Seasonal dynamics of indicators of metabolism and oxygen transport system of blood of athletes-skiers of Khanty-Mansiysk

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Postgraduate student **A.S. Stepanov**[1]
PhD **A.E. Gubina**[1]
Dr. Med., Associate Professor **An.P. Koinosov**[1]
PhD, Associate Professor **D.A. Pogonyshev**[2]
[1]Khanty-Mansiysk state medical academy, Khanty-Mansiysk
[2]Nizhnevartovsk State University, Nizhnevartovsk

Corresponding author: ap.koynosov@hmgma.ru

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Abstract

Objective of the study was to evaluate seasonal changes in the parameters of metabolism, blood oxygen transport system and physical performance of athletes specializing in cross-country skiing and biathlon in the conditions of Khanty-Mansiysk.

Methods and structure of the study. The study involved young skiers and biathletes, a total of 21 people, of high sports qualification. The age of the surveyed was 17-21 years. The examination was carried out in two stages - May-June ("Spring"), October-November ("Autumn") and included a laboratory blood test (biochemical and general clinical analysis), determination of physical performance and vital capacity of the lungs, bioimpedance analysis of body composition.

Results and conclusions. Data analysis showed statistically significant seasonal differences in a number of indicators: changes in the level of aspartate aminotransferase, total and direct bilirubin, creatinine, cortisol, erythrocyte count, hematocrit, hemoglobin saturation of erythrocytes, the relative value of maximum oxygen consumption, the content of the fat component in the body, body mass index. The revealed shifts in important systems (oxygen transport, endocrine, enzyme) reflect the adaptation of metabolic processes to the action of changing natural and climatic factors and physical loads, and can be used in organizing the training process for athletes from the northern region.

Keywords: *athlete, adaptation, anabolism, seasonal rhythms, hypoxia, erythrocytes, physical performance.*

Introduction. The training of athletes in the conditions of the North is associated with the impact on the body of natural and climatic factors that affect the course of physiological processes [1,2, 3]. Seasonal rhythms of changes in the course of metabolic processes are consistent with the ambient temperature and light regime [4]. Of considerable interest is the study of the metabolic profile in different periods of the year in athletes training outdoors and subject to a significant influence of environmental factors. Pronounced changes in the cardiovascular system, hematopoietic apparatus, external respiration and gas exchange determine the interest of specialists in the field of sports in hypoxia [2]. The possible use of natural conditions for the purpose of hypoxic training determines the expediency of studying this problem.

Objective of the study was to evaluate seasonal changes in the parameters of metabolism, blood oxygen transport system and physical performance of athletes specializing in cross-country skiing and biathlon in the conditions of Khanty-Mansiysk.

Methods and structure of the study. The study involved young skiers and biathletes, a total of 21 people, of high sports qualification. The age of the surveyed was 17-21 years old, the sports experience was 5-12 years, and the northern experience was more than three years. The examination was carried out in two stages - May-June ("Spring"), October-November ("Autumn") and included a laboratory blood test (biochemical and general clinical analysis), determination of physical performance and vital capacity of the lungs, bioimpedance analysis of body composition.

Statistical data analysis was performed using the IBM SPSS Statistics 26 software package. The Wilcoxon test was used to compare related samples. A value of $p < 0.05$ (95%) was taken as the critical level of significance. The results of nonparametric data processing methods were presented as median (Me), first (Q1) and third (Q3) quartiles.

Results of the study and their discussion. Analysis of the obtained biochemical parameters demonstrates significant seasonal changes in a number of values. A statistically significant (p=0.027) decrease in the level of aspartate aminotransferase (AST) was revealed during the "Autumn" period; increase in total (p=0.002) and direct bilirubin (p=0.004), creatinine (p=0.007), cortisol (p=0.002), vitamin D (p=0.0001) in the same period. We also calculated a number of diagnostically important indices: De Ritis coefficient (AST/ALT), muscle tissue damage index (CPK/AST), anabolism index (testosterone/cortisol*100%). According to the results of the analysis, statistically significant seasonal changes in the De Ritis coefficient (p = 0.005) were revealed, this indicator increases during the "Autumn" period (Table 1).

Intense physical activity increases the activity of transaminases in the blood. The AST/ALT coefficient calculated by us makes it possible to judge the absence of signs of liver damage in athletes. The increase in AST activity in the blood is a reflection of the increase in heart function during physical activity during the "Spring" period.

An increase in the content of bilirubin due to the non-conjugated fraction with a slight increase in the level of bound pigment in the "Autumn" period is due to increased destruction of erythrocytes due to intensive training at the pre-competitive stage of preparation.

The data obtained make it possible to judge the predominance of catabolism processes in the "Autumn" period, as evidenced by a significant increase in the level of cortisol (p=0.002), lower values of the anabolism index.

The analysis of the indicators of the oxygen transport system of the blood revealed their significant seasonal changes in the study group. A statistically significant decrease in the number of erythrocytes (p=0.003), hematocrit (p=0.001) was found in the "Autumn" period. At the same time, the average content of hemoglobin in an erythrocyte (p=0.002) and the level of saturation of erythrocytes with hemoglobin (p=0.0001) in the spring period were lower than in autumn. No statistically significant seasonal changes in hemoglobin levels were found (Table 2).

Seasonal restructuring of erythropoiesis activity is a time-delayed process, with a gradual change in red blood parameters depending on the intensity and duration of exposure to environmental factors [3]. Taking into account the life span of erythrocytes of 90-120 days, the decrease in the indicators of the oxygen transport system of the blood by the period "Autumn", in our opinion, is associated with a decrease in the

Table 1. *Seasonal dynamics of some biochemical parameters of young athletes, Me (Q1–Q3)*

Index	«Spring» (n=21)	«Autumn» (n=21)	p
ALT, U/l	17,00 (13,60-23,20)	23,50 (16,10-26,60)	0,052
AST, U/l	31,60 (27,95-41,05)	27,90 (21,05-32,15)	**0,027***
AST/ALT, c.u.	1,85 (1,39-2,15)	1,13 (0,93-1,72)	**0,006***
Bilirubin total, mmol/l	10,50 (7,70-15,95)	16,80 (14,10-19,70)	**0,002***
Bilirubin direct, mmol/l	0,21 (0,10-0,25)	0,29 (0,21-0,37)	**0,004***
Urea, mmol/l	6,04 (5,65-7,25)	6,11 (5,50-6,53)	0,322
Creatinine, µmol/l	80,10 (74,70-90,10)	94,90 (82,75-109,85)	**0,007***
CPK, mmol/l	152,00 (79,70-246,90)	180,50 (118,90-258,10)	0,274
CPK/AST, c.u.	5,33 (2,88-7,04)	7,28 (6,01-10,00)	0,092
CK-MV, mmol/l	13,60 (9,65-22,15)	13,60 (10,70-16,30)	0,614
Total protein, g/l	72,00 (69,50-74,50)	70,00 (67,50-72,50)	0,056
Cortisol, ng/ml	307,80 (257,42-366,55)	363,90 (339,20-385,80)	**0,002***
Testosterone total, ng/ml	8,24 (6,47-10,74)	8,26 (5,64-10,92)	0,985
Anabolism index, %	2,46 (2,20-3,38)	1,99 (1,54-2,70)	0,079
Vitamin-D, ng/ml	14,05 (12,20-24,45)	26,21 (19,76-28,84)	**0,0001***

Note: the comparison of related samples was carried out by the nonparametric Wilcoxon test; differences are significant at p<0.05.*

Table 2. *Seasonal dynamics of indicators of the oxygen transport system of the blood and erythrocyte indices of male athletes, Me (Q1–Q3)*

Index	«Spring» (n=21)	«Autumn» (n=21)	p
Erythrocytes, 1012/l	5,38 (5,22-5,71)	5,24 (5,16-5,45)	0,003*
Hemoglobin, g/l	157,00 (148,00-165,00)	157,00 (151,50-160,50)	0,304
Hematocrit, %	48,14 (45,70-51,06)	46,61 (45,11-47,81)	0,001*
Average erythrocyte volume, fl	89,00 (85,50-91,00)	88,00 (85,50-91,50)	0,211
Average content of hemoglobin in an erythrocyte, pg	28,70 (27,80-29,45)	29,80 (28,50-30,70)	0,002*
Level of saturation of erythrocytes with hemoglobin, g/l	324,00 (318,50-329,00)	336,00 (330,00-338,50)	0,0001*

Note: the comparison of related samples was carried out by the nonparametric Wilcoxon test; differences are significant at p<0.05.*

Table 3. *Seasonal dynamics of indicators of physical performance, maximum oxygen consumption, lung capacity of young athletes, Me (Q1–Q3)*

Index	«Spring» (n=21)	«Autumn» (n=21)	p
Maximum oxygen consumption, ml/min/kg	56,00(53,80-60,30)	60,00(56,95-61,45)	0,019*
Maximum oxygen consumption, ml/min	4026,00 (3639,50-4267,00)	4085,00 (3766,50-4332,00)	0,140
Maximum load, metabolic equivalent (METS)	17,20(16,6-20,0)	17,30(17,1-19,3)	0,468
Oxygen pulse, ml, (absolute MOC/HR)	20,50(18,20-22,10)	20,40(18,35-21,85)	0,154
Aerobic threshold reached at heart rate, bpm/minute	141,00(129,00-150,00)	139,00(114,50-149,50)	0,984
VC, l	5,67(5,38-6,23)	5,78(5,31-6,04)	0,092

Note: the comparison of related samples was carried out by the nonparametric Wilcoxon test; differences are significant at p<0.05.*

Table 4. *Seasonal dynamics of indicators of basic metabolism and body composition of young athletes, Me (Q1–Q3)*

Index	«Spring» (n=21)	«Autumn» (n=21)	p
Basal metabolic rate, kcal	1784,00 (1656,00-1844,00)	1774,00 (1670,50-1861,00)	0,940
Mass of skeletal muscles, kg	37,40(34,10-39,00)	37,20(34,15-39,40)	0,444
The content of the fat component, kg	6,40(4,75-8,40)	5,20(3,05-7,10)	0,001*
Lean mass, kg	61,70(56,70-64,65)	61,40(56,75-65,10)	0,232
BMI, kg/m^2	22,20(20,85-23,25)	21,60(20,65-22,60)	0,009*

Note: the comparison of related samples was carried out by the nonparametric Wilcoxon test; differences are significant at p<0.05.*

activity of erythropoiesis, observed in the period from April to September, in which the intensity of the effect of low air temperature on metabolic processes was minimal.

In the study group, a statistically significant (p=0.019) increase in the relative values of the IPC was revealed in the "Autumn" period (Table 3). The increase in the relative oxygen consumption of skiers by the period "Autumn" largely reflects the response to the action of training loads, however, the contribution of the seasonal state of physiological systems to the increase in this indicator is also probable.

In the study of seasonal changes in the level of basal metabolism and body composition in male athletes, statistically significant differences in the content of the fat component (p=0.001) and BMI (p=0.009) were revealed, an increase in these indicators was noted during the "Spring" period.

Conclusions. Specific natural and climatic conditions cause seasonal restructuring of the work of physiological and enzyme systems and affect the course of metabolic processes.

For athletes whose training takes place in the conditions of the northern region, seasonal changes in the parameters of the oxygen transport system of the blood are typical. Hypoxia, as a result of the use of certain natural conditions, in our case, typical for the city of Khanty-Mansiysk in the autumn-winter period, causes shifts in important physiological systems (oxygen transport, endocrine, enzyme) close to mountain training, which is undoubtedly important when organization of the training process for skiers and biathletes.

When planning the correction of the metabolic profile of athletes training in the conditions of Khanty-Mansiysk, it is advisable to schedule it for September and October (the basic period of preparation), thereby ensuring a long duration of adaptation to the tendency of predominance of catabolism processes in the “Autumn” period.

To plan the greatest volume of training loads, preference should be given to the period of late summer and early autumn.

Using the effect of natural conditions (climatic) and their influence on physiological systems and metabolic processes can help ensure the preservation of increased functional capabilities of athletes for a long time.

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