The impact of intermittent normobaric hypoxia-hypoxic training on the blood and biochemical parameters of an athlete

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Abstract

Objective of the study was to assess the impact of intermittent hypoxia-hypoxic training on the biochemical and hematological characteristics of an athlete.

Methods and structure of the study. The research involved a group of ten male athletes aged 16 to 17, who were swimmers and had achieved the level of first-category sports and were candidates for master of sports. The athletes were in the preparatory phase of their training.

All participants underwent a series of interval normobaric hypoxia-hypoxic training sessions using the OXYTERRA device, a Russian-made device. The training protocol consisted of five cycles, each cycle consisting of five minutes of hypoxia (oxygen concentration of 13%) followed by three minutes of hyperoxia (oxygen concentration of 32%).

Results and conclusions. It has been confirmed that of interval normobaric hypoxia-hypoxic training results in a rise in hemoglobin levels following a series of treatments for athletes who engage in swimming. The analysis revealed statistically significant variations in lactate dehydrogenase activity before and after the treatment cycle, indicating an enhancement in the delivery of oxygen to tissues and an activation of recovery processes in athletes.

Keywords: *interval hypoxic-hyperoxic training, athletes, hemoglobin, creatine kinase, lactate dehydrogenase.*

Introduction. In clinical practice, interval hypoxic-hyperoxic training (IHHT) at normal atmospheric pressure (normobaric) is widely used, but the use of such therapy to improve recovery processes and the effect on the dynamics of hematological and biochemical markers in athletes has been little studied. All tissues of our body require a constant supply of oxygen at a rate corresponding to changing metabolic needs. The oxygen delivery chain begins in the lungs and ends in the mitochondria, the search for factors that allow regulating and activating the work of each link in the process of restoring the functional state of the body, ensuring an increase and expansion of the athlete's functional reserves is an urgent task of sports medicine. Hypoxia in organs and tissues activates increased pulmonary ventilation, an increase in the minute volume of blood circulation, a decrease in blood pressure, as well as the activation of biochemical reactions at the cellular level aimed at overcoming the lack of oxygen [1]. Hyperoxia, in turn, increases the level of oxyhemoglobin and tissue oxygen saturation, increases the rate of oxygen utilization, namely the intensity of the aerobic pathway of ATP synthesis in mitochondria, increases the rate of calcium transport, increasing the contractile function of muscles [8].

Objective of the study was to assess the impact of intermittent hypoxia-hypoxic training on the biochemical and hematological characteristics of an athlete.

Methods and structure of the study. The scientific experiment involved 10 male athletes, aged 16-17, swimming, 1st sports category and candidates for master of sports, in the preparatory period. The training sessions were held as usual 10-11 times a week for 1.5-2 hours. All athletes underwent interval normobaric hypoxic-hyperoxic training according to the standard protocol: 5 cycles, including 5 minutes of hypoxia (oxygen concentration 13%) and 3 minutes of hyperoxia (oxygen concentration 32%). There were 2-3 training sessions per week, 10 training sessions in total. Interval normobaric hypoxic-hyperoxic training was performed using the OXYTERRA device, Russia. Venous blood was collected before the IHGT procedure, after 1 training session, and after the interval normobaric hypoxic-hyperoxic training course. Biochemical parameters were determined in blood serum using vacuum tubes with a coagulation activator. The serum was obtained by centrifugation at 10 000 rpm for 15 minutes on a Mindray 800 automatic biochemical analyzer (China) using calibrators and control materials from the manufacturer. The dynamics of the following biochemical parameters were determined: lactate dehydrogenase (LDH) and creatine phosphokinase (CPK) activity; concentration of total protein, urea, creatinine, cholesterol and triglycerides; level of iron, phosphorus, calcium in the blood serum. Clinical blood analysis was performed in whole venous blood taken on a Mindray BC-6800 Plus automatic hematology analyzer; the number of erythrocytes, leukocytes, platelets, hemoglobin, hematocrit volume, erythrocyte indices, the number of reticulocytes and the content of hemoglobin in a reticulocyte (RHE) were determined.

Results of the study and discussion. According to the clinical blood test, no parameters exceeding the reference value limits were detected before and after interval normobaric hypoxic-hyperoxic training (Table 1).

Initially, the clinical blood test parameters did not exceed the reference values. After 1 training session,

Table 1. Results of clinical blood analysis for the entire observation period

Indicators	Group 1 (Before) M±SD (min;max)	Group 2 (1 procedure) M±SD (min;max)	Group 3 (10 procedures) M±SD (min;max)	p
Erythrocytes, 10^12/l	4,8± 0,25 (4,5;5,2)	4,8 ±0,27 (4,4;5,3)	4,96 ±0,3 (4,6;5,7)	p>0,05
Hemoglobin, g/l	145 ±6 (137;152)	148 ±5 (140;157)	153 ±5 (146;164)	$p_{1,3}$=**0,01**
Hematocrit, %	43,7 ±1,6 (41,7;46,3)	43,1± 1,7 (41;45,8)	44 ±2 (41,5;48)	p>0,05
MCV, fl	90,2 ±2,7 (84,7;94,6)	89,5 ±2,5 (84,6;93,4)	89,9± 2,6 (84,2;94)	p>0,05
MCH, pg	30,5± 1,2 (27,9;32,1)	30,5±0,9 (28,7;31,6)	30,6 ± 0,9 (28,7;31,5)	p>0,05
MCHC, g/l	339 ± 8 (330;355)	341± 7 (330;353)	340 ±4 (334;349)	p>0,05
RDW, %	13 ±0,6 (12,2;14)	12,9 ±0,6 (12;13,7)	12,9 ±0,5 (12;13,5)	p>0,05
Reticulocytes, 10^12/l	0,07± 0,02 (0,05;0,12)	0,07± 0,01 (0,05;0,11)	0,07 ±0,02 (0,06;0,12)	p>0,05
RHE, pg	29,6 ±1,6 (25,3;30)	29,6 ±1,6 (25;31)	30 ±0,7 (28;31)	p>0,05
Platelets, 10^9/l	259 ±40 (213;319)	258± 32 (219;307)	262 ±44 (211;319)	p>0,05
Leukocytes, 10^9/l	5,1±0,7 (3,6;6)	5,7± 1,3 (3,9;8,6)	5,3±0,7 (4,6;6,5)	p>0,05
Neutrophils, %	51,2±7 (41,8;62)	57,3± 11 (41;78)	48± 17 (37;58)	p>0,05
Lymphocytes, %	36,3± 6,2 (29,1;45,5)	32,6 ±9,4 (14;49)	34,5± 4,2 (29;44)	p>0,05
Monocytes, %	8,5± 0,9 (7,1;10,4)	7,2 ±1,1 (5,5;9,2)	8,5±0,85 (7;9,6)	p>0,05

no statistically significant differences were found. After 10 procedures, a statistically significant difference in hemoglobin concentration was noted and amounted to 153±5 g/l (p=0,01).

The biochemical blood test data are presented in Table 2.

Most of the parameters before training did not exceed the reference limits. Creatine phosphokinase activity before training was increased and amounted to 254±203 (min58; max750) U/L. No statistically significant differences were found after 1 procedure. After 10 procedures, a statistically significant difference was noted in the serum iron content and amounted to 16±6 μmol/L (p=0,01) and lactate dehydrogenase activity – 152±31 U/L (p=0,04). A tendency towards a decrease in creatine phosphokinase activity was revealed – 154±62 U/L (p>0,05). Our study has shown for the first time an increase in hemoglobin concentration after a course of interval normobaric hypoxic-hyperoxic training in swimmers (p=0.01). This is due to the activation of hematopoiesis under the influence of alternating hypo- and hyperoxia [4, 6, 7]. But the activation was smooth, since no increase in the number of erythrocytes and reticulocytes was noted.

The study observed a decrease in the content of serum iron in athletes after the end of the cycle of procedures (p = 0.01), but within the reference values. Thus, no iron deficiency was detected, in addition, the hemoglobin content in reticulocytes (RHE) was within the normal range, which indicates the safety and physiological nature of such a decrease and proves the effectiveness of normobaric hypoxic-hyperoxic training.

In the biochemical blood test, an assessment was made of a group of markers of muscle damage induced by regular intense physical activity. These markers include urea, creatinine, CPK, LDH. The average value of urea and creatinine both before and after the therapy were within the reference values, which indicates that the athletes received adequate physical activity. No effect of the interval normobaric hypoxic-hyperoxic training on these parameters was noted. The average value of creatine kinase activity exceeded the reference level for the entire observation period. Since the generally accepted clinical norms of enzyme activity were developed without taking into account the effect of physical activity, therefore, the increased average data on the marker level obtained in our study can

Table 2. Results of biochemical blood analysis for the entire observation period

Indicators	Group 1 (Before) M±SD (min;max)	Group 2 (1 procedure) M±SD (min;max)	Group 3 (10 procedures) M±SD (min;max)	p
Total protein, g/l	71,2 ±3,9 (64;77)	71,6 ±4,9 (65;77)	69,8 ±3 (65;73)	p> 0,05
Urea, mmol/l	5,4 ±1,3 (3,6;7,6)	4,9 ±1,02 (3,8;7,1)	5,2 ±0,7 (3,8;6,3)	p>0,05
Creatinine, μmol/l	94 ±18 (72;122)	94± 22 (60;125)	90 ±17 (60;115)	p>0,05
CPK, U/L	254 ±203 (58;750)	319 ±286 (57;914)	154± 62 (75;240)	p>0,05
Cholesterol, mmol/l	3,8 ±1,6 (2,45;6)	4,1 ±1,2 (2,9;6,4)	4,1 ±1,2 (2,7;6,4)	p>0,05
Triglycerides, mmol/l	1 ±0,6 (0,4;2,1)	0,9 ±0,6 (0,3;2,5)	1,4± 0,9 (0,4;2,8)	p>0,05
LDH, U/L	174 ±33 (137;242)	181 ±28 (151;235)	152± 31 (110;216)	$p_{1,3}$ = **0,04**
Iron, μmol/l	22±5 (16;35)	20± 5 (14;32)	16 ±6 (8;31)	$p_{1,3}$ = **0,01**
Phosphorus, mmol/l	1,3 ±0,2 (0,9;1,6)	1,1 ±0,2 (0,9;1,6)	1,5 ±0,08 (1,4;1,6)	p>0,05
Calcium, mmol/l	2,5± 0,09 (2,4;2,7)	2,56 ±0,1 (2,4;2,7)	2,62± 0,05 (2,5;2,7)	p>0,05

be considered an adaptive response of the athlete's body to the load [2, 5]. After the cycle of procedures, a tendency towards a decrease in enzyme activity in the blood was noted, which indicates an improvement in recovery processes under the influence of interval normobaric hypoxic-hyperoxic training. The study obtained statistically significant differences in LDH activity before and after the cycle of procedures, which shows an improvement in blood supply and oxygen delivery to tissues, as well as activation of recovery processes in athletes under the influence of interval normobaric hypoxic-hyperoxic training [3].

Conclusions. Inclusion of interval normobaric hypoxic-hyperoxic training in courses into the training process leads to acceleration of recovery processes and better tolerance of constantly increasing physical loads. To assess the effectiveness of the interval normobaric hypoxic-hyperoxic training program, the clinical significance of determining the dynamics of hemoglobin, serum iron, creatine phosphokinase and lactate dehydrogenase in the blood is shown.

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