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The study of the effect of drinks based on extracts of herbal adaptogens on the functional status of athletes during physical activity

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ABSTRACT

Adverse environmental factors, stress, lack of sleep and rest, and heavy physical exertion, deplete the human body. In particular, the reserves of the main metabolites, water, and oxygen, are very limited. People, especially athletes, need to take special dietary supplements with adaptogenic properties to adapt to stressful extreme loads. In this study, the influence of using extracts of leuzea, ginseng, and *Eleutherococcus* on athletes' performance, endurance, strength, and emotional state is carried out. The studies were conducted on four groups of male athletes aged from 19 to 25 years. For three weeks, diagnostics of vital lung capacity, Stange, and Genchi tests are carried out, and data on the general impressions of athletes are collected. According to the research results, the use of adaptogens leads to an increase in physical performance. After the first week of the study, a positive effect on the human body are noticed: improve well-being and increased athletic performance. When using *Eleutherococcus*, there was a change in the work of the central nervous system (motor functions): tasks begin to be performed in an organized and accelerated manner without deterioration of well-being, but the volume of strength exercises remained the same. When using the drug leuzea, muscle strength was noted, which allowed to increase the load. There is a positive effect of phytopreparations on the body, namely on the functions of the cardiovascular, central nervous and endocrine systems. In 4 participants who took leuzea, the performance in power competitions improved by 18.5% compared to the control group. The intake of *Eleutherococcus* and ginseng is accompanied by an increase in the activity of neurotransmitter cells, i.e., the effect on the mesolimbic system. In addition, a study of hematological blood parameters and hormonal statuses at the beginning and end of the study was conducted with the subjects who took leuzea extract. So, the use of the drug leuzea leads to the following positive changes: a more significant increase in ESR, a more significant increase in hemoglobin, compared with the control group. The conclusion is made about the practicality of taking biologically active additives based on some plant adaptogens.

Keywords: herbal extract, adaptogen, sport, adaptive potential

INTRODUCTION

The main metabolites, water, and oxygen reserves in the human body are very limited. To maintain a high efficiency level in the body, it is necessary to constantly replenish metabolic reserves as they are spent. Proper and balanced nutrition ensures the entry into the body of all substances necessary for the normal course of metabolic reactions that form the basis of most vital functions and are responsible for human health **[1]**.

However, with heavy physical exertion, which every athlete has to face, traditional eating regimes do not allow covering the daily energy consumption. Therefore, athletes often experience a deficiency of individual nutrients, which manifests in difficulties in carrying out certain types of energy transformations or increasing the overall level of energy production. The consequence of this situation is increased fatigue in the body, as well as a decrease in the body's resistance to various adverse factors (sudden temperature changes, infections, stress, etc.) **[2]**, **[3]**. It is possible to solve the problem of relative nutritional deficiency in intense training and competition conditions by introducing a special diet and using special biologically active food additives containing vitamins, essential trace elements in bioavailable form, and other biologically active substances of natural origin **[4]**, **[5]**, **[6]**, **[7]**. To adapt to stressful loads, athletes need special biologically active additives with adaptogenic effects **[8]**, **[9]**.

Adaptogen preparations are made from raw materials of plant or animal origin. In addition, minerals can also serve as adaptogens. Functionally, adaptogen preparations are involved in optimizing the physiological processes of the body, in particular, normalizing metabolic processes **[10]**. This leads to the economical use of reserve substances and energy sources, strengthens the body's protective functions, and increases the body's ability to resist tissue destruction. Repeated use of adaptogens in violation of homeostasis caused by physical exertion leads to forming a structural trace **[11]**. In some cases, researchers of the effect of physical exertion on the body's physiological processes suggest using adaptogens of plant origin to maintain homeostasis **[12]**, **[13]**, **[14]**.

When using adaptogens of plant origin, microsomal enzymes and antioxidants are synthesized in the body, which contributes to the activation of the process of withdrawal from the body or utilization of xenobionts and free radical metals **[15]**, **[16]**, **[17]**. Herbal preparations are often made from Safflower leuzea, Rhodiola rosea, lemongrass, golden root, ginseng, *Eleutherococcus*, and other plants [18]. The relevance of the search for natural adaptogens is also dictated by the fact that they are quickly incorporated into the biochemical process and are not toxic even with prolonged use **[19]**.

Thus, the use of adaptogen drugs is necessary in cases where the body requires extremely high performance and the fastest recovery. At the same time, these drugs should be as harmless as possible and not have a negative effect on the body in the distant future. Such properties are mainly possessed by preparations made from objects of plant origin.

Research in this direction will make it possible soon to abandon the use of chemical medicinal and synthetic drugs in favor of natural ones.

This work aimed to assess the impact of the systematic use of beverages based on herbal extracts-adaptogens on the functional state of athletes.

Scientific hypothesis

The systematic use of adaptogens of natural origin in the form of beverages based on aqueous extracts will help improve the body's adaptive capabilities and increase athletes' physical performance.

MATERIAL AND METHODOLOGY

Samples

Extracts of herb adaptogens: safflower leuzea, ginseng, eleuterococus.

Chemicals

We used reagents of recognized analytical purity and distilled water. The work used the following chemicals: Ethanol, Sodium carbonate, and Ascorbic acid. All chemicals above were purchased by LenReactive LLC (Sants Petersburg, Russia) and were of analytical grade quality.

Animals and Biological Material

The study on athletes was conducted following the standards of the Helsinki Declaration of the World Association "Ethical principles of scientific medical research with human participation" and "Rules of Clinical Practice in the Russian Federation" (2003). All athletes gave their voluntary consent to participate in the study. Blood sampling was carried out on an empty stomach before training loads in the morning.

Instruments

Ultrasound dispersant UZD 1-0.063/22 (UZT, Krasnodar, Russia), immunochemical analyzer Immulite 1000 (DPS, New York, USA), complex for stress tests Cardiovit AT-104 Esp. (Schiller, Bern, Switzerland), bicycle ergometer ERG-911 BP (Schiller, Bern, Switzerland), biochemical blood analyzer Olympus AU 400 (Olympus Europa SE & Co. KG, Hamburg, Germany), hematology analyzer MEK 7222 (NihonKohden, Tokyo, Japan).

Laboratory Methods

The study of the antioxidant activity of leuzea, ginseng, and *Eleutherococcus* extracts was carried out by the spectrophotometric method according to Rzhepakovsky et al. (2022) **[20]** concerning ascorbic acid.

The study of the functional state of athletes was carried out by express analysis of the state of health with data processing in the program "Diamond" of the Youth Health Center (Vladikavkaz, Russia).

General physical performance was determined by the method of V. L. Karpman **[21]**. The main indicators of adaptation to physical activity were:

1. Heart rate. There is a linear relationship between the heart rate and the intensity of the load, so in sports practice, heart rate is often used as a criterion for assessing the intensity of training.
2. Blood pressure. Speed-power and strength sports increase blood pressure, and low-intensity cyclical (walking, slow running, swimming, skiing, rowing, cycling) – reduce.
3. The vital capacity of the lungs is an indicator reflecting the functional capabilities of the respiratory system.
4. Adaptive potential – the limit of a person's resistance to physical exertion shows how quickly the body adapts to a stressful situation.
5. The Rouffier index – reflects the adaptive capabilities of the cardiovascular system in response to a dosed load and simultaneously characterizes the overall endurance level.
6. The Skibinsky index – reflects the functional capabilities of the respiratory and circulatory organs and the body's resistance to hypoxia.
7. The Stange test is a functional test for assessing the state of the cardiovascular and respiratory systems, which consists in determining the maximum duration of arbitrary breath retention after inhalation.
8. The Genchi test is a functional test for assessing the state of the cardiovascular and respiratory systems, which consists in determining the maximum duration of arbitrary breath retention after exhalation.

Blood biochemical parameters were studied using the Olympus AU series biochemical analyzer (Germany). Hematological analysis was performed on a hematological analyzer MEK 7222 (Nihon Kohden, Japan). The level of cortisol and testosterone was determined on the immunochemical analyzer Immulite 1000 (DPS, USA). Functional diagnostic methods were carried out using the Cardiovit AT-104 Esp. The stress test complex is complete with the ERG-911 BP bicycle ergometer (Schiller, Switzerland).

Description of the Experiment

Sample preparation: The The extracts were obtained at room temperature using an ultrasonic dispersant. Water was used as an extractant. Ultrasonic extracts were treated using the device UZD 1-0.063/22. Ultrasonic exposure to solid plant raw materials was carried out with an intensity of 18 to 22 kHz for 3-5 minutes. Extracts were made in a ratio of 1:10. 10 g was poured into a chemical cup of dry crushed roots of Safflower leuzea, *Eleutherococcus*, and ginseng, and 100 cm^3 of distilled water was poured, after which the generator nozzle was immersed in this cup, and the raw materials were processed.

It should be noted that during ultrasonic treatment, the medium was heated to 60 °C, which does not lead to the inactivation of adaptogens. After the treatment was completed, the solution was filtered out. The prepared extracts are shown in Figure 1.

Figure 1 Snapshot of prepared adaptogen extracts. From left to right: ginseng, leuzea, *Eleuterococcus*.

Number of samples analyzed: 3.
Number of repeated analyses: 3.
Number of experiment replication: 1.
Design of the experiment: At Powders of ginseng, leuzea, and *Eleutherococcus* roots were purchased for the experiment. Drinks were prepared from plant powders by ultrasonic extraction, which athletes systematically used for 3 weeks.

The experimental athletes were selected in the age category of 19-25 years (mainly amateur athletes), men of average height and build (Table 1). The volunteers were randomly divided into four groups of 20 people each. The first group was a control group; athletes did not use any additives to their main diet. Athletes of the second group used ginseng extract, the third group - Eleuterococus, the fourth group - leuzea.

Thus, the athletes of groups 2-4 took extracts of three types in the prescribed volume (330 ml) daily before each training session for three weeks to identify the adaptive properties of the studied extracts. Athletes of the control group consumed 330 ml of water instead of prepared drinks.

Table 1 Anthropometric and functional indexes of experimental athletes.

Group	**Group 1**			**Group 2**			**Group 3**			**Group 4**		
Number of people	**20**			**20**			**20**			**20**		
The additive used	**Clean water**			**Ginseng Extract**			***Eleuterococcus* Extract**			**Leuzea Extract**		
	mean	min	min	mean	min	min	mean	min	min	mean	min	min
Age, years	21	19	25	22.2	19	25	21.6	20	23	21	19	24
Height, cm	177.4	172	183	176.6	172	180	176.8	174	180	175.8	169	182
Weight, kg	77.8	64	88	80.8	72	89	79.2	67	87	79.8	72	87
BMI	22.7	20.6	26.3	25.9	23.5	28.1	25.4	21.4	27.8	25.9	22.6	30.5
Heart rate	85.4	67	112	87	65	107	81.6	65	110	86.2	78	96
AD system, mmHg.	116.4	110	120	119	110	125	115	110	120	119	115	125
AD diast., mmHg.	73.8	65	85	74	60	85	74	70	80	79	70	80
Adaptive potential	2.23	1.9	2.7	2.37	2.1	2.7	2.25	2.0	2.6	2.4	2.3	2.5
Rufier Index	17	12	21	13.4	8	18	12.2	9	16	12.8	8	16
Skibinsky Index	1.76	0.73	3.1	1.48	0.79	2.42	1.64	1.23	2	1.91	1.5	2.7

Studies of the functional state of the experimental subjects were conducted in the health center of polyclinic No.1, Vladikavkaz (Russia), as well as in the laboratories of the North Ossetian State Medical Academy.

During the experiment, the dynamics of changes in the functional state of athletes were determined, as well as the main blood parameters were determined, according to which a conclusion was made about adaptation to physical exertion in the training cycle.

Statistical Analysis

Statistical processing of experimental data. The results were processed using the statistical package PASW Statistics 18, version 18.0.0 (SPSS Inc., USA). Verifying the normality of the signs distribution was carried out using the Kolmogorov-Smirnov criteria. The critical significance level when statistical testing hypotheses in the study was assumed to be 0.05.

RESULTS AND DISCUSSION

As can be seen from the graph (Figure 2), *Eleutherococcus* extract has the highest indicator of antioxidant activity (AOA index) – 871.5 mmol/l, which confirms the results of previous studies **[22]**. Leuzea extract was characterized by an antioxidant activity value of 832.9 mmol/l, which is 37.2% higher than ginseng extract. Nevertheless, all the prepared extracts were characterized by a relatively high AOA value on the ascorbic acid scale, indicating a high extractive yield during ultrasonic extraction.

The main and invariable property of adaptogens is an increase in the physical work performed **[23]**. The importance of adaptogens as regulators of homeostasis is significant. This is primarily due to increasing environmental pollution and urban stress, which lead to previously rare diseases **[24]**. Adaptogenic drugs enable a modern person to tolerate various external negative effects more easily, increasing his resistance to various extreme factors **[25]**.

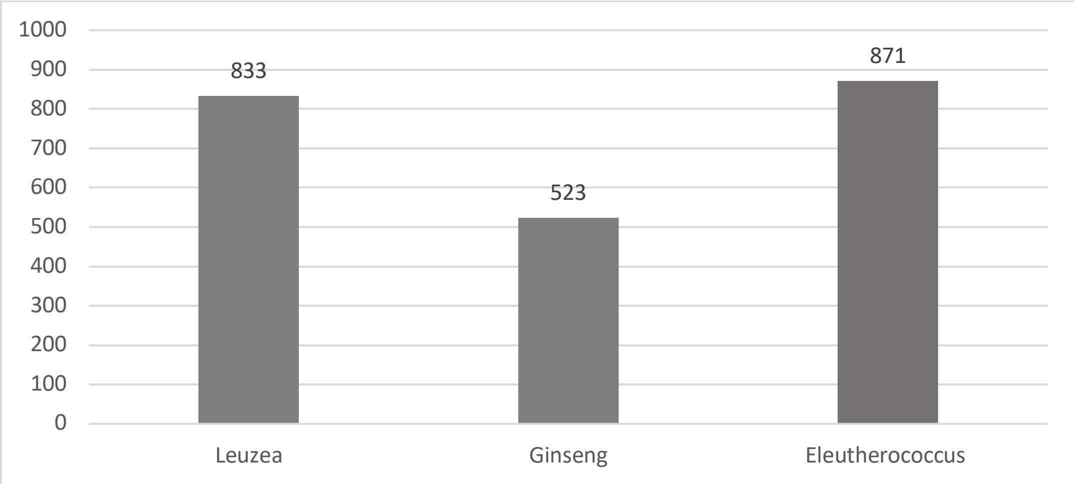

Figure 2 Results of studies of antioxidant activity of model systems, mg/l in terms of ascorbic acid.

To conduct experimental studies on the study of the functional state and adaptation to the physical exertion of amateur athletes, 4 groups of volunteers were organized among students of the North Ossetian State Medical Academy. The first group was a control group, i.e. athletes were subjected to physical exertion but did not take the studied extracts. The next three groups were differentiated by the type of extracts taken – ginseng, *Eleutherococcus*, and leuzea. Physical activity was organized daily throughout the study and took place at a submaximal intensity with a cycle of 3 minutes.

The results of a three-week cycle of studies of the main functional indicators of experimental amateur athletes are presented in Figures 3-5.

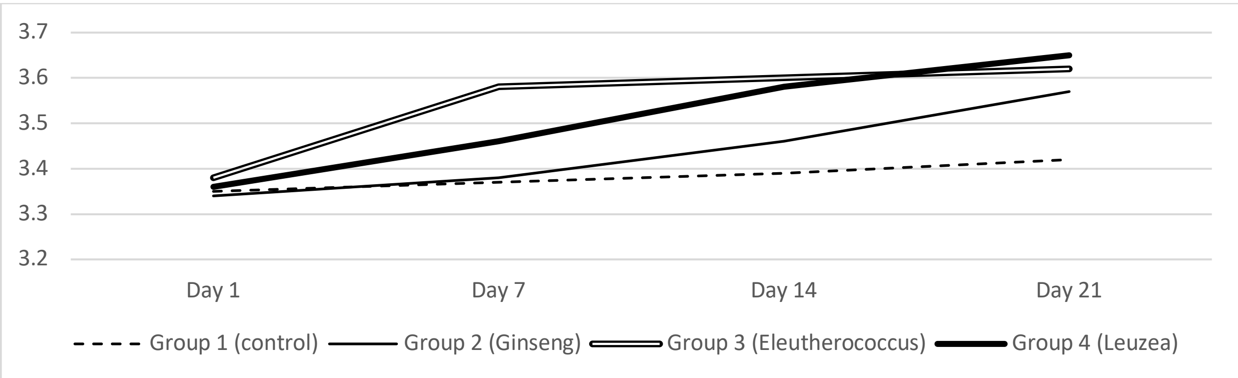

Figure 3 Dynamics of the vital capacity of the lungs of the studied athletes.

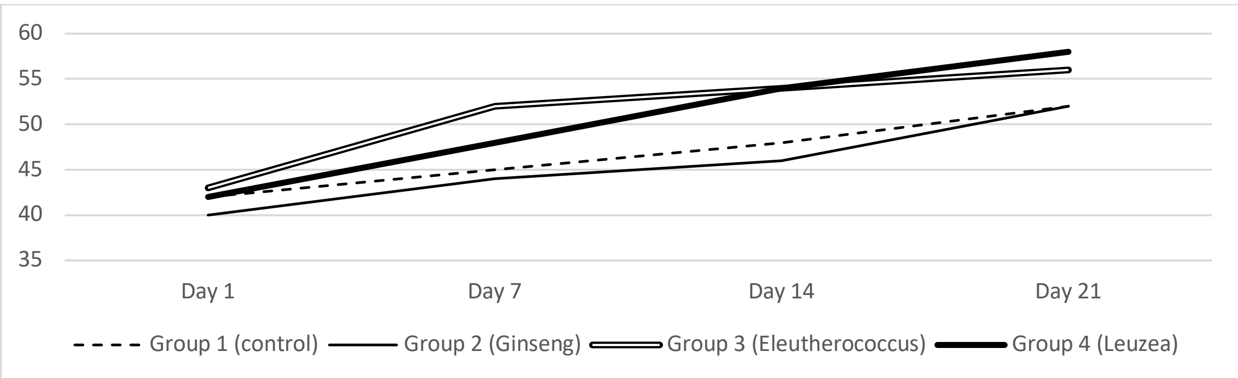

Figure 4 Dynamics of the Stange test of the studied athletes.

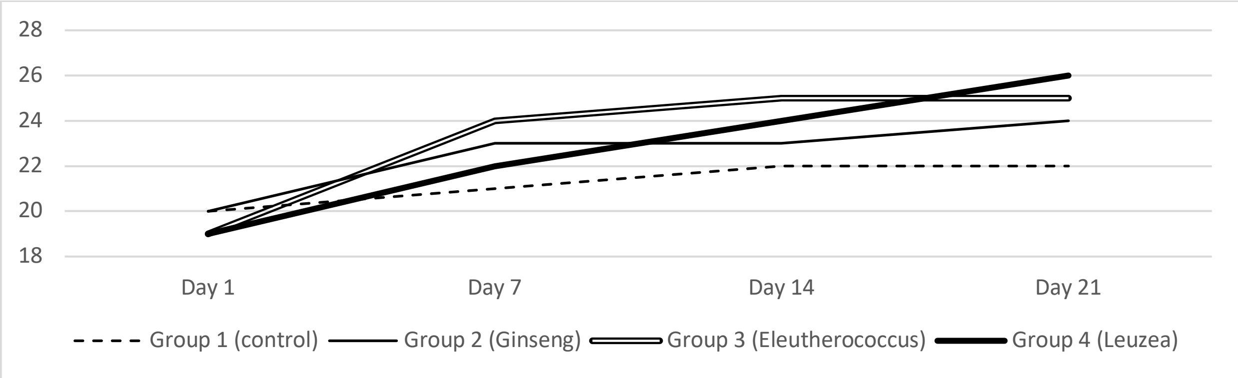

Figure 5 Dynamics of the Genchi test of the studied athletes.

The research results showed that even weekly use of adaptogens led to increased physical performance, which corresponds to reports of other researchers **[8]**, **[11]**, **[26]**. The positive effect on the human body was noticed after the first week of the study. Compared with the control group, there is an improvement in well-being, and an increase in athletic performance. The volunteers who took the *Eleutherococcus* drug showed a change in the work of the central nervous system (motor functions): tasks began to be performed in an organized and accelerated manner without deterioration of well-being, but the volume of strength exercises remained the same. In turn, muscle strength was noted when using the drug leuzea, which made it possible to increase the load. Even though the effect of the drug based on leuzea manifested itself only in the 2nd week of testing, the sum of the effects of its use was higher than that of other drugs. At the same time, reactions related to the metabolism of sex hormones were noted among the participants. Combining the data obtained, it is possible to note the positive effect of phytopreparations on the body, namely on the functions of the cardiovascular, central nervous, and endocrine systems. General indicators such as endurance, resistance to hypoxia, reaction speed, and muscle strength have also improved, which can be proved by **[27]**, **[28]**, **[29]**.

Several authors provide supporting material in favor of the anabolic action of adaptogens from the ginseng family **[30]**, **[31]**, **[32]**, **[33]**. Also, doubts are expressed about the presence of similar properties in herbal preparations **[34]**, **[35]**. At the same time, the anabolic effect is explained only by improving the energy supply of both working tissues and sex glands. And this may apply to most phytopreparations. Leuzea drugs have great potential, as they help in the fight against this phenomenon, preventing it. In 4 participants who took Leuzea, the performance of power competitions improved by 18.5% compared to the control group.

The property of leuzea preparations to accelerate the processes of protein synthesis and harmlessness make them a promising source of phytoecdysteroids, which, affecting protein metabolism, do not cause disturbances in the hormonal picture of healthy people.

The effect on the work of muscles is carried out through the anabolic effect of adaptogens on the body **[36]**, **[37]**, **[38]**. The intake of *Eleutherococcus* and ginseng is accompanied by increased activity of neurotransmitter cells, i.e. the effect on the mesolimbic system. This is also evidenced by the fact that the volunteers who took *Eleutherococcus* drug noted a good sleep throughout the study.

Figure 6 shows the growth dynamics of each studied indicator at the end date of the experiment.

The effect of adaptogen extracts on the functional indexes of athletes was studied between group 5 (control group) and group 6 (experimental group). At the same time, group 5 was formed from 12 people with average indicators based on group 1, and group 6 was formed from 12 people with average indicators based on group 2 taking leuzea extract. At the first stage of studies with adaptogen extracts, the normal values of blood pressure, heart rate, and blood pressure were determined, which made it possible to create two groups equal in average functional indicators – group 5 (control), which was offered to take 330 ml of water before a training session and group 6 (experimental), whose members took 330 ml of a prepared drink based on leuzea extract, which had the best effect on the functional abilities of experimental athletes. The duration of the studies at the second stage was also 21 days.

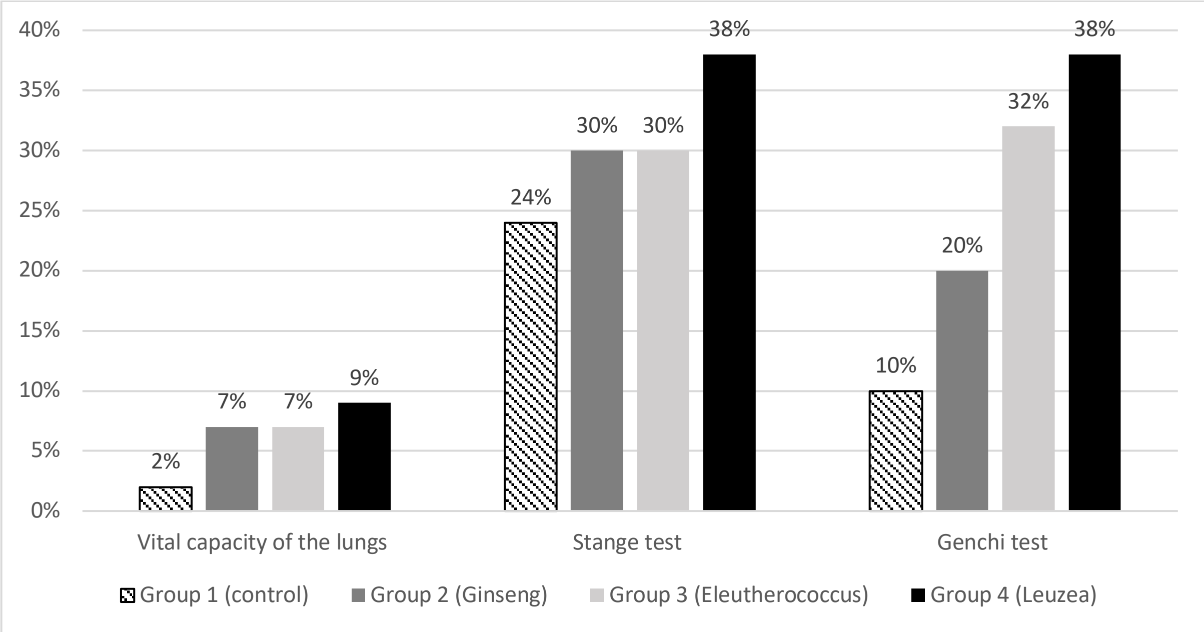

Figure 6 Relative growth of the studied indicators.

The research object at the second stage was hematological blood parameters since they can be used to determine the effect of physical stress on the state of the cardiovascular system. The results of the studies are presented in Figure 7.

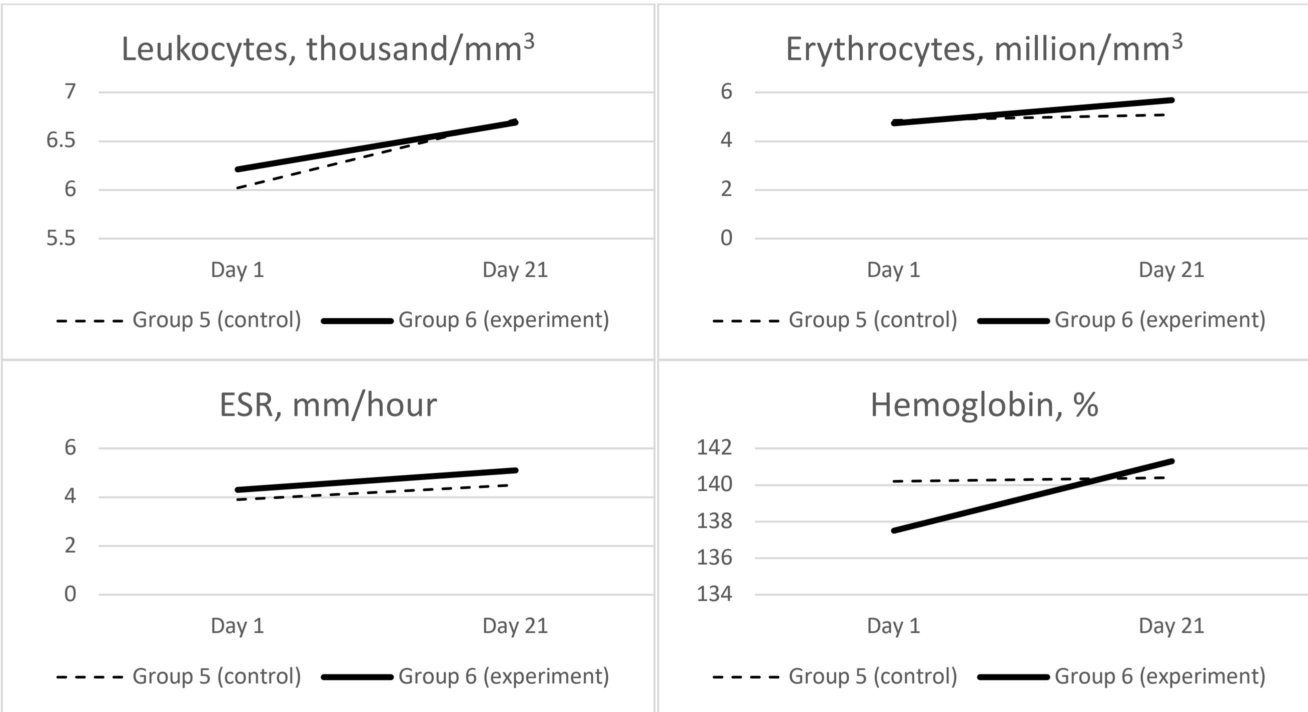

Figure 7 Results of the study of hematological parameters of the blood.

The level of erythrocytes in the blood of athletes of the control and experimental groups at the beginning of the experiment corresponded to the physiological norm and amounted to 4.85 ±0.16 and 4.73 ±0.17 million/mm^3, respectively **[39]**. Physical exertion contributed to an increase in the content of red blood cells in both groups; however, in the case of taking leuzea extract, the difference over three weeks of training was more significant.

In the control group, the ESR at the beginning of the experiment corresponded to 3.9 ±0.52 mm/h. At the end of the experiment, this value did not significantly change – 4.5 ±0.8 mm/h. There were no significant differences in this indicator at the beginning and end of observations and in the experimental group of subjects. Thus, during the 21 days of the training cycle, the ESR did not undergo significant changes in students of both groups, although some tendency to increase this indicator can be traced in both groups.

As expected, the increased number of erythrocytes in the tested athletes taking leuzea extract also increased the blood hemoglobin content from 136.3 ±0.95% to 141.3 ±0.80% by the end of the training cycle. At the same time, in the control group, who performed the same amount of physical activity but did not receive leuzea extract, the blood Hb content by the end of the training was almost equal to the initial one.

Following the change in the hematological parameters of the subjects' blood, changes were also found in the hemorheological characteristics of the blood of volunteer athletes. Samples were taken once after 21 days of training since the beginning of the research. The results of the studies are presented in Figure 8.

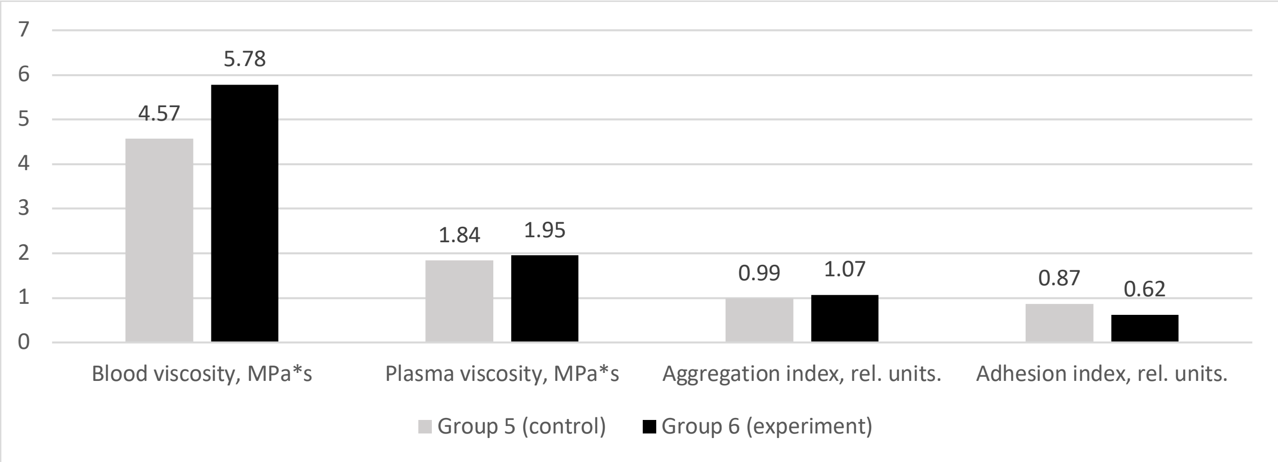

Figure 8 Results of studies of the hemorheological characteristics of the subjects' blood.

It is known that an increase in plasma protein content stimulates the process of aggregation **[40]**, **[41]**, **[42]**. In the study, the experimental group's erythrocyte aggregation index was 1.07 ±0.02 a. u., whereas, in control, its value was 0.99 ±0.01 a. u. Changes in the parameters characterizing the deformability of erythrocytes were less significant. Thanks to an integrated approach to the study of blood flow, it was possible to identify those intravascular factors that have the most significant impact on the state of the cardiovascular system during physical exertion. In the study, such factors were an increase in plasma viscosity, erythrocyte aggregation, and leukocyte adhesion. These changes cause an increase in blood viscosity in individuals with higher adaptive capabilities of the body **[43]**, **[44]**. In addition, the revealed hemorheological changes increase the efficiency of oxygen transport **[45]**. In addition, a slight decrease in protein concentration was observed in the control group, indicating the insufficiency of anabolic processes, as indicated by a decrease in testosterone synthesis (Table 2).

Table 2 Indicators of the hormonal status of athletes against the background of taking natural adaptogens.

Indicators	Group 5 (control)		Group 6 (experiment)	
	Day 1	Day 21	Day 1	Day 21
Cortisol mg/dl (norm 11.3-25)	16.4	18.6	16.5	19.5
Testosterone ng/dl (norm m:105-545)	436.3	241.0	358.3	266
Testosterone/cortisol (male) c.u.*10^2	0.028	0.011	0.022	0.015

Such changes indicate a lack of adaptive potential of the body and the presence of signs of overtraining. The study of hormonal status showed that the studied indicators in the analyzed groups had no statistically significant dynamics and were within the reference values. However, in the comparison group, there was a significant decrease in the testosterone/cortisol ratio index, which characterizes the tension of metabolic processes and increased catabolism. In contrast, the cortisol level practically did not change, which can be regarded as the initial stage of maladaptation **[46]**, **[47]**.

Thus, the results showed that for immediate adaptation to physical activity, the best option is using drinks based on eleuterococus extracts. With systematic training, the best adaptive potential was observed in people who took drinks based on leuzea extract.

Taking a drink based on leuzea extract directly affects the hematological parameters of the blood, increasing the level of red blood cells and, accordingly, hemoglobin, which is a factor of adaptation to physical exertion.

CONCLUSION

The results of the conducted studies have shown that using adaptogen extracts during the week significantly increases efficiency. The earliest effect was provided by the drug *Eleutherococcus* in the form of reducing fatigue and increasing the resistance of hypoxia. Athletes who take *Eleutherococcus* extract noted an improvement in well-being, an increase in athletic performance, low irritability, and sound sleep. At the same time, they also note the lack of dynamics of strength exercises. In turn, the drug leuzea makes it possible to significantly increase physical activity after two weeks; athletes note a significant increase in muscle strength. According to the results of the three-week experiment, data were obtained that in the control group the vital capacity of the lungs increased by 2%, the result of the Stange Test improved by 24%, and the result of the Genghi Test improved by 10%. At the same time, the group taking the ginseng drug shows the following dynamics: +7% – vital capacity of the lungs, +30% – Stange Test, +20% – Genghi Test. The group taking *Eleutherococcus*: +7% – lung capacity, +30% – Stange Test, +32% – Genghi Test. The group taking the drug leuzea: +9% – lung capacity, +38% – Stange Test, +38% – Genghi Test. In 4 participants who took Levzea, the performance in power competitions improved by 18.5% compared to the control group. According to the results of the experiments, it was the drug leuzea that showed the greatest effect. In addition, the use of levzea significantly increased the content of red blood cells in the blood (from 4.73 to 5.68 million/mm^3, that is, by 20.08%), compared with the control group (from 4.85 to 5.08 million/mm^3, that is, by 4.74%). Consequently, the hemoglobin level increased significantly (from 137.5% to 141.3%), compared with the control group (from 140.2 to 140.4). Thus, the results showed that for immediate adaptation to physical activity, the best option is to drink drinks based on *Eleutherococcus* extracts. With systematic training, the best adaptive potential was observed in people who took drinks based on leucea extract. Taking a drink based on levzea extract directly affects hematological blood parameters, increasing the level of red blood cells and, accordingly, hemoglobin, which is a factor of adaptation to physical exertion.

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