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Effect of Echinacea Purpurea on Physical Work Capacity in Case of Intensive Noise Exposure

Key words: *Echinacea purpurea, physical work capacity, noise*

Annotation: *The experiment with male SHK strain mice demonstrates how Echinacea purpurea optimizes work capacity of animals exposed to chronic noise of 80 dB for 4 hours during 20 days. The intragastric introduction of echinacea 20% tincture at a dose of 1 ml/kg twice a day has doubled the swimming endurance time in mice until absolute fatigue (with a 7% attached to tail). Echinacea has exhibited energy-saving effects under the noise stress by retarding the depletion of glycogen and adenosine triphosphate reserves in liver tissue and skeletal muscles.*

The harmful effect of intense chronic environmental noise on human organism has been proved in numerous clinical and experimental studies (1,5,9). Besides hearing disorders, the noise exposure causes failure of adaptive capabilities, somatic dysfunction, affects cardiovascular, digestive, nervous, endocrine, immune and other systems, and provokes many metabolic disorders in organs and tissues (3, 6, 11, 13). It is recommended to study human exposure to extreme environmental factors at physiological level in pre-clinical and pre-morbid state, when the adaptation is likely to occur spontaneously or respond to pharmacological correction. The appropriate criterion of physiological state appears to be the physical work capacity in human. It is well known that both mental and work capacities decrease in case of acoustic discomfort (2). However, the physiological and biochemical aspects of human organism′s work capacity in case of exposure to acute and chronic noise are understudied. The pharmacological correction becomes possible only in case the dynamics of development and multi-factor pathogenesis of noise-induced disorders are understood.
This paper aims to study the physical work capacity in mice exposed to acute and chronic noise and estimate the possibility of its pharmacological correction with a multipurpose preparation of *Echinacea purpurea* (L.) Moench.

Materials and methods

The adult male SHK mice raised in “Andreevka” Research Centre for Biomedical Technologies of RAMS with initial body weight varying in the range of 22 to 24 g were used in three series of experiments. The animals were kept in a vivarium under the standardized conditions, were fed with compound feed (OOO “Laborotorkorm”, Russia) and got plenty of

water. Each experimental group comprised 7 animals. The animals were as required by the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes.

The acute and chronic acoustic discomfort in mice has been caused by a single and twentyfold exposure to noise of 80 dB(A) that is equivalent to the noise of a high capacity highway, for 4 hours every day from 08 am till 12 am. The noise was produced using magnetic tape records and measured with sound level meter Larson - Davis Model 800 B, serial 1375-97, as required by GOST 12.1.005-86 “Noise Measurement Techniques at Workplaces”. The physical work capacity in animals was estimated by swimming to full fatigue by attaching a weight equal to 7% of body mass to the tail in a test chamber of 70x50x40 cm in size at 30 °C, immediately after a 4-hour noise exposure.

The 20 % water-alcohol tincture produced from the roots of *Echinacea purpurea* (L.) Moench (fam. *Asteraceae*) was used in the study. The mice were given the dealcoholized preparation (echinacea) intragastrically at a dose of 1 ml/kg twice a day (9 am and 4 pm). The animals were decapitated under brief ether narcosis. The quadriceps skeletal muscle tissues and liver have been tested for concentration of glycogen and adenosine triphosphate (ATP), as established in experimental pharmacology. A package “Statistica, v. 6.0” was used for statistical data processing. The Student's t-test was applied for assessing statistical significance of the difference. The data were represented as mean ± standard error of mean.

Results

The first stage of the experiment was aimed at identifying the effects of exposure to noise of different intensity on physical work capacity. The control animals were kept in the vivarium with background noise varied in the range of 25-30 dB. The 60 dB noise considerably increased the locomotor activity in mice. Immediately after the noise load, their swimming endurance time was 11 % higher than that of the control group (Table 1). This 4-hour exposure to more intense noise caused hyperexcitability of animals (with Staube reflex in some of them). The swimming time proved to be shorter compared to the control group: at 80 and 100 dB it was shorter by 30% and 48%, respectively. It should be noted that the 60 dB noise level had insignificant adverse effects on the physical work capacity of animals, whereas the swimming time until fatigue in mice was observed to considerably decrease at an intense noise equal to 80 and 100 dB (Table 1).

The further experimental work included noise exposure to a noise of 80 dB. The long-term exposure to noise of this level tends to provoke psychosomatic diseases in human. It is often recorded when carrying out noise assessments at workplaces, entertainment centres and near city roads and highways.

The preliminarily introduced preparation had considerable effects on the work capacity in mice exposed to a high-level noise. The swimming endurance in mice taking echinacea was higher compared to the mice of the 'noise' group that had not taken the drug: 25 and 13% at 80 and 100 dB, respectively (Table 1).

Table 1

Effects of acute noise exposure on physical work capacity in mice and its correction with Echinacea

Intensity noise, dB	noise, min %	noise + echinacea, min %
30 (control)	21.0 ± 1.14 100	
60	23.3 ± 1.22 111	22.7 ± 1.25 108
80	14.8 ± 0.84* 70	19.9 ± 1.27** 95
100	10.9 ± 0.99* 52	13.7 ± 0.80** 65

*- The difference is statistically significant in comparison with the "control" group; **- The difference is statistically significant in comparison with the "noise" group. The percentage is given relative to the "control" group.

Table 2 provides data from the longitudinal examination of the same mice, the physical work capacity of which was assessed during chronic noise exposure of 80 dB for 4 hours per day during twenty days. Before being exposed to noise, the animals in both groups were forced to swim that was initial level. During all the observation periods, the swimming time in mice from the control group (without noise) differed slightly from the initial level. In the meantime, the physical work capacity in mice exposed to noise has proved to be reliably lower than the initial level: by 36, 20, 16 and 46 % on the 1-, 5-, 10- and 20th days of noise exposure. Judging from these figures related to the physical work capacity, the adaptation of mice to chronic noise did not occur within 20 days (Table 2). This almost twofold decline of the physical work capacity in mice after 20 days of noise exposure allows to suggest that this period appears to be the days allows to suggest that this is a time of failure of adaptive and compensatory mechanisms, discernible somatic disorders and functional transformations in animal organisms.

Table 2

Dynamics of physical work capacity in mice exposed to chronic noise

noise exposure, days	control, min %	noise, min %
0(initial) level)	22.0 ±1.58 100	20.3 ±1.12 100
1	23.1 ± 1.44 105	13.1 ±1.27* 64
5	19.1 ±1.98 87	16.3 ±1.10 80
10	21.1 ±1.41 96	17.0 ±1.47* 84
20	22.8 ±1.42 104	10.9 ± 1.81* 54

*- The difference is statistically significant in comparison with the initial level of our group.

The glycogen and ATP contents were determined in liver and skeletal muscles of mice

immediately after the chronic noise exposure. It is commonly known that both metabolites are crucial for energy provision of physical work capacity in human and animals. It holds true that disorders of energy-related metabolic response in animal organism are most likely to cause a decrease in the physical work capacity.

Table 3 provides data about concentration of glycogen and ATP in liver and quadriceps muscle twenty days after the noise exposure in mice. As determined the chronic noise exposure in mice induces a decrease of both metabolites levels in tissues. The contents of glycogen and ATP in liver were by 30 and 23 % lower than the control values, respectively. The changes in the skeletal muscles are regarded as similar ones: the concentrations of glycogen and ATP decreased by 23 and 29 %, respectively due to noise. These findings suggest that noise exposure considerably decreases energy reserves in organism, thus damaging the adaptive potential. The decrease of the physical work capacity in mice can be accounted for by the noise-induced energy imbalance.

Normalizing effect of Echinacea on the content of energy maintenance in the tissues was observed. For example, the level of glycogen and ATP in liver were 93 % in "noise+echinacea" group, whereas in "noise" group these values were 70 and 77 % as against "control" group. At the same time, the of glycogen and ATP in skeletal muscle of "noise+echinacea" group decreased by 18 and 24 % relative to "noise" group (Table 3).

Table 3

Effect of echinacea on concentration of glycogen and ATP in liver and skeletal muscle in mice exposed to chronic noise (80 dB, 20 days)

indices	control	noise	noise+echinacea
Liver glycogen, μMol/g ATP, μMol/g	224.6 ± 16.2 2.50 ± 0.15	157.8 ± 11.3* 1.92 ± 0.11*	208.3 ± 12.9** 2.33± 0.08**
Skeletal muscle glycogen, μMol/g ATP, μMol/g	21.7 ± 1.74 3.21 ± 0.22	16.6 ± 1.06* 2.28 ± 0.14*	20.5 ± 1.23** 3.05 ± 0.10**

* - The difference is statistically significant with respect to the control group. ** - The difference is statistically significant with respect to the "noise" group.

Discussion

Maintaining high work capacity and regulating psychophysiological structure of behaviour in extreme conditions may require pharmacological correction. There are few facts indicating that the herbal remedies can hinder occurrence or development of somatic and metabolic disturbances due to high ambient noise exposures. However, it has been reported about protective effects of *Acorus calamus* L., *Allium sativum* L., *Astragalus chinensis* L., *Glycyrrhiza glabra* L., *Ligusticum wallichii* Franch., *Ocimum sanctum* L., *Rhodiola rosea* L. during acute noise exposure (95 - 105 dB) (4, 7, 8, 10, 14). The extracts from these herbs

exhibited protective effects at the metabolic level: hindering the generation of free radicals and lipid peroxidation in the animal brain, occurrence of hepatic cytolysis, exerted glycogen-conserwing and creatine phosphate-conserving effects during noise exposures.

This study shows that the noise, which is not relevant adequate to genotype-dependent and phenotype-dependent levels of physiological perception of acoustical stimulation, is known to decrease the physiological work capacity in animals, thus resulting in failure of adaptation to continuous noise exposure. Echinacea exhibits an energy-stabilizing effect allowing to optimize the physical work capacity of animals during acute and chronic noise exposures. Influencing the energy component of homeostatic mechanisms that regulate the physical work capacity in animals is deemed to serve as the major mechanism for the improvement of physical endurance (duration of physical work) in animals. Many researchers highlight the stimulative effect of ecinacea during exercise training and physical fatigue of human and animals (12).

The findings indicate of a favourable effect of echinacea that provides a wholly new homeostatic situation related to increasing compensatory and adaptive processes in animal organism. This allows to recommend *Echinacea purpurea* for the maintenance and optimization of human physical work capacity in case of ambient noise exposure.

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