CHARACTERISTICS OF INFORMATIVE BIOMARKERS FOR STRENGTH TRAINING IN VOLLEYBALL ATHLETES

CARACTERÍSTICAS DOS BIOMARCADORES INFORMATIVOS PARA TREINAMENTO DE FORÇA NOS ATLETAS DE VOLEIBOL

CARACTERÍSTICAS DE LOS BIOMARCADORES INFORMATIVOS PARA EL ENTRENAMIENTO DE FUERZA EN ATLETAS DE VOLEIBOL

Review Article
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Artículo de Revisión

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ABSTRACT

Introduction: The relevance in studying the characteristics of biochemical markers on the training process of volleyball players is conditioned to the specificity of these parameters for such sport, considering the degree and nature of physical activity mostly in open kinetic chain. Objective: To select the most relevant biomarkers for strength training in volleyball athletes and to verify their consistency with other biochemical status parameters. Methods: A review of the scientific and methodological literature in the field of volleyball training was performed and the biochemicals were tested with statistical-mathematical methods. The optimal set of biochemical markers for an effective control of the training process in open kinetic chain sport was established, which can be used to evaluate the tolerability of training loads in several of its stages. Results: Effective clinical and laboratory tests were determined to solve medical and biological monitoring tasks in the training process. The possibility of using biochemical control data to assess the prospects of a high level of functional status in the pre-competition period was demonstrated. Conclusion: The results obtained can be used as part of the medical and biological support in the training process of volleyball athletes, and can be introduced in national medical and biological subject cycles. ***Evidence level II; Therapeutic studies - outcomes research.***

Keywords: Biomarkers; Volleyball; Physical Functional Performance; Resistance Training.

RESUMO

Introdução: A relevância no estudo das características dos marcadores bioquímicos sobre o processo de treinamento dos jogadores de voleibol está condicionada à especificidade desses parâmetros para tal esporte, considerando o grau e a natureza da atividade física majoritariamente em cadeia cinética aberta. Objetivo: Selecionar os biomarcadores mais relevantes para treinamento de força em atletas de voleibol e verificar a sua consistência com outros parâmetros do status bioquímico. Métodos: Efetuou-se uma análise da literatura científica e metodológica no campo do ensino do voleibol e os bioquímicos foram testados com métodos estatístico-matemáticos. Foi estabelecido o conjunto ideal de marcadores bioquímicos para um controle eficaz do processo de treinamento no esporte de cadeia cinética aberta, que pode ser usado para avaliar a tolerabilidade das cargas de treinamento em várias de suas etapas. Resultados: Foram determinados testes clínicos e laboratoriais eficazes para resolver tarefas de monitoramento médico e biológico no processo de treinamento. Foi demonstrada a possibilidade de utilizar dados de controle bioquímico para avaliar as perspectivas de um alto nível de estado funcional no período pré-competição. Conclusão: Os resultados obtidos podem ser utilizados como parte do suporte médico e biológico no processo de treinamento de atletas de vôlei, podendo ser introduzidos em ciclos de disciplinas médicas e biológicas nacionais. ***Evidência nível II; Estudos terapêuticos – pesquisa de resultados.***

Descritores: *Biomarcadores, Voleibol, Desempenho Físico Funcional; Treinamento de Força.*

RESUMEN

Introducción: La relevancia en el estudio de las características de los marcadores bioquímicos sobre el proceso de entrenamiento de los jugadores de voleibol está condicionada a la especificidad de estos parámetros para dicho deporte, considerando el grado y la naturaleza de la actividad física sobre todo en cadena cinética abierta. Objetivo: Seleccionar los biomarcadores más relevantes para el entrenamiento de fuerza en deportistas de voleibol y verificar su consistencia con otros parámetros del estado bioquímico. Métodos: Se realizó una revisión de la literatura científica y metodológica en el campo del entrenamiento del voleibol y se comprobaron los bioquímicos con métodos estadístico-matemáticos. Se estableció el conjunto ideal de marcadores bioquímicos para un control eficaz del proceso de entrenamiento en el deporte de cadena cinética abierta, que puede utilizarse para evaluar la tolerabilidad de las cargas de entrenamiento en varias de sus etapas. Resultados: Se determinaron pruebas clínicas y de laboratorio eficaces para resolver las tareas de seguimiento médico y biológico en el proceso de formación. Se demostró la posibilidad de utilizar los datos de control bioquímico para evaluar las perspectivas de un alto nivel de estado funcional en el período previo a la competición. Conclusión: Los resultados obtenidos pueden ser utilizados

como parte del apoyo médico y biológico en el proceso de entrenamiento de los atletas de voleibol, y pueden ser introducidos en los ciclos de las disciplinas médicas y biológicas nacionales. ***Nivel de evidencia II; Estudios terapéuticos - investigación de resultados.***

Descriptores: *Biomarcadores; Voleibol; Rendimiento Físico Funcional; Entrenamiento de Fuerza.*

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INTRODUCTION

Currently, the highest requirements are imposed on sports in the international arena. The level of athletes' qualification is constantly increasing, which causes high competition. The quality and methods of the training process require an increasingly sophisticated approach. To improve the level of training, there is an increasing need for enhanced monitoring of biochemical processes in the athlete's body. Volleyball belongs to acyclic sports and is characterised by the speed-strength nature of muscle work. The development of speed and strength abilities requires maximum dedication and, at the same time, rational control of the athlete's condition to prevent overtraining and sports injuries.

A comprehensive examination of the athlete's body is possible using biochemical markers. The structure and volume of biochemical research in professional sports are quite flexible conditioned upon the appearance of the latest research data. In addition, an important role in these changes is played by amendments to the Anti-Doping Code and to the regulation of the volume of biochemical laboratory tests in high-performance sports. One of the important tasks of sports doctors is the correct assessment of the results of clinical and laboratory studies and their effective use in their practical activities, including coaching. The results analysis of biochemical markers allows making a decision on the interruption, termination or correction of the training process, carrying out measures to improve the training environment, the need for medical rehabilitation of athletes. The relevance of this work consists in the selection of key biochemical indicators for assessing the training level and tolerability of physical loads typical of the game "Volleyball", and generalising the experience of the authors-coaches and researchers. Considering the versatility of the load tolerance topic in sports, studies by other authors were included in this work.[1,2]

MATERIALS AND METHODS

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. A study was approved by National Ethics Commission of the Ministry of Health of the People's Republic of China, October 4, 2020, No 2860-A.

The study of the features of biochemical tolerability markers of training loads in volleyball athletes was carried out in four stages:

The analysis of the current regulatory framework for biochemical control in high-level athletes was carried out, biochemical markers relevant to this topic were identified, and also the current approved standards of general physical and special physical training for enrollment in groups at the stage of higher sports mastery in the "Volleyball" were studied.

The mechanism of the game was determined and the characteristics of the main movements were given.

A correlation between the training load in volleyball and biochemical changes in the body of volleyball players was carried out, the energy characteristics of competitive and training activities were given.

A theoretical analysis of existing research in the pedagogical, medical and sports literature was carried out. This stage includes the analysis and statistics of laboratory biochemical studies in a group of volleyball athletes. The most informative biochemical markers for diagnosing the athletes' condition and physical load tolerance are determined, the regularities of recovery and physical exertion are considered.

RESULTS AND DISCUSSION

This paper considers studies of the training process of volleyball athletes with the determination of the relationship with certain biochemical markers for adaptation to sports practice of the diagnostic reliability assessments of the biochemical indicators used to control the training load tolerability.[3-5] Since the biochemical changes caused by training are an adaptation of the body to a certain type of muscle activity, it should be expected that training in various physical exercises should lead to unequal biochemical changes in the body. Stable growth of sports results is ensured by timely monitoring of the state of the athlete's body.[6] A high level of an athlete's speed depends on the content of ATP (adenosine triphosphate) in the muscles. The speed and strength qualities are also affected by the rate of ATP cleavage under the influence of a nerve impulse, and the speed of its resynthesis (Figure 1).

During high-speed exercises, ATP resynthesis occurs almost completely conditioned upon anaerobic reactions (glycolytic and phosphocreatine) (Figure 2).

Muscle activity leads to varying degrees of fatigue. Fatigue is a protective mechanism against physical exertion. The degree of fatigue should be adequate to the training process and be replaced by a rest phase in time to protect the athlete's body from injuries and physical exertion.[7] The recovery process in the training activity of a volleyball player is a necessary stage for achieving high sports results. The reserves of energy substances (glycogen, ATP, creatine phosphate) are depleted in proportion to the degree of fatigue. The amount of these energy substrates provides a kind of work intensity.[8] Fatigue also adds to an accumulation of their metabolic products in the blood (inorganic phosphates, lactic acid, creatine). Therefore, the athlete's physical exertion is controlled by these indicators. A prolonged increase in urea level in the blood after the end of the load, changes in the components of the immune system of the blood, a decrease in the hormones of the sympathoadrenal

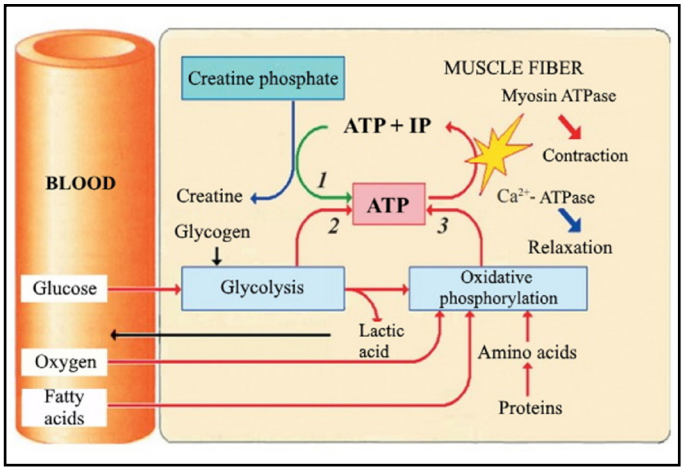

Figure 1. The scheme of energy support for the activity performance: 1, 2, 3 – the processes of ATP resynthesis.

system in the blood and urine diagnoses the development of fatigue and physical exertion. (Figure 3)

The development of lactic acid (lactate), which then enters the athlete's blood, completes the glycolytic mechanism of ATP resynthesis. Lactic acid enters the blood gradually after the end of the physical load and reaches its maximum concentration 3-7 minutes after the end of the load. (Figure 4)

According to U.S. Badykshanov, the norm of lactic acid content in the blood without the presence of loads is 1-1. 5 mmol/l, and its accumulation and development in the muscles increases with short-term intensive physical work and reaches about 30 mmol/kg of weight with physical exertion. The conditional limit of anaerobic metabolism corresponds to

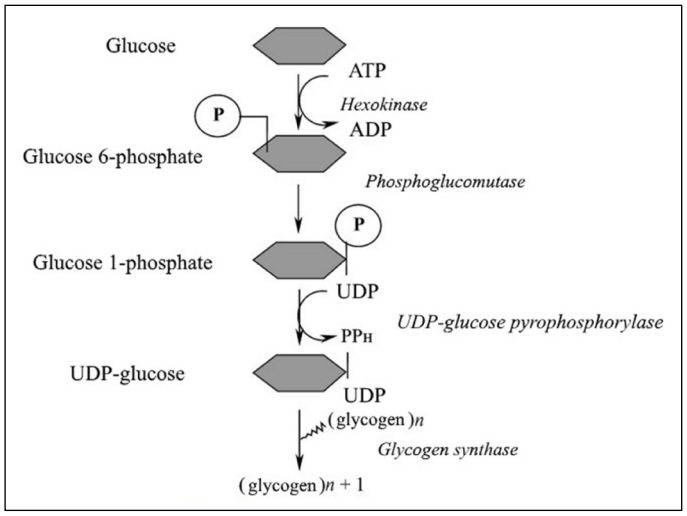

Figure 2. Scheme of glycogen resynthesis.

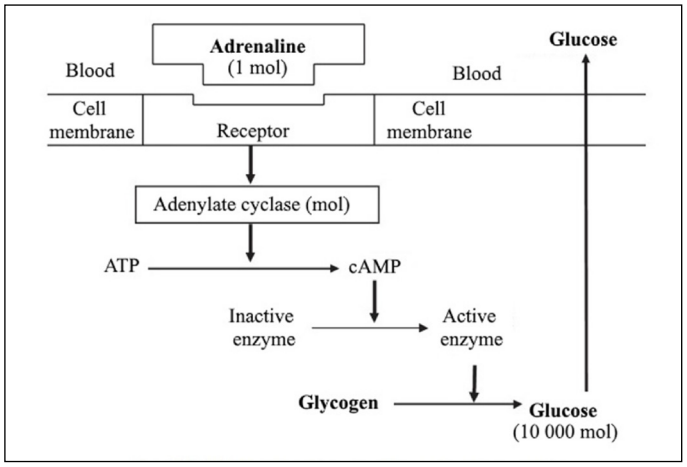

Figure 3. The mechanism of glucose development as a result of signal transmission by adrenaline.

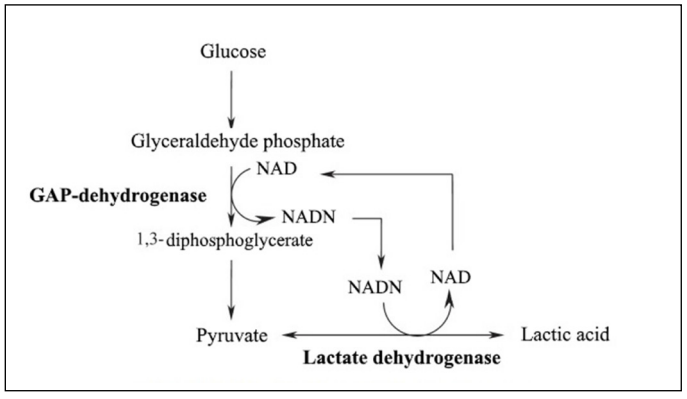

Figure 4. Scheme of lactic acid development.

4 mmol of lactate in 1 litre of blood and is designated as the threshold of anaerobic metabolism (TANM), or the lactate threshold (LT).[9] A high concentration of lactic acid in the blood is a biochemical marker and corresponds to a significant training level, given a good sports result. The level of lactic acid determines the anaerobic glycolytic capabilities of the body and is indicative when selecting athletes, planning the training process and recovery activities. The lactate content should be monitored for each athlete at all training stages. The improvement of the athlete's fitness can be marked by a decrease in the lactate content, and its increase – by a deterioration in physical form. The concentration of free fatty acids in the blood is also a biomarker and reflects the rate of lipolysis of triglycerides in the liver and fat depots. Normally, their content in the blood is 0.1-0.4 mmol/l and increases with prolonged physical loads.[10] This marker reflects the connection degree of lipids to the energy supply processes of muscle activity, including the efficiency of energy systems or the coupling degree between lipid and carbohydrate metabolism, which is an indicator of a high level of athlete's functional training.

E.A. Semenova et al.[2] believe that standard biochemical markers do not have sufficient specificity and are more informative for monitoring an already advanced state of physical exertion and overtraining than for early diagnosis. One of the promising biomarkers that can be used for early diagnosis and prediction of physical exertion and overtraining is DNA circulating in the blood. The nucleic acids circulating in the blood increase significantly after various loads: "at rest, the content of circulating DNA is 1.32-18.01 pkg/mcl, while immediately after physical load, its level reaches 334.4±139.41 pkg/mcl".[2] The appearance of circulating DNA in the bloodstream in high concentration against the background of strenuous prolonged physical loads can be an early sign of the onset of physical exertion and overtraining.

The latest research allows comparing the molecular sport-related mechanisms available to each person by decoding the genome. Genetic markers associated with the development and expression of physical qualities (speed, strength, endurance, agility, flexibility) can be used in the sports selection system to clarify sports specialisation and to optimise the training process. Due to the development of omics technologies, it is now possible to explain the presence and development of certain physical and mental qualities necessary for certain sports and to identify the risks of exposure to many diseases. This diagnostic mechanism is caused by DNA polymorphisms, the heritability of which varies from 30% to 50%.[11] The global international organisation Bioversity International (Italy), which studies genetic diversity, has been recommending genetic analysis using molecular DNA markers since the mid-1990s. Other molecular markers (methyl groups, transcripts, telomeres, circulating DNA, metabolites, etc.), in addition to predicting sports success, allows assessing the current functional state of an athlete, including the overtraining phenomenon.

In this paper, the circulating nucleic acids (circulating DNA) in the blood were considered as omics biochemical tolerability markers of training loads common to representatives of different sports. These indicators are used for the early diagnosis of physical exertion. Genetic omics markers allow predicting success in certain sports and are a separate extensive topic for study. The reader is invited to independently explore this topic explained by its interest. Currently, omics technologies are a relatively young area, so the methods of genomic and postgenomic medicine are not yet included in the standard treatment and diagnostic protocols but are available on a paid basis. Notably, in laboratory practice, there are other studies that allow tracing the reactions of the endocrine system of an athlete to physical loads. Such studies include indicators of tissue hypoxia during physical exertion, indicators of homeostasis

(microcirculation), indicators of peroxidation (assessment of hypoxia and reperfusion of tissues), products of lipid peroxidation.

In addition, the opinion of O. Volodchenko and others[12] on the choice of saliva as a test sample for analyzing the dynamics of the training process is interesting. This method includes information content, accessibility and ease of collection, and security for participants. Indicators of lipid peroxidation and glycolysis (concentration of lactic and pyruvic acids) were determined before and after training. The above-mentioned authors note that there was a significant increase in the activity of lipid peroxidation and lactic acid concentration (by 4 times); the analysis of correlation matrices confirms the absence of pronounced changes. Previously, the assessment of oxidative stress and the level of antioxidant protection was confirmed through measurements in saliva.[13]

F.A. Kadejiani and K.E. Cater[14] note that overtraining syndrome (OTS) and related conditions cause a decrease in the effectiveness of training conditioned by an imbalance between the training volume, nutrition and recovery time. In their research and search for uniform biomarkers of physical exertion, the authors came to the following results. Comparing the muscle, hormonal and inflammatory parameters in athletes suffering from OTS, healthy athletes and people leading a sedentary lifestyle, the authors noted that the metabolism in men with the overtraining syndrome was characterised by an increase in the estradiol level, a decrease in testosterone, an excessive reaction of muscle tissue to physical exertion and changes in the immune system, which also confirms the diversity of a set of biochemical markers for detecting physical load tolerance.

CONCLUSIONS

Determination of biochemical tolerance markers of physical loads allows solving various issues of the training process. Among them is the calculation of an adequate training load based on the data of the obtained indicators, monitoring the processes of the body adaptation to training, diagnostics of pre-pathological and pathological changes in metabolism. In the course of studying this topic and the works of other authors, a conclusion is formed that the physical exertion of a volleyball player is controlled by the following biochemical factors: the accumulation of metabolic products in the blood of such indicators as lactate, creatine, inorganic phosphates. These substances are markers of depletion of adenosine triphosphate (ATP), creatine phosphate and glycogen reserves in tissues conditioned upon maximum and supermaximum physical loads on the athlete's body. In addition, with prolonged exercise and the development of fatigue and physical exertion, the urea level in the blood of volleyball players increases, the components of the immune system change and the adrenaline concentration and its metabolic products in the blood and urine decreases. The recovery of the athlete's body is controlled by the normalisation of metabolites of carbohydrate, lipid and protein metabolism. A marker of lactic acid concentration, an increase in fatty acids and ketone bodies is important for assessing recovery.

The author declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. JZ: is the sole author of this article.

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