CHANGES IN BIOCHEMICAL INDICATORS IN SCIENTIFIC LOAD TRAINING IN TENNIS PLAYERS

ALTERAÇÕES DOS INDICADORES BIOQUÍMICOS NO TREINAMENTO CIENTÍFICO DE CARGA EM JOGADORES DE TÊNIS

CAMBIOS DE LOS INDICADORES BIOQUÍMICOS EN EL ENTRENAMIENTO CIENTÍFICO CON CARGA EN TENISTAS

Original Article
Artigo Original
Artículo Original

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ABSTRACT

Introduction: The level of physical training of tennis players directly affects the performance of competitive and athletic ability of tennis players. The uniqueness of tennis is that it places high demands on athletes' skills, tactics, and fitness. This requires constant monitoring of their biomarkers for real-time control of athletes' health. Objective: Study the impact of scientific methods of load training on tennis players and their changes in biomarkers. Methods: This paper tests tennis players' immune, physiological, and biochemical indices after load training. Results: After training, tennis players' immune, physiological, and biochemical indices show evident differences. Conclusion: Scientific load training helps improve tennis players' physiological and biochemical indices and immune function. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Exercise; Tennis; Athletes; Biomarkers.

RESUMO

Introdução: O nível de treinamento físico dos jogadores de tênis afeta diretamente o desempenho da capacidade competitiva e atlética dos tenistas. A singularidade do tênis é que ele coloca altas exigências nas habilidades, táticas e aptidão física dos atletas. Isto exige um monitoramento constante de seus biomarcadores para controle em tempo real na saúda dos atletas. Objetivo: Estudar o impacto dos métodos científicos de treino com carga em jogadores de tênis e suas alterações nos biomarcadores. Métodos: Este artigo testa os índices imunes dos tenistas e os índices fisiológicos e bioquímicos relacionados após o treinamento com carga. Resultados: Após o treinamento, os índices imunológicos e os índices fisiológicos e bioquímicos correspondentes dos jogadores de tênis apresentam diferenças evidentes em relação aos anteriores. Conclusão: O treinamento científico de carga ajuda a melhorar os índices fisiológicos e bioquímicos e a função imunológica dos jogadores de tênis. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Exercício Físico; Tênis; Atletas; Biomarcadores.*

RESUMEN

Introducción: El nivel de entrenamiento físico de los tenistas afecta directamente al rendimiento de la capacidad competitiva y atlética de los tenistas. La singularidad del tenis es que exige mucho a los deportistas en cuanto a habilidades, táctica y forma física. Esto requiere un seguimiento constante de sus biomarcadores para controlar en tiempo real la salud de los deportistas. Objetivo: Estudiar el impacto de los métodos científicos de entrenamiento de carga en los tenistas y sus cambios en los biomarcadores. Métodos: En este trabajo se analizan los índices inmunológicos de los tenistas y los índices fisiológicos y bioquímicos relacionados tras el entrenamiento con carga. Resultados: Tras el entrenamiento, los índices inmunológicos y los correspondientes índices fisiológicos y bioquímicos de los tenistas muestran diferencias evidentes con respecto a los anteriores. Conclusión: El entrenamiento con carga científica ayuda a mejorar los índices fisiológicos y bioquímicos y la función inmunitaria de los tenistas. **Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.**

Descriptores: *Ejercicio Físico; Tenis; Atletas; Biomarcadores.*

DOI: http://dx.doi.org/10.1590/1517-8692202329012022_0312 Article received on 06/06/2022 accepted on 07/15/2022

INTRODUCTION

Tennis has high requirements for players' skills, tactics, and physical fitness. During heavy training, we need to implement scientific physical monitoring. This allows the coach to know the training and the players well. However, at present, little is known about the changes in athletes' various physiological and biochemical indicators and immune functions before and after heavy-load training.[1] This paper conducts 4-week active monitoring of male tennis players preparing for the National University Tennis Championships during heavy-duty training. Explore the changes in related indicators in this way. The article is expected to provide references for tennis coaches to grasp the physical function of athletes accurately and formulate and adjust training plans.

METHOD

Research object

Eight male tennis players are preparing for the National University Tennis Championships.[2] After the health check, it was found that all the test team members were healthy and had no organic disease, immune history, or genetic history.

Research methods

Training arrangements

The heavy load training is carried out for 4 weeks. After training for 6 days a week, adjust for 1 day. The training volume is slightly increased every Wednesday and Saturday, and the competition is arranged.[3] The training session takes about 3 hours. The content of the training day is arranged in addition to comprehensive special skills training for hitting, serving, and receiving, and special physical training and pace exercises. At the same time, it also includes special training for strength and speed training and skills that highlight physical stamina.

Measurement indicators and methods

We draw 5ml of blood from the elbow vein in a calm state every Monday morning before and after the heavy load training. Immediately use a small amount of whole blood for whole blood cell testing.[4] The rest of the blood samples were centrifuged, and the serum was collected at -20°C to be tested.

Specific measurement indicators: T lymphocyte subsets $CD4^+$ and $CD8^+$ levels, serum immunoglobulin A (IgA), immunoglobulin G (IgG), immunoglobulin M (IgM) levels, hemoglobin (Hb), creatine kinase (CK), blood urea nitrogen (BUN), lactate dehydrogenase (LDH).

Human body weight-bearing lower limbs assisted kinematics simulation

The Z_i axis is the rotation axis of the revolute joint. The direction of X_i the axis is determined by Z_i axis and Z_{i+1} axis. The direction of the Y_i axis is determined by the right-hand rule.[5] Therefore, the moving coordinate system at the hip joint is (x_0, y_0, z_0). The motion coordinate system at the knee joint is (x_1, y_1, z_1). The motion coordinate system at the ankle joint is (x_2, y_2, z_2). The relative pose relationship between each coordinate system can be solved by using the principle of homogeneous transformation.

$$ {}^{i-1}_{i}T = \begin{bmatrix} \cos\theta_i & -\sin\theta_i\cos\alpha & \sin\theta_i\sin\alpha & a\cos\theta_i \\ \sin\theta_i & \cos\theta_i\cos\alpha & -\cos\theta_i\sin\alpha & a\sin\theta_i \\ 0 & \sin\alpha & \cos\alpha & d \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (1) $$

$\alpha_i = 0, d_i = 0, a_1 = l_1, a_2 = l_2$ in the same plane, so the transformation matrix can be obtained:

$$ {}^{0}_{2}T = {}^{0}_{1}T\,{}^{1}_{2}T = \begin{bmatrix} \cos(\theta_1+\theta_2) - \sin(\theta_1+\theta_2) 0 l_1\cos\theta_1 + l_2\cos(\theta_1+\theta_2) \\ \sin(\theta_1+\theta_2) \quad \cos(\theta_1+\theta_2) 0\; l_1\sin\theta_1 + l_2\sin(\theta_1+\theta_2) \\ 0 \quad 0 \quad 1 \quad 0 \\ 0 \quad 0 \quad 0 \quad 1 \end{bmatrix} \quad (2) $$

In this way, the pose coordinate (x_2, y_2) of the end is obtained as:

$$ \begin{cases} x_2 = l_1\cos\theta_1 + l_2\cos(\theta_1+\theta_2) \\ y_2 = l_1\sin\theta_1 + l_2\sin(\theta_1+\theta_2) \end{cases} \quad (3) $$

To solve the above equation inversely, we can get:

$$ \begin{cases} \theta_1 = \arctan\dfrac{y_2}{x_2} + \arccos\dfrac{x_2^2 + y_2^2 + l_1^2 - l_2^2}{2l_1\sqrt{x_2^2 + y_2^2}} \\ \theta_2 = \pi - \arccos\dfrac{l_1^2 + l_2^2 - x_2^2 - y_2^2}{2l_1 l_2} \end{cases} \quad (4) $$

Data processing

All data were processed with SPSS11.0 statistical software for T-test statistical processing.[6] The treatment results are expressed as mean±standard deviation. $P<0.05$ is the significance level of the difference.

There is no need for a code of ethics for this type of study.

RESULTS

Comparison results of physiological and biochemical indicators (Hb, CK, BUN, LDH)

It can be seen from Table 1 that the Hb level of athletes was significantly reduced after heavy-load training ($P<0.05$). After heavy training, the CK, BUN, and LDH increased, with a significant difference ($P<0.05$).

Comparison results of immune indexes (WBC, IgA, IgG, IgM)

It can be seen from Table 2 that the levels of IgA, IgG, and IgM in the blood of athletes after heavy-load training decreased, and there was a significant difference ($P<0.05$). However, the white blood cell count (WBC) did not change significantly before and after heavy-load training ($P>0.05$).

Comparison results of T lymphocyte subgroup factors ($CD3^+$, $CD4^+$, $CD8^+$, $CD4^+/CD8^+$)

It can be seen from Table 3 that the percentage of $CD4^+$ and the ratio of $CD4^+/CD8^+$ after heavy-load training decreased, and the difference was significant ($P<0.05$). However, $CD3^+$ and $CD8^+$ did not see significant changes before and after heavy load training ($P>0.05$).

DISCUSSION

The main physiological function of Hb is to transport oxygen and carbon dioxide in the body, and it also has a certain effect on maintaining the body's acid-base balance.[7] Athletes showed a significant decrease

Table 1. Changes of biochemical indicators before and after heavy load training.

Biochemical Indicators	Before heavy training	After heavy training
Hb (g/L)	150.6±4.2	144.2±3.5
CK (U/L)	284.3±14.9	546.3±33.4
BUN (mmol/L)	5.43±0.28	6.42±0.34
LDH (U/L)	163.8±7.4	205.2±5.82

Table 2. Changes of immune indexes before and after heavy load training.

Immune index	Before heavy training	After heavy training
WBC ($\times10^9$/L)	5.92±0.31	5.21±0.31
IgA (g/L)	1.75±0.08	1.37±0.09
IgG (g/L)	11.82±0.55	9.91±0.44
IgM (g/L)	1.73±0.09	1.21±0.08

Table 3. Changes of T lymphocyte subgroup factors before and after heavy training.

Immune index	Before heavy training	After heavy training
$CD3^+$ (%)	64.9±1.46	61.6±1.27
$CD4^+$ (%)	36.8±1.36	30.2±0.95
$CD8^+$ (%)	26.7±1.19	29.7±1.27
$CD4^+/CD8^+$	1.41±0.23	1.13±0.14

in hemoglobin levels when they were overtired. Hb is often used as an indicator of excessive fatigue. In this study, Hb decreased significantly after 4 weeks of heavy-load training ($P<0.05$). This may be due to high--volume training to accelerate the destruction of red blood cells. Hb is freed from red blood cells and participates in muscle protein synthesis and red blood cell regeneration. Therefore, it can be considered that the decline in Hb is a reaction in the early stage of high-volume training. CK and LDH are often used as indicators to reflect exercise load. An increase in exercise intensity will cause an increase in both indicators.[8] CK is one of the key enzymes of energy metabolism in skeletal muscle cells. Its activity plays an important role in the energy supply during short-term, maximum-intensity exercise. With the extension of exercise time, CK activity will increase significantly. Therefore, the change of serum CK activity is a sensitive index to assess the athlete's muscles to withstand stimulation and skeletal muscle microcell damage and recovery.

After 4 weeks of heavy-load training, the CK value and LDH level were significantly increased ($P<0.05$). The significant increase of CK value and LDH activity may be due to the damage of skeletal muscle cells and tissue cell membrane permeability.[9] Overtraining can cause local muscle cell damage, muscle fiber necrosis, and decomposition due to excessive muscles use. This causes CK and LDH in the muscle cells to be released into the blood in large quantities.

BUN is an indicator that reflects the athlete's collective fatigue and the assessment of functional status. In tennis practice, high-load sports training will use protein as fuel. This significantly increases BUN generation.[10] Therefore, it can be used as an indicator for predicting the size of exercise load and fatigue monitoring. In this study, BUN levels increased significantly after 4 weeks of heavy-load training ($P<0.05$). The morning fasting BUN value of normal people in China is 5-20mg/dL, and the quiet value of the blood urea of athletes is generally at the upper limit of ordinary people's normal value. The production and excretion of urea are usually in a balanced state, so the quiet value of BUN remains relatively stable. However, the energy balance in the muscles is disrupted during long-term high-intensity exercise. At this time, the catabolism of protein and amino acids is strengthened, and urea production increases to increase the blood content. This may be related to the mechanism by which exercise causes BUN to increase. 1) The glucose-alanine cycle is strengthened during strenuous exercise. This cycle enables pyruvate, an intermediate product of glucose oxidative decomposition in muscles, to be transported to the liver on time and to maintain normal blood sugar levels. At the same time, the amino acid decomposition product in the muscle is transported to the liver to synthesize urea, thereby promoting the participation of the amino acid in the muscle for energy supply. 2) Exercise strengthens the aging decomposition of enzyme proteins in muscles, and its metabolic end product, urea, increases accordingly. 3) Long-term strenuous exercise destroys the muscle energy balance. At this time, ATP cannot be quickly re-synthesized.[11] The AMP generated at this time is easily deaminated in the muscle. The removed ammonia is converted to urea to increase blood urea.

Leukocytes are cells that contain a variety of immune functions. It can protect the body from pathogenic microorganisms. It is an important component of the body's immune function. In this study, tennis players after 4 weeks of heavy training, the white blood cell count (WBC) gradually decreased to the lower limit of the normal value. This indicates that the body's immune level has been reduced, but no significant difference has been seen.[12] The reason may be due to the increase in white blood cell turnover rate, but it is still in a controllable range.[13] Tennis players' IgA, IgG, and IgM levels were significantly reduced after 4 weeks of heavy-load training ($P<0.05$).[14] This shows that the athlete's immunity has declined. Strenuous exercise has a suppressive effect on the immune system, thereby increasing the athlete's susceptibility to disease.

T lymphocytes are extremely important cells in the cellular immune response. It has not only immune effect function but also immune regulation function. The subgroups of T lymphocytes restrict and assist each other and are in balance.[15] Once either party increases or decreases, it will affect the other party. Formation imbalance can lead to various immune damage or diseases. This study found that the $CD4^+/CD8^+$ cell ratio of tennis players significantly decreased after 4 weeks of heavy training ($P<0.05$). This phenomenon may be related to the body's immune regulation function disorder caused by excessively strenuous exercise training.[16]

CONCLUSION

There were significant changes in serum Hb, CK, BUN, and LDH biochemical indicators before and after heavy-load training. IgA, IgG, IgM, $CD4^+/CD8^+$, and other immune indicators also have significant changes before and after heavy-load training. Four weeks of heavy-load training caused a certain degree of damage to the physical function of tennis players and reduced the athlete's immune function.

All authors declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. YiMin Yang: article review and writin; Di Hu: data analysis and intellectual concept of the article.

REFERENCES

1. Bozdoäÿan T. The effect of differential learning method on the international tennis number level among young tennis player candidates. Educ Res Rev. 2020;15(5):253-60.
2. Harjanto MD, Jariono G. Method of Strengthening Arm Muscles Against the Ability of The Tennis Flat Service Stroke (Experimental Study in Students of Muhammadiyah University of Surakarta). IJERSC. 2021;2(4):743-50.
3. Baturkina GV, Budyakova TP. Social perception as a factor in the professional success of a tennis player. Amazonia Investiga. 2019;8(23):431-9.
4. Gunarto P. The Effect of Feeding Drill Training Method and Coordination Toward Ability of Forehand Groundstroke Depth. Gelanggang Pendidikan Jasmani Indonesia. 2021;5(1):19-23.
5. Utomo NS, Sulaiman S, Nasuka N. The Influence of Volley Training Method and Agility on Tennis Players' Backhand Volley Accuracy. J Phys Educ Sports. 2019;8(2):102-7.
6. Kilit B, Arslan E. Effects of high-intensity interval training vs. on-court tennis training in young tennis players. J Strength Cond Res. 2019;33(1):188-96.
7. Yildiz S, Pinar S, Gelen E. Effects of 8-week functional vs. traditional training on athletic performance and functional movement on prepubertal tennis players. J Strength Cond Res. 2019;3(3):651-61.
8. Ninglan T, Soegiyanto S, Sulaiman S. Effect of Arm Muscles and Long Arm Power Exercises on the Results of Accuracy in Forehand Smash Blows in Table Tennis Games at Silaberanti Club, Palembang. J Phys Educ Sports. 2019;8(4):88-94.
9. Tomov D, Tomova D, Atanasov D. Tennis ball as a factor in the initial tennis training of junior high school (12-year-old) students. J Phys Educ Sport. 2021;21(5):2745-51.
10. Colibăşanu FB, Branişte G. Effectiveness of The Application of Tactical Training Models of Tennis Players in The Trading Shots Phase and Completion of The Point. Bulletin of the Transilvania University of Brasov. Series IX, Sciences of Human Kinetics. 2020;13(2):35-42.
11. Yildirim Y, Kizilet A. The Effects of Differential Learning Method on the Tennis Ground Stroke Accuracy and Mobility. EduLearn. 2020;9(6):146-54.
12. Chalakov M. Optimizing the Control of Technical Performance of Forehand Stroke Among 12-Year Old Tennis Players Using Martin's Sigma Method. Trakia J Sci. 2020;18(1):682-8.
13. Rahim MRA, Shapie MNM, Abdullah NM, Parnabas V, Hasan H, Khir ZM. Review on the Transformation of Tennis Development in Malaysia. MJSSR. 2021;17(1):73-88.
14. Mulya G, Agustryani R. GUSTA Exercise Model: A Tennis Skill for Beginners. Syst Rev Pharm. 2020;11(6):1273-8.
15. Chavan SG, Prashanth AS. Enlightening the concept of Snayugatavata and its management through Ayurvedic aspect in correlation to Tennis Elbow. J Ayurveda Integr Med Sci. 2019;4(04):225-30.
16. Krause LM, Buszard T, Reid M, Pinder R, Farrow D. Assessment of elite junior tennis serve and return practice: A cross-sectional observation. J Sports Sci. 2019;37(24):2818-25.