METABOLISM AND PHYSICAL FITNESS CHARACTERISTICS IN TABLE TENNIS PLAYERS

CARACTERÍSTICAS DO METABOLISMO E APTIDÃO FÍSICA EM JOGADORES DE TÊNIS DE MESA

CARACTERÍSTICAS DEL METABOLISMO Y LA APTITUD FÍSICA EN JUGADORES DE TENIS DE MESA

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ABSTRACT

Introduction: The physical fitness of Chinese table tennis players is critical as the continuous development in sports technologies increases the demands for physical fitness during competitions. And the physical quality of table tennis players is a problem that cannot be ignored. Objective: Analyze the energy supply characteristics of table tennis and its special training methods based on the sport's temporal and spatial characteristics of the actual load. Methods: Sport performance is analyzed by the scoring system using video kinematic analysis, scientific literature research, and logical analysis methods. The research on energy supply in Chinese athletes according to the characteristics of the three energy metabolism systems is developed. Considering the different metabolic characteristics and physical content for a specific training protocol experiment. Results: Female table tennis players obtained significantly higher time, density, and hitting efficiency than male players (P<0.05). Table tennis is a sport that uses mainly aerobic energy, complemented by anaerobic exercises. Conclusion: Table tennis is a medium-intensity intermittent sport composed of short-term bursts with the ball and low--intensity activities without the ball. Competition in table tennis is based on aerobic energy delivery, with no oxygen-based movement. Athletes need to combine aerobic and anaerobic exercises during exercise. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Racquet Sports; Energy Metabolism; Physical Education and Training.

RESUMO

Introdução: A condição física dos jogadores chineses de tênis de mesa encontra-se em nível crítico pois o contínuo desenvolvimento nas tecnologias do esporte aumenta as exigências para a aptidão física durante as competições. E a qualidade física dos jogadores de tênis de mesa é um problema que não pode ser ignorado. Objetivo: Analisar as características de fornecimento de energia do tênis de mesa e seus métodos especiais de treinamento com base nas características temporais e espaciais da carga real do esporte. Métodos: Analisa-se o desempenho esportivo por sistema de pontuação usando análise cinemática por vídeo, pesquisa de literatura científica e métodos de análise lógica. Desenvolve-se a pesquisa sobre o fornecimento de energia nos atletas chineses de acordo com as características dos três sistemas de metabolismo energético. Considerando as diferentes características metabólicas, experimenta-se o conteúdo físico para um protocolo específico de treinamento. Resultados: As jogadoras de tênis de mesa obtiveram tempo, densidade e aproveitamento de rebatidas significativamente maiores que os jogadores masculinos (P<0,05). O tênis de mesa é um esporte que utiliza principalmente a energia aeróbica, complementada por exercícios anaeróbicos. Conclusão: O tênis de mesa é um esporte intermitente de média intensidade, composto de explosões de curto prazo com a bola e atividades de baixa intensidade sem a bola. A competição no tênis de mesa é baseada no fornecimento de energia aeróbica, sem movimento baseado em oxigênio. Os atletas precisam combinar exercícios aeróbicos e anaeróbicos durante o exercício físico. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Esportes com Raquete; Metabolismo Energético; Educação Física e Treinamento.*

RESUMEN

Introducción: La aptitud física de los jugadores de tenis de mesa chinos se encuentra en un nivel crítico, ya que el continuo desarrollo de las tecnologías de este deporte aumenta las exigencias de aptitud física durante las competiciones. Y la calidad física de los jugadores de tenis de mesa es un problema que no se puede ignorar. Objetivo: Analizar las características del suministro de energía del tenis de mesa y sus métodos especiales de entrenamiento en función de las características temporales y espaciales de la carga real del deporte. Métodos: El rendimiento deportivo se analiza mediante un sistema de puntuación que utiliza el análisis cinemático de vídeo, la investigación de la literatura científica y los métodos de análisis lógico. Se desarrolla la investigación sobre el suministro de energía en los atletas chinos según las características de los tres sistemas del metabolismo energético. Teniendo en cuenta las diferentes características metabólicas, se experimenta el contenido físico para un protocolo de entrenamiento específico. Resultados: Las jugadoras de tenis de mesa obtuvieron un tiempo, una densidad y una eficacia de golpeo significativamente mayores que los jugadores masculinos (P<0,05). El tenis de mesa es un deporte que utiliza principalmente energía aeróbica, complementada con ejercicios anaeróbicos. Conclusión: El tenis de mesa es un deporte intermitente de intensidad media, compuesto por ráfagas de corta duración con la pelota y actividades de baja intensidad sin la

pelota. La competición en el tenis de mesa se basa en el suministro de energía aeróbica, sin movimiento basado en el oxígeno. Los atletas deben combinar el ejercicio aeróbico y el anaeróbico durante el ejercicio. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Deportes de Raqueta; Metabolismo Energético; Educación y Entrenamiento Físico.*

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INTRODUCTION

Table tennis is a technology-leading net game. Technology is the key to the success or failure of the game, and the continuous improvement of the level of modern technology and tactics has also increased the demand for its physical fitness. A survey by Zhang Yingqiu of the Beijing Institute of Sports found that in an intensive table tennis match, the frequency of arm movement reached 25%, the frequency of arm swing reached 1000 times, the blood pressure increased by 16 mmHg, the heart rate was 92 beats/min, and the body weight decreased by 0.5~0.8 kg. It can be seen that the physical load of players in table tennis is not inferior to other sports activities.[1] The gap between the skills and technical abilities of the world's top table tennis players is shrinking, and the level of physical fitness of the players in the game often determines the game's results. Athletes' physical training plays an increasingly important role in table tennis. In this paper, the training content, training load, training method, and training method are designed according to the spatiotemporal characteristics of modern table tennis and the energy supply characteristics of the energy metabolism system.[2] This paper expects to improve the function of the energy metabolism system of table tennis players in a competitive state. This ensures that the athlete's physical fitness is at its peak during competition.

METHOD

Research objects

This paper mainly investigates the male and female table tennis players in the Chinese Table Tennis Super League.

Investigation method

Analysis of video data

This study used freeze-frame images of 1/25 second for data acquisition.[3] At the same time, this paper uses a 0.025-second camera to analyze the data of 15 games of male and female players in the National Table Tennis Super Championship.

Data Analysis

On this basis, we collected 54 related pieces of literature. This lays a solid foundation for the theoretical research of this paper.

Strength characteristics of table tennis players

This paper evaluates the physical fitness indexes of table tennis players through the statistics and sampling of the strength indexes of table tennis players.[4] This paper establishes a mathematical model for evaluating the effectiveness of table tennis players' strength training performance based on the rotational inertia of the center of mass. The kinetic energy of the table tennis doubles force is:

$$Q = \sum_{j=0}^{6} l_j h v_j \tag{1}$$

Use the Lagrange equation to express the angle of impact of a ping pong ball:

$$\Gamma = R - Q \tag{2}$$

In this paper, the analysis of sports force characteristics is linked to it, and the force output characteristic formula of table tennis doubles is obtained:

$$\frac{d}{dt}\left[\frac{\partial \Gamma}{\partial \dot{e}_j}\right] - \frac{\partial \Gamma}{\partial e_j} = X_j, (j = 1, 2, \cdots, 6) \tag{3}$$

X_j is the output dynamic torque generated by the table tennis player during the game. e_j is the distribution of the center of gravity of the athlete's body when performing doubles.[5] The vector H represents the gravity force vector output by the table tennis doubles. From this, it can be concluded that the joint force moment of the table tennis player is:

$$L(e)e + R(e, e) + H(e) = X \tag{4}$$

This paper uses the sound adjustment principle of inertial output to take the mechanical steady-state control characteristic value λ_j (j = 1, 2,⋯,6) of table tennis double as the steady-state control quantity of its energy.

$$\begin{cases} \lambda_1 = e_1 \\ \lambda_2 = e_1 - e_2 \\ \lambda_3 = e_2 - e_3 \\ \lambda_4 = e_4 - e_3 \\ \lambda_5 = e_5 - e_4 \\ \lambda_6 = e_5 - e_6 \end{cases} \tag{5}$$

L represents the lower extremity mass matrix and H represents the strength vector of two table tennis players.[6] In this way, the paper obtains the standard characteristic curves $l_{\Gamma 3}$ and l_{R3} of the force and inertia force of table tennis doubles.

$$x_{\Gamma 3} = l_1 \sin \lambda_1 + l_2 \sin(\lambda_1 - \lambda_2) + \alpha_3 \sin(\lambda_1 - \lambda_2 + \lambda_3) - \alpha_0 \tag{6}$$

Data Analysis

This paper uses the mathematical analysis program of SPSS13.0 to process the collected data about the sensitivity and quality of volleyball.

Ethical Compliance

Research experiments conducted in this article with animals or humans were approved by the Ethical Committee and responsible authorities of Hubei University of Technology following all guidelines, regulations, legal, and ethical standards as required for humans or animals.

RESULTS

Time and space characteristics

This paper mainly discusses the time characteristics of table tennis from the aspects of total time, ball activity, game density, hitting interval, and unit round interval time. Play density is the percentage of ball

movement in the entire game. Hit clearance is the space between two shots.[7] The total time, ball time, game density, and hitting clearance of female players in the game are higher than those of male players. This is because female players' hitting power, speed, and spin speed are lower than male players (Table 1 and 2).

Research on energy supply and time characteristics in table tennis

Through the study of the timing characteristics of table tennis, it can be seen that table tennis is an intermittent and moderate sports competition. According to the three major energy systems (ATP-CP system, glycolysis energy supply system, and aerobic oxidation system), characteristics of this paper believe that it is a sports event that integrates aerobic energy supply and anaerobic energy supply.[8] When there is a ball, it uses anaerobic energy as energy. Athletes rely on aerobic energy for energy without the ball. (Table 3)

Table tennis is a sport based on aerobic energy. Most non-sporting events and short breaks during competition take up much time. In a large-scale domestic table tennis event, a player has to go through seven to ten days of intense and fierce competition. According to the rules of table tennis competitions, there shall be no less than ten matches with two wins from three matches in one day and no fewer than seven matches with three wins from five matches.[9] According to a player's playing time, you can play ten games and twenty innings a day. This is a physical exercise from a physical and metabolic standpoint.

Players do a lot of exercise during this process. The content includes swinging and running, these are not pure aerobic supply, but ATP-CP provides energy. This allows the athlete to move more in just a few seconds.[10] The interval between each round of table tennis is 17 seconds, while the half-course response of ATP-CP is 20~30 seconds. After a round of competition, the energy of ATP-CP will be reduced to 50% of its original value. This also inevitably leads to the lack of oxygen and the accumulation of lactic acid in Chinese table tennis. Without good aerobic endurance, the aerobic supply system continuously provides ATP and CP to promote lactic acid excretion in the body. This makes it challenging to ensure that players maintain sufficient physical strength in technical movements and various events.

Table 1. Characteristics of Men's Playing Hours.

Competitor	Cross-board to cross-board	Horizontal board to straight board	Straight to straight
Number of Board	Four innings	Four innings	Four innings
Total time (min)	20.3-30.5333	19.35-30.3667	19.1-29.9667
Playing time with the ball (min)	15.2667-24.4667	9.9-20.7333	9.5333-21.0667
Competition intensity %	79.16-84.32	53.8947-71.89	52.53-74.00
Hitting Clearance (min)	0.0025-0.0068	0.0025-0.0072	0.0023-0.0067
Unit round time (min)	0.0045-0.0918	0.005-0.0885	0.0047-0.0715
Unit round interval time (min)	0.1-0.25	0.0833-0.2833	0.0667-0.2333

Table 2. Characteristics of Women's Participation Hours.

Competitor	Cross-board to cross-board	Horizontal board to straight board	Straight to straight
Number of Board	Four innings	Four innings	Four innings
Total time (min)	21.4667-32.2	20.3333-32.3667	20.1-30.8
Playing time with the ball (min)	16.1333-27.1333	11.7333-23.2333	10.3667-22.0667
The intensity of the competition	0.7916-0.8874	0.6074-0.7558	0.5432-0.7537
Hitting Clearance (min)	0.0027-0.008	0.0027-0.0077	0.0025-0.007
Unit round time (min)	0.0037-0.1102	0.006-0.1085	0.0063-0.1048
Unit round interval time (min)	0.1167-0.2333	0.05-0.2833	0.0667-0.2

Table 3. Three central energy supply systems.

Energy supply system	Energy supply time	The total amount of released energy (mol/g min)	Energy release rate (mol/min)
ATP-CP energy supply	8s-10s	21	1.8-3.2
glycolysis for energy	30s-90s	316	1.05
Glycogen oxidation for energy	1min-5min	3789	0.53
Fat oxidation for energy	Above 3min	12632	0.25

DISCUSSION

In recent years, with the development of the World Table Tennis Federation and the continuous improvement of the scientific nature of physical education, Chinese table tennis has attracted more and more attention in physical education. In 1997, Chinese table tennis reached its peak.[11] The coaches have developed a series of training plans to help Chinese table tennis players exercise their physical fitness. At the same time, the coaches have improved various preparations and rehabilitation exercises before the game. This dramatically reduces the chances of an athlete getting injured. National team coaches conduct physical fitness tests and training quality tests on athletes. The coaches test athletes' hormones, blood, etc., to determine the athlete's functional status and fatigue. Through these training plans, the goal of improving athletes' physical condition and fatigue can be achieved.

The improvement of the sports level of athletes is inseparable from practical physical training. The technical sensitivity and technical characteristics of athletes lead to the problems of high training frequency, long time, high density, and high quality. It is necessary to have a highly competitive ability.[12] The 800-meter run is very difficult for athletes with good physical fitness. Under such circumstances, it is difficult for players to maintain a high level in the game, let alone the use of technology. When an athlete has sufficient physical preparation and can do well in multiple sports, the athlete's competitive performance will be significantly improved. At present, many scholars have integrated energy metabolism and physical training. At the same time, these scholars have transformed the long-standing exercise method based on the development of quality grading to the exercise method based on the development of energy.

Anaerobic exercise

In table tennis, each serving competition is a short-term, high-intensity, rapid, anaerobic-driven movement. The anaerobic metabolism of a player in a game is a critical factor in determining the game's outcome, and its intensity will affect the implementation of rapid techniques and techniques. Athletes should consider table tennis's particularity when performing anaerobic training.

Aerobic training

Table tennis has the characteristics of "short-term load-intermitten-t-short-term load." This results in a lower average load level throughout the exercise. While emphasizing speed and endurance, athletes should also pay attention to the cultivation of endurance. Their aerobic capacity determines an athlete's physical fitness. Improving the overall physical fitness of athletes is the key to improving the overall quality of athletes. It is also essential to increase the overall fitness level of athletes. The remarkable physical fitness improvement of athletes in table tennis is different from other sports, and it requires a lot of challenging sports. This requires a high level of energy supply.

On the other hand, the mutual conversion of active and intermittent exercise leads to a more significant overall load. Aerobic energy requirements are also higher throughout the exercise. Athletes must use a proven aerobic exercise regimen.

CONCLUSION

There is no absolute aerobic metabolic training and anaerobic metabolic training in any exercise. The choice of anaerobic and aerobic exercise for athletes according to their circumstances. Aerobic exercise is essential in table tennis. It requires a high-intensity energy supply to help athletes recover and replenish their strength. Athletes need to improve their physical fitness level by combining aerobic and anaerobic exercise in their daily training.

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REFERENCES

1. Grinko V, Kudelko V, Yefremov AA, Klokova S. Effect of aerobic direction on the flexibility of students. Dynamics and forecasting. J Phys Educ Sport. 2020;20(4):1727-33
2. Zaferanieh A, Haghighi AH, Kakhak SAH, Maleki A, Cè E, Esposito F. Effect of ballistic and power training on performance adaptations of élite table tennis players. Sport Sci Health. 2021;17(1):181-90
3. Ferrandez C, Marsan T, Poulet Y, Rouch P, Thoreux P, Sauret C. Physiology, biomechanics and injuries in table tennis: A systematic review. Sci Sports. 2021;36(2):95-104
4. Maheshwari A, Pandey G, Shukla M, Rawat VS, Yadav T. Electromyographical Analysis of Table Tennis Forehand Stroke Using Different Ball Material. Teor ta Metod Fiz Vihov. 2022;22(2):249-54
5. Farhan MA, Kazmi SY, Irfan A, Sami W, Faraz A, Ali MI. Awareness and practice of physical activity among male medical undergraduates at majmaah university, Saudi Arabia. PAFMJ. 2021;71(5):1669-75
6. Zheng C, Gu N, Wang X, Xiao Y. RETRACTED ARTICLE: The features of precipitation in coastal areas based on remote sensing images and the effects of table tennis players' physical training. Arab J Geosci. 2021; 14(12):1-21
7. Wallin H, Jansson E, Wallquist C, Hylander Rössner B, Jacobson SH, Rickenlund A, et al. Aerobic exercise capacity is maintained over a 5-year period in mild-to-moderate chronic kidney disease: a longitudinal study. BMC Nephrol. 2020;21(1):1-11
8. Liu X, Han L. Monitoring of Athletes' Body Movement Status in Competitions Based on Physiological Indicators of Mice. Rev Cient Fac Cienc Vet Univ Zulia. 2020;30(2):940-8
9. Haryanto J, Denay N. The instrument of the push stroke technique skill in table tennis: validity and reliability. Journal of Educational and Learning Studies. 2022;4(2):205-8
10. Picabea JM, Cámara J, Nakamura FY, Yanci J. Comparison of heart rate variability before and after a table tennis match. J Hum Kinet. 2021;77(1):107-15
11. Yuan Q, Zhang Y, Leng H. The impact of urban park accessibility in cold regions on leisure-time physical activity levels of older adults during the winter. Int Rev Spat Plan Sustain Dev. 2022;10(3):16-32
12. Bańkosz Z, Stefaniak T. Elbow joint position and hand pressure force sense under conditions of quick reaction in table tennis players. Kinesiology. 2021;53(1):95-103