated exposure to vibration, there is an increase in excitation of the central nervous system and the level of biogenic amines - serotonin and histamine and neurohormones (acetylcholine) in brain tissue.

Table 2 presents the results of determining enzyme activity in the cerebral hemispheres of white rats exposed to general vibration.

The table shows that when exposed to vibration in the tissue of the cerebral hemispheres, the activity of alkaline phosphatase on the 15th, 30th and 60th days of the experiment was within the limits of physiological fluctuations, and on the 90th and 120th days of the experiment a significant decrease was noted. The decrease in the activity of dehydrogenase enzymes (LDH, GDH and SDH) was more pronounced. Obviously, a decrease in

the activity of alkaline phosphatase, lactate, glutamate and succinate dehydrogenase in brain tissue is associated with the effect of vibration on the functional state of the central nervous system.

The state of activity of the enzymes transaminases, cholinesterase and ribonuclease of the brain under repeated exposure to vibration is reflected in Table 3.

When animals were exposed to vibration, alanine aminotransferase (ALT) activity slightly increased in the brain of experimental rats to 111.3 and 117.4% on days 15 and 30; in the remaining periods it was within the control level. The activity of aspartate aminotransferase (AST) increased significantly, especially on days 60-120 of the experiment. Cholinesterase activity at all times decreased from 61.1-60.0%.

Inhibition of ribonuclease activity in the brain was observed with repeated exposure to vibration. A decrease in ribonuclease activity causes depolarization of high-polymer ribonucleotides, which leads to disruption of brain protein biosynthesis.

When exposed to vibration, our studies indicate a disruption of redox processes in brain tissue - a decrease in lactate dehydrogenase, glutamate dehydrogenase, succinate dehydrogenase, and malate dehydrogenase.

The data obtained showed that with repeated exposure to vibration, significant changes in the activity of enzymes and the content of the studied substrates in the brain tissue are observed. The observed changes in the activity of enzymes and the content of the studied substrates of brain tissue and the associated disturbances in the basic biochemical metabolic processes in them may be the direct cause of serious disorders of the functions of the nervous system.

Table 2 The effect of vibration on the activity of dehydrogenases and alkaline phosphatase in the brain

№	Duration of the study	Groups	Statistical indicators	Alkaline phosphatase μmol/g.h	Dehydrogenase (μmol/g.h.)			
					ЛДГ	ГДГ	СДГ	МДГ
1		Control	M±м	43,5±1,01	43,5±1,41	20,0±0,41	38,0±0,67	27,3±0,81
2	Day 15	Experience	M±м %	37,4±1,47 109,0	33,1±1,60* 86,7	17,5±0,30 87,5	30,77±0,80 81,0	24,4±0,76 89,4
3	30 day	Experience	M±м %	39,5±1,23 90,8	31,4±0,11 89,9	16,1±0,61 80,5	32,1±0,28 84,5	26,1±0,83
4	60 day	Experience	M±м %	38,4±0,79 88,3	32,6±1,33** 74,9	16,3±1,37 81,5	31,8±0,37 83,7	23,9±0,62 87,2
5	90 day	Experience	M±м %	34,6±0,9** 79,5	31,7±1,13 72,7	15,7±0,71** 78,5	27,6±0,82** 72,6	24,3±0,71 89,0
6	120 day	Experience	M±м %	35,2±1,04* 80,9	31,4±0,96 72,2	13,2±0,94*** 66,0	25,6±1,12** 67,4	21,6±0,80 79,1

Note. Reliability against control: *p<0,05; **p<0,01; ***p<0,001

Table 3 The state of activity of some brain enzymes under repeated exposure to general vibration

№	Duration of the study	Groups	Statistical indicators	Transaminase, μmol/g.h		Cholinesterase μmol/g.h.	Ribonuclease μmol/g.h.
				АЛТ	АСТ		
1		Control	M±м	2,03±0,05	5,05±0,083	385,1±12,4	93,3±1,21
2	Day 15	Experience	M±м %	2,26±0,07 111,3	5,88±0,03 116,4	235,6±8,13** 61,1	78,5±0,92* 84,1
3	30 day	Experience	M±м %	2,38±0,04 117,4	5,80±0,07 114,8	232,8±10,2** 60,4	81,4±0,90 87,2
4	60 day	Experience	M±м %	2,00±0,13 98,5	6,27±0,06** 124,1	240±7,06** 62,3	82,1±0,72* 88,0
5	90 day	Experience	M±м %	2,10±0,09 103,4	6,53±0,07*** 129,3	271,5±6,05* 70,5	74,2±1,65** 79,5
6	120 day	Experience	M±м %	2,00±0,07 98,5	6,53±0,07** 129,3	231,1±6,08** 60,0	73,9±1,96*** 79,2

Note. Reliability in relation to control: *p<0,05; **p<0,01; ***p<0,001

4. Conclusions

1. With repeated exposure to general vibration, there is a disturbance in the process of transamination of alanine aminotransferase, aspartate aminotransferase, cholinesterase, the activity of enzymes of the tricarboxylic acid cycle (GDH, SDH and MDH), alkaline phosphatase, ribonuclease and lactate dehydrogenase, as well as the content of total protein, serotonin, histamine and acetylcholine in the brain brain.

2. In the brain tissue of animals that were exposed to the studied factor (vibration), there is an increase in transaminases - ALT, AST, the content of serotonin, histamine and acetylcholine and inhibition of the activity of lactate dehydrogenase, glutamate dehydrogenase, succinate dehydrogenase and malate dehydrogenase in the brain, and the activity also significantly decreased cholinesterase, alkaline phosphatase, ribonucleotides and total protein content.

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