Adaptive mechanisms of athletes' bodies under extreme conditions

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Abstract

Objective of the study is to provide theoretical and experimental justification for the basic principles of constructing a comprehensive system of special relaxation training aimed at improving the functional state of athletes' bodies, increasing the rate of skeletal muscle relaxation, and improving the effectiveness of the training process.

Methods and structure of the study. The dynamics of hypoxic resistance, the rate of voluntary relaxation (RVR) of skeletal muscles, and the power of the braking-relaxation functional system of urgent adaptation and protection (BRFSP) of the body from extreme influences during long-term adaptation to various adaptogenic factors were studied. All subjects were divided into two groups: group 1 consisted of athletes with initially high BRFSP capacity (experimental), and group 2 consisted of athletes with initially low BRFSP capacity (control). The purpose of this grouping was to determine the influence of the initial BRFSP power on the nature of long-term adaptation of the parameters under consideration under the influence of various adaptogenic factors.

Results and conclusions. An increase in the activity of the central nervous system's braking systems and muscle RVR, as an urgent adaptive response to intense physical exertion, occurs when BRFSP is activated by extreme influences. The dependence of muscle character and RVR on the functional state of the central nervous system has been demonstrated. The functional state of the central nervous system also largely determines the power of BRFSP. The results of the studies provide a basis for the methods and principles of special relaxation training aimed at increasing the effectiveness of the training process.

Keywords: *central nervous system, training process, relaxation, physical performance.*

Introduction. The problem of ensuring effective training of athletes in extreme conditions and creating functional prerequisites for maintaining health is becoming increasingly relevant [1, 5, 6]. One way to solve this problem is to use effective modern and physiologically sound technologies while simultaneously employing a rational system of comprehensive diagnosis and correction of functional status. This allows for expanding the range of compensatory capabilities of the body. Ensuring optimal adaptation to muscle loads is one of the conditions for maintaining health and improving professional skills [1, 2, 4, 7]. Muscle relaxation, in particular, the rate of voluntary relaxation (RVR) of skeletal muscles, is no less important a quality characterising the functional state and functional capabilities of the body than the contractile characteristics of muscles. In studies devoted to the study of the rate of relaxation of skeletal muscles [2, 3, 5, 6], the beneficial effect of special exercises that improve the RVR of skeletal muscles on the central nervous system, the formation of rational types of blood circulation, coordination of movements, speed, endurance, technical skills, growth of special physical working capacity (SPWC) and sports results has been shown.

Objective of the study is to provide theoretical and experimental justification for the basic principles of constructing a comprehensive system of special relaxation training aimed at improving the functional state of athletes' bodies, increasing the rate of skeletal muscle relaxation, and improving the effectiveness of the training process.

Methods and structure of the study. The dynamics of hypoxic resistance (HR), skeletal muscle RVR, and the power of the brake-relaxation functional system of rapid adaptation and protection (BRFSP) of the body from extreme influences during long-term adaptation to various adaptogenic factors were studied. All subjects were divided into two groups: group 1 consisted of athletes with initially high BRFSP power (experimental), and group 2 consisted of athletes with

initially low BRFSP power (control). The purpose of this grouping was to determine the influence of the initial BRFSP power on the nature of long-term adaptation of the parameters under consideration under the influence of various adaptogenic factors (SAF). The more BRFSP is activated, the faster and more effective the adaptation process is, leading to an increase in skeletal muscle RVR and the formation of a relaxation type of long-term adaptation (RTLA).

Results of the study and discussion. Analysis of the research results showed that various adaptogenic factors and their combinations lead to different dynamics of HR, RVR of skeletal muscles, and BRFSP power of the body from extreme exposures during long-term adaptation. When reviewing the results of the examinations, it was found that in group 1 of athletes, the greatest increases in RVR were achieved by using a combination of altitude hypoxia, simulated in a general-purpose pressure chamber (7 sessions), and physical training (RVR increase of 30.5% in 10 days), as well as a combination of 10 sessions of biofeedback based on electroencephalograms with physical training (PT) (RVR increase of 11.8% in 30 days). The combination of the same exercises with relaxation exercises had a greater effect (15.0% increase in RVR over 30 days). In group 2, the increases in all parameters were lower. Conventional physical training was significantly less effective in both groups. The combination of SAF with physical training provides a several times greater effect. The results of the studies showed that, regardless of the adaptogenic factors or their combinations used, subjects with high baseline BRFSP (group 1) had higher increases in HR and RVR parameters compared to subjects in the second group (low BRFSP) (Figure 1)

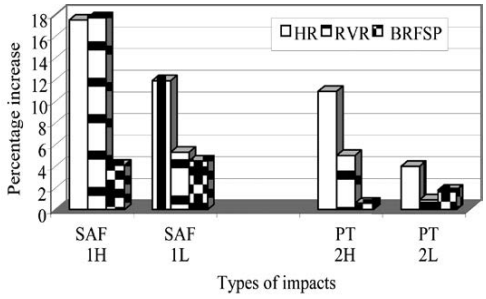

Figure 1. Dynamics of HR, RVR of skeletal muscles and BRFSP power under the influence of adaptogenic factors and their combinations

The combination of SAF with physical training in athletes with high BRFSP power over 23 days resulted in a 17.8% increase in HR ($p<0.001$), a 19.1% increase in muscle RVR ($p<0.001$), and a 4.4% increase in BRFSP power ($p<0.01$). In athletes with low BRFSP power under the same conditions, HR increased by 11.9% ($p<0.01$), muscle RVR by 5.0% ($p<0.05$), and BRFSP power by 3.1% ($p<0.01$). When using training physical loads in athletes with high BRFSP power, after 150 days of training, HR stability increased by 1.0% ($p<0.01$), muscle RVR by 6.9% ($p<0.05$), and BRFSP power by 0.8% (not significant). Athletes with low BRFSP power also showed positive (not significant) dynamics in the parameters under consideration, but the increases were significantly smaller than in the first group. Considering that SAF exposure lasted only 23 days, while physical training lasted 150 days, the differences in the effectiveness of these exposures were even greater when calculated on a per-day basis. After combined exposure to physical exercise and other SAF, compared to conventional physical training, the daily increase in HR, RVR and BRFSP parameters was higher in athletes with high BRFSP power. The results show that the use of combined SAF exposure is many times more effective than conventional physical exercise. The effectiveness of any exposure is several times higher in athletes with higher BRFSP power.

In the next series of studies, an experimental assessment of the effectiveness of the relaxation training system we developed in the training process was carried out. The footballers of the experimental team, along with conventional physical training, used a relaxation training system that included the following activities: a weekly cycle of barochamber training, regular use of relaxation exercises and breath-holding exercises, and use of a sauna once a week.

The control team trained according to the standard programme and did not use any additional training methods. Polymyographic, cardiological, biochemical, psychophysiological and ergometric research methods were used to study the patterns of performance dynamics and the functional state of various body systems during long-term adaptation.

The first examination was conducted at the beginning and the last at the end of the competitive season. The direction of changes in the teams was different. In the experimental team, by the end of the season, compared to the beginning, there was a significant ($p<0.001$) increase in muscle RVR and a significant ($p<0.01$) decrease in the adaptation type classification index (ATCI), indicating a shift towards RTLA. In the control team, on the contrary, RVR decreased significantly ($p<0.01$), and the ATCI value increased significantly ($p<0.05$), indicating the formation of a hypertrophic type of adaptation.

The dynamics of all parameters considered were different. In the experimental group, the dynamics were positive, while in the control group, they were negative. In the experimental team, significant ($p<0.05$ - $p<0.001$) increases were found in 16 out of 20 parameters. Muscle contraction characteristics increased insignificantly, but muscle RVR increased by 17.6% ($p<0.001$).

As a result, ATCI significantly decreased (by 15.2%; $p<0.01$), indicating the formation of RTLA. Ergometric characteristics of physical working capacity increased: starting by 16.5% ($p<0.01$), maximum by 23.7% ($p<0.001$), finish by 6.8% ($p<0.05$), average by 8.3% ($p<0.001$), and pedalling speed on the bicycle ergometer by 12.1% ($p<0.01$). All cardiological, biochemical, and neurophysiological parameters characterising energy efficiency and the speed of recovery processes improved significantly. The efficiency of cardiac activity increased by 25.0% ($p < 0.001$), the efficiency of glycolysis by 26.4% ($p < 0.05$), creatine phosphate by 4.5% ($p < 0.05$) and phosphorus by 25.0% ($p < 0.05$). The pulse recovery rate increased by 8.7% ($p<0.001$). Resistance to fatigue improved by 13.6% ($p<0.01$), recovery rate by 7.2% ($p<0.01$) and completeness of recovery by 12.3% ($p<0.01$) of muscle contractile properties. The overall efficiency coefficient (OEC) of the body's systems also increased significantly (by 16.9%; $p<0.001$). Positive dynamics were also revealed by psychophysiological studies.

A different picture was observed in the control team. The footballers in this team showed negative dynamics in almost all parameters, and a statistically significant deterioration ($p<0.05$ - $p<0.001$) was found in 13 of them. The integral indicator – OEC of body systems – decreased by 11.2% ($p<0.001$). The deterioration in SPWC and the functional state of the control team's footballers by the end of the season is a natural phenomenon, explained by chronic fatigue that accumulates during an intense competitive period. The improvement in all parameters studied by the end of the season in the experimental team is unusual. This proves the effectiveness of the developed relaxation training system, which also increases the effectiveness of the entire training process. An improvement in SPWC was also found in the veteran team players who used a similar training system. The number of injuries was minimised. This confirms the correctness of the direction we have chosen to improve the special training of athletes.

Conclusions. An increase in the activity of the CNS braking systems and muscle RVR, as an urgent adaptive response to intense physical exertion, occurs when BRFSP is activated by extreme influences. The dependence of muscle character and RVR on the functional state of the CNS has been demonstrated. The functional state of the CNS also largely determines the power of BRFSP.

The results of the studies make it possible to substantiate the methods and principles of developing special relaxation training aimed at increasing the effectiveness of the training process. There are known methods for increasing the SPWC of athletes based on increasing the volume of physical activity. They are effective for achieving the main goal, but do not ensure the preservation of athletes' health. With an increase in the volume and intensity of loads, sports injuries and morbidity increase.

There are known ways to improve health, where moderate physical activity plays a healing role. This does not contribute to the progress of sports results. It is necessary to find new ways to solve these complex and almost incompatible problems – achieving the highest levels of SPWC and preserving the health of athletes, which we have combined into one problem – increasing the effectiveness of motor activity.

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