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Rapid Communication

Performance of Young Athletes

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Abstract

The purpose of the study is to study the relationship between biomarkers of cellular energy exchange and the performance of young athletes.

Research Methods: The examination included children from 12 to 18 years old. The main group was divided into two subgroups depending on the nature of the training load - representatives of cyclic (46) and game (48) sports. The control group consisted of 37 children, engaged only in physical education at school. Special research methods: tandem chromatography-mass spectrometry and cardiorespiratory stress testing.

Results: In the studied groups revealed significant differences in the indicators of cellular energy, as well as in performance data. It was found that the carnitine content and maximum oxygen consumption are significantly higher among athletes of cyclic sports compared to playing sports (at $p < 0.001$). More effective functioning of cellular energy and a high level of performance in athletes with a predominance of aerobic exercise have been proven. With a comprehensive study of the energy status of young athletes, it is possible to predict the level of physical performance. The contribution of the level of free carnitine to the variance of the absolute MIC indicator is 20.9%.

Keywords: Young Athletes; Carnitine Metabolism; Physical Performance

Introduction

A feature of youth sports is the need to ensure harmonious physical development of a child engaged in intense physical activity, which is associated with the anatomical and physiological characteristics of the body at different age periods. When constructing training and competitive processes, it is first of all necessary to remember about maintaining the health of a young athlete. In this regard, the biomedical aspects of physical education and sports come to the fore [1,2]. The development of the preventive orientation in medicine in general, and in pediatrics, in particular, as well as medical "mitochondriology" has allowed the creation of effective diagnostic tools (clinical, biochemical, morphological and molecular genetic criteria for mitochondrial insufficiency). This allows us to assess the polysystemic disorders of cellular energy exchange.

Tissue hypoxia, as well as biochemical and structural changes resulting from its effect, lead to the death of mitochondria, can limit working capacity, lead to the development of fatigue and a sharp deterioration in the state of the body with intense physical exertion [3,4]. Under hypoxia, the metabolism of fatty acids changes, which is characterized by a violation of their beta oxidation. This process is associated with a decrease in carnitine levels, as a result of which intracellular accumulation of intermediate metabolic products of fatty acids, acyl carnitines, and acyl-CoA occurs. Carnitine is a substance that is necessary for conducting metabolic processes in the cell and maintaining tissue safety and plays the role of a transporter of long chain fatty acids through the inner mitochondrial membrane with the participation of a special enzyme system. In this regard, the issue of studying the properties of carnitine during intense physical activity is widely discussed in sports medicine. It was at this time that the features of the transport of fatty acids into the mitochondrial matrix and the maintenance of the ratio of acetyl-CoA/CoA in the cell by carnitine became relevant. Carnitine is able to prevent the accumulation of lactic acid in skeletal muscle, which is the main cause of fatigue. Due to a sufficient amount of free carnitine and increased activity of the respiratory chain in the muscles, aerobic energy production and performance increase [5]. Due to cellular changes in response to physical activity, a comprehensive study is needed to diagnose energy-deficient conditions. This approach necessitates the use of various research methods, both at the level of the organism as a whole and at the cellular level [6,7].

The aim of our study is to study the relationship between indicators of cellular energy exchange and the physical performance of young athletes.

Objects and Research Methods

The study was carried out at Kazan State Medical University. The research materials were subjected to statistical processing using the methods of parametric and non-parametric analysis in accordance with the results of checking the compared sets for the normality of distribution. The accumulation, adjustment, systematization of the initial information and visualization of the obtained results were carried out in Microsoft Office Excel 2007 spreadsheets. Statistical analysis was performed using the IBM SPSS Statistics 20. The statistical significance of differences between groups in the case of multiple comparisons was estimated using one-way analysis of variance by calculating criterion F Fisher. The obtained values are given in the form M ± m, where M is the average value, m is the average error of the average value.

The study included 94 children aged 12 to 18 years, 29 of whom have been intensively involved in sports for at least 12 hours a week

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Table 1: Comparison of carnitine metabolism in the study groups depending on the type of physical activity*.

Carnitine metabolism	Study group			F	p
	Game sports	Cycling sports	Control group		
Free carnitine (C0), mcmol/L	29,9 ± 1,0	36,3 ± 0,8	32,0 ± 1,0	13,9	<0,001
Bound carnitine (AK), μmol/L	16,0 ± 0,7	16,3 ± 0,7	14,3 ± 0,5	1,7	>0,05
AK/C0	0,54 ± 0,02	0,46 ± 0,02	0,46 ± 0,02	4,9	<0,01

*F - Fisher test; p is the certain probability of an error-free forecast of the statistical significance of differences between groups; M ± m, where M is the average value, m is the average error of the average value

(3 or more times a week) for the last 6 or more months. The main group of children - young athletes was divided into two subgroups depending on the type of physical activity - 46 representatives of cyclic (average age 17 ± 0.42 years) and 48 representatives of playing sports (average age 16.21 ± 0.29 years) [8]. Sports qualifications of the athletes included in the study: I adult rank (22 children), candidate for master of sports (50 children), master of sports (22 athletes). 37 children were included in the control group - boys with low motor activity, engaged in physical education only as part of the school curriculum. At the time of the study, children did not have acute infectious diseases.

To establish the features of cellular energy exchange, the tandem chromatography-mass spectrometry method was used, implemented on the basis of the laboratory of molecular and biochemical diagnostics of the Scientific Research Clinical Institute of Pediatrics, Russian National Research Medical University N.I. Pirogova using spectrometers from Agilent, USA. As a material for the study, a capillary blood sample is taken on a special filter paper, which is dried at room temperature. Then, after a standard preanalytical procedure, the dried drop of blood is directly subjected to spectrometry. After analysis for each sample, an individual report is compiled containing the test substances. The advantage of this technique is the maximum automation of the analysis.

The level of Maximum Oxygen Consumption (MIC) was used as an indicator of the physical performance of young athletes. The MPC index will be determined using cardiorespiratory stress testing using a bicycle ergometer and an automatic analyzer of expired air in the laboratory of the Department of Natural Scientific and Biomedical Disciplines of the Volga State Academy of Physical Culture, Sports and Tourism. During cardiorespiratory stress testing, loads with stepwise increasing power “to failure” were used on an eBike bicycle ergometer, Germany. Directly to determine the maximum oxygen consumption during tests, an exhaled air is analyzed using an automatic gas analyzer ADInstruments “PowerLab” RTK 14. The advantage of automatic analyzers is the ability to continuously record oxygen concentration both at rest, during loading and during a recovery period.

Research results and discussion [9]. During the study of the state of carnitine metabolism, as an indicator of cellular energy, we obtained and analyzed the following main parameters: the level of free carnitine and bound carnitine, as well as their ratio. Statistically significant differences in the studied groups are proved using the Fisher test. Our results are presented in Table 1.

Of differences between groups; M ± m, where M is the average value, m is the average error of the average value based on the results obtained, when comparing the content of free carnitine in children depending on the type of sports load, it was found that this indicator has statistically significant differences between the groups (Fisher’s criterion F was 13.9; p <0.001). When applying the posterior criterion according to the Tukey method, the content of free carnitine was significantly higher in athletes involved in cyclic loads, compared with both representatives of the game species (p <0.001) and the control group (p <0.01). The revealed differences may indicate the presence of more efficient cellular energy in representatives of cyclic loads. When comparing the level of bound carnitine in all three groups, there were no statistically significant differences (F=1.7; p> 0.05).

Table 2: Comparison of absolute BMD (l/min) and relative BMD (ml/kg/min) depending on the type of physical activity.

Type of load	Absolute BMD		Relative BMD	
	Boys	Girls	Boys	Girls
Game sports	н/д	2,17 ± 0,07	н/д	38,4 ± 1,0
Cycling sports	4,06 ± 0,14	2,57 ± 0,03	60,4 ± 1,3	44,9 ± 1,9
Control group	2,68 ± 0,08	н/д	40,0 ± 2,8	н/д

We found significant differences between the AK/C0 values measured in the compared groups (F=4.9; p <0.01). Pairwise comparisons of the index values allowed us to detect statistically significant differences in the level of AK/C0 when comparing representatives of sports games with representatives of cyclic species (p <0.05) and with a control group (p <0.05).

When examining the state of physical performance by examining the level of maximum oxygen consumption, statistically significant differences were also found in representatives of different sports depending on the type of physical activity. The obtained data on the state of the absolute and relative (taking into account body weight) IPC are presented in Table 2.

The revealed differences may indicate the presence of more efficient cellular energy and high performance among representatives of aerobic exercise. According to the results obtained, the differences in both absolute and relative BMD between the compared groups were statistically significant (p <0.001). When comparing the absolute indicator of the IPC between groups, it was found that in boys - representatives of cyclic sports, the level of IPC is higher than in representatives of game types and control groups at p <0.001. When studying the relative indicator of the IPC, calculated depending on body weight, similar patterns were established. The data obtained by us are related to the specifics of the exercise performed mainly by aerobic swimmers, as well as gender differences in the studied groups. It is known that the formation of the energy supply system occurs at different age periods, depending on gender. Thus, the absolute indicators of BMD in boys reaches its maximum values at the age of 15 years [10]. A high level of IPC is one of the prerequisites for an athlete (especially a representative of cyclic sports) to achieve high results, as it characterizes the state of endurance of an athlete, but does not guarantee them. The athlete's performance is primarily determined by the maximum oxygen consumption rate. The higher the BMD, the greater the absolute power of the maximum aerobic load. In addition, the higher the IPC, the relatively easier and therefore the longer the performance of aerobic work. At the same time, for the representatives of game sports, the IPC is not a limiting factor for achieving results. Game sports require tactical, technical, high-speed qualities from an athlete.

We compared the levels of absolute and relative BMD and the level of free carnitine. The study revealed significant reliable correlation between the studied parameters. So, the dependence of the absolute BMD on the content of free carnitine is described by the regression equation (1):

YMPK (a) = 1.01 + 0.05 * XC0, (1)

Where YMPK (a) is the absolute MPC (l/min), XC0 is the content of free carnitine (μmol/l).

The correlation coefficient of the two indicators characterizing this relationship was 0.46, which on the Cheddock scale corresponds to a moderate tightness of the relationship between the indicators. It was found that the contribution of the level of free carnitine to the variance of the absolute MIC indicator is 20.9%. The level of statistical significance of the revealed correlation correlates with $p < 0.01$. Thus, it becomes possible to predict the level of absolute maximum oxygen consumption depending on the level of free carnitine.

Findings

- The level of free carnitine is higher in young athletes involved in cyclic sports compared to representatives of playing sports, with $p < 0.001$, which indicates a more efficient cellular energy in children of the first subgroup.

- The indicators of both absolute and relative maximum oxygen consumption are higher among representatives of cyclic sports (with $p < 0.001$). The data obtained indicate a higher physical performance among representatives of cyclic sports.

- There is a positive correlation between the level of free carnitine and the absolute maximum oxygen consumption, the correlation coefficient is 0.46. A regression model has also been compiled characterizing the relationship between the two indicators.

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