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DIAGNOSTICS OF BIOCHEMICAL INDICATORS OF PHYSICAL FITNESS OF ATHLETES

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Abstract

The study presents an analysis and synthesis of scientific literature data on the use of biochemical indicators of enzyme activity in athletes. It has been shown that the activity of creatine phosphokinase, aspartate aminotransferase, alanine aminotransferase, and cardiac troponin in blood serum represents one of the most informative markers of the functional state of muscular, cardiac, and hepatic tissues. These parameters are actively used in monitoring the training process and determining the physical load of athletes.

Keywords: laboratory diagnostics, biochemical analysis, heart, muscles, troponins, creatine kinase, enzyme activity, informative markers of functional state.

Introduction. Modern sports require strict attention to the functional preparedness of athletes, since their bodies undergo physiological changes that affect the quantitative composition of metabolites, in the regulation of which enzymes play a crucial role. The determination of enzyme activity in blood serum is widely used not only to analyze the training process and evaluate the adaptive capacity of athletes' bodies to intense physical activity, but also as an informative test for assessing metabolic processes in various organs and tissues. Key criteria for the effective application of these parameters include:

• studying baseline value fluctuations at rest (morning, fasting) depending on sex and age;

• determining the effects of training loads of various types on the body;

• identifying informative indicators of the body's functional state;

• establishing optimal means and methods for improving athletic performance;

• monitoring changes during increasing workload intensity;

• preventing decompensation of physiological functions in athletes [1].

The modern training system is characterized by high intensity and workload levels close to physiological limits, which require adequate and informative methods to control adaptation to strenuous muscular activity. Therefore, biochemical diagnostics, including blood and urine analyses, become highly relevant. This approach allows for an optimal assessment of nutrition, hydration, muscle and cardiovascular condition, detection of inflammation, injury, and metabolic shifts caused by training, as well as efficient control of the training process.

Accurate interpretation of biochemical data and its use for optimizing training load adjustments are critical. Hence, it is advisable to rely on indicators that provide reliable information on the immediate effect of physical exertion and the character and duration of recovery. The evaluation of biochemical enzyme activity in athletes' blood serum after training or competition offers valuable insight into intracellular metabolism [2–3].

Methods. The study presents a comprehensive analysis of biochemical research focused on determining the concentrations of organic substances formed as a result of metabolic reactions in athletes' bodies, and measuring enzyme activity in biological fluids (serum, plasma, blood, urine).

Results. One of the key challenges in sports biochemistry today is establishing reference ranges for highly qualified athletes, whose biological characteristics differ from those of the general population. Two main conceptual approaches to defining reference intervals for laboratory parameters in trained individuals have emerged:

• the first is based on the selection of study groups and appropriate statistical processing of laboratory data;

• the second emphasizes individual interpretation of laboratory results obtained over different time periods [6, 12].

It should be noted that transferring reference values derived from healthy untrained individuals to athletes is inappropriate, as it fails to reflect the physiological processes specific to their bodies.

Screening studies among various athlete groups allow identification of common indicators reflecting adequate physical load during short-term and long-term adaptation processes. These studies demonstrate the need to develop reference ranges taking into account sport type, age, sex, and training stage.

Discussion. High-intensity training characteristic of modern professional sports causes significant changes in numerous blood biochemical parameters, which are crucial for optimizing training regimens. The ongoing search for laboratory biomarkers that accurately reflect metabolic processes under physical load remains a priority. Among the most sensitive indicators are muscle-related biomarkers such as creatine kinase and cardiac troponin.

Troponin I (TnI) measured in blood is the gold standard for diagnosing myocardial infarction and is an absolutely specific marker of cardiac muscle injury. Multiple increases in TnI levels usually indicate acute myocardial infarction, with elevated levels persisting for up to seven days after damage [2, 6]. Literature data indicate that troponin elevation can occur under various conditions involving myocardial stress or damage:

• intensive and prolonged physical exercise;

• increased sarcolemmal permeability leading to troponin release from cardiomyocytes;

• elevated reference levels in athletes, indicating myocardial strain or insufficient adaptation to load;

• predictive significance of post-exercise troponin levels for cardiovascular complications, especially in endurance athletes over 50 years old [7, 9].

Another important indicator in training monitoring is cardiac creatine phosphokinase (CK-MB). The dynamics of CK activity serve as a criterion for assessing short-term and long-term adaptation of endurance athletes to various training intensities. The rate of CK elimination into the bloodstream is individual, and its dynamics may reflect the delayed effect of muscle workload. However, individual variability complicates establishing standardized physiological norms. Notably, CK activity correlates with sex, necessitating reference ranges for male and female athletes [3, 8].

Proper interpretation of CK results depends on the training phase and other influencing factors. CK and its cardiac isoenzyme CK-MB are used for diagnosing muscle tissue and myocardial damage. CK-MB activity helps assess the extent of cardiac injury and the nature of recovery within 24–48 hours.

The upper limit of aspartate aminotransferase (AST) activity in athletes' serum is generally accepted as 40 U/L. In patients with myocardial infarction, cardiac troponins—specific markers of muscle injury—reach diagnostic levels within six hours and remain elevated for 7–14 days, accompanied by an increase in CK-MB. Quantitative assessment of these markers is of particular importance for diagnosing myocardial necrosis in sports medicine. Establishing safe troponin levels in athletes' blood allows for better control of permissible cardiac workloads [2, 6].

Elite athletes typically undergo comprehensive medical examinations depending on their training cycle (preparatory, base, pre-

competition, competition, and recovery stages). Standard laboratory evaluations include red and white blood cell counts, platelet indices, and leukocyte differentials.

When deviations from reference values occur, detailed testing provides a clearer picture of health status, for example:

• elevated eosinophils may indicate steroid use, parasitic infection, or rheumatoid arthritis;

• blood thickening reflected in increased ESR may indicate deficiencies of calcium, vitamin C, or zinc.

Comprehensive biochemical testing provides detailed lipid profiles and data on micro- and macroelement concentrations. Proteins, carbohydrates, fats, iron, sodium, calcium, potassium, phosphorus, and magnesium form the basis for tailoring training intensity. Test selection depends on medical history and athletic goals:

• bilirubin, ALT, AST – liver function;

• creatinine, urea – kidney function;

• amylase, lipase – pancreatic health;

• myoglobin, creatine kinase, troponins – cardiovascular and musculoskeletal markers;

• glucose, total protein, cholesterol – metabolic quality.

Special attention is given to hormone studies to adjust training loads:

• Thyroid-stimulating hormone (TSH) regulates T3 and T4 production, affects water retention, heart rate, and metabolism;

• Testosterone influences fat reduction, endurance, and training efficiency;

• Estradiol deviations affect body composition and metabolic rate;

• Cortisol excess leads to visceral fat accumulation and muscle dystrophy, while deficiency under stress may cause adrenal crisis;

• Gonadotropic hormones (LH/FSH) are important for muscle mass regulation.

Protein metabolism assessment includes:

• total protein – indicator of amino acid exchange and muscle synthesis;

• albumin – regulates water balance and nutrient transport;

• transferrin – reflects iron metabolism and protein nutrition;

• nitrogen balance – shows differences between protein intake and utilization.

Immune status evaluation also plays an important role. Protein deficiency can suppress immune function, which can be monitored through blood tests or skin antigen tests.

Training at all stages involves therapeutic observation and non-invasive assessments: urine tests, ECG, heart rate monitoring, blood pressure measurement, respiratory function, and dynamometry. Anthropometric control is maintained through:

• BMI – body mass index;

• TSF – triceps skinfold thickness to assess muscle-to-fat ratio and protein nutrition.

Conclusion. A comprehensive analysis of literature data identified key factors influencing the quality of biochemical research in sports science. Studying the dynamics of clinical and laboratory parameters measured at rest and after training loads enables objective evaluation of energy systems, load tolerance, and recovery efficiency.

Clinical laboratory diagnostics provide invaluable support to coaches in detecting and preventing overtraining syndrome. Monitoring enzyme activity in the training process helps select optimal exercises of various types and intensities that do not cause destructive effects in muscle tissue.

Biochemical control should be combined with other diagnostic parameters—clinical blood analysis, urea, total serum protein, C-reactive protein, lipid and carbohydrate profiles, and hormone levels. These data allow assessment not only of physiological system status but also of the metabolic response to physical load.

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