INFLUENCE OF HIGH-INTENSITY EXERCISE ON PHYSICAL FITNESS OF SWIMMERS

INFLUÊNCIA DO EXERCÍCIO DE ALTA INTENSIDADE SOBRE A APTIDÃO FÍSICA DOS NADADORES

INFLUENCIA DEL EJERCICIO DE ALTA INTENSIDAD EN LA APTITUD FÍSICA DE LOS NADADORES

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ABSTRACT

Introduction: High-intensity swimming requires athletes to have explosive power, endurance, lactic acid resistance, aerobic metabolism, and other qualities. Pre-competition physical training is mainly based on high interval training, promoting ATP-CP synthesis in the body. It can enhance the resistance to lactic acid and promote lactic acid clearance. Objective: This article explores the effect of high-intensity pre-competition training on the physical fitness of swimmers. The results can be used as a reference for swimmers to perform high-intensity training before the competition. Methods: Eight swimmers were selected by random sampling. The study subjects received eight weeks of high-intensity training before the competition. The athletes' gas metabolism and anaerobic thresholds were detected before and after training. At the same time, the physiological and chemical indicators of the experimental subjects were detected in this paper. Finally, this paper analyzes the experimental results by employing mathematical statistics. Results: The metabolism function of the athletes changed significantly in the later period of pre-competition training ($P<0.05$). Serum lactate concentration had no significant effect on the anaerobic threshold ($P>0.05$). Conclusion: High-intensity exercise has a particular promotion effect on improving the physical quality of swimmers. This exercise can lay a solid foundation for the swimmer's physical fitness. ***Level of evidence II; Therapeutic studies – investigation of treatment results.***

Keywords: Swimming; Competitive Behavior; Physical Fitness; High-Intensity Interval Training; Anaerobic Threshold.

RESUMO

Introdução: A natação de alta intensidade requer que os atletas tenham uma força explosiva, resistência, tolerância ao ácido láctico, metabolismo aeróbico e outras qualidades. O treinamento físico pré-competição é baseado principalmente no treinamento de alto intervalo, o que pode promover a síntese de ATP-CP no corpo. Ele pode aumentar a resistência ao ácido láctico e promover a sua eliminação. Objetivo: Este artigo explora o efeito do treinamento pré-competição de alta intensidade sobre a aptidão física dos nadadores. Os resultados podem ser usados como referência para os nadadores realizarem treinamentos de alta intensidade antes da competição. Métodos: Oito nadadores foram selecionados por amostragem aleatória. Os sujeitos do estudo receberam oito semanas de treinamento de alta intensidade antes da competição. O metabolismo dos gases e os limiares anaeróbicos dos atletas foram detectados antes e depois do treinamento. Paralelamente, os indicadores fisiológicos e químicos dos sujeitos experimentais foram detectados neste trabalho. Finalmente, este trabalho analisa os resultados experimentais empregando estatísticas matemáticas. Resultados: A função metabólica dos atletas alterou-se significativamente no último período de treinamento pré-competição ($P<0,05$). A concentração sérica de lactato não teve efeito significativo no limiar anaeróbico ($P>0,05$). Conclusão: O exercício de alta intensidade tem um efeito especial de promoção na melhoria da qualidade física dos nadadores. Este exercício pode estabelecer uma base sólida para a aptidão física do nadador. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Natação; Comportamento Competitivo; Aptidão Física; Treinamento Intervalado de Alta Intensidade; Limiar Anaeróbico.*

RESUMEN

Introducción: La natación de alta intensidad requiere que los atletas tengan fuerza explosiva, resistencia, tolerancia al ácido láctico, metabolismo aeróbico y otras cualidades. El entrenamiento físico previo a la competición se basa principalmente en el entrenamiento de alto intervalo, que puede promover la síntesis de ATP-CP en el cuerpo. Puede aumentar la resistencia al ácido láctico y favorecer su eliminación. Objetivo: Este trabajo explora el efecto del entrenamiento de alta intensidad previo a la competición en la condición física de los nadadores. Los resultados pueden servir de referencia para que los nadadores realicen un entrenamiento de alta intensidad antes de la competición. Métodos: Se seleccionaron ocho nadadores por muestreo aleatorio. Los sujetos del estudio recibieron ocho semanas de entrenamiento de alta intensidad antes de la competición. Se detectó el metabolismo gaseoso y los umbrales anaeróbicos de los atletas antes y después del entrenamiento. Paralelamente, en este trabajo se detectaron los indicadores fisiológicos y químicos de los sujetos experimentales. Por último, este documento analiza los resultados experimentales empleando estadísticas matemáticas. Resultados: La función metabólica de los atletas cambió significativamente en el último período de entrenamiento previo a la competición ($P<0,05$). La concentración de lactato *sérico no tuvo un efecto significativo sobre el umbral anaeróbico (P>0,05). Conclusión: El ejercicio de alta intensidad tiene un efecto promotor especial en la mejora de la calidad física de los nadadores. Este ejercicio puede establecer una base sólida para la aptitud física del nadador.* ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Natación; Conducta Competitiva; Aptitud Física; Entrenamiento de Intervalos de Alta Intensidad; Umbral Anaerobio.*

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INTRODUCTION

A large cycle of athlete's training in competitive swimming includes the general aerobic capacity development stage, the particular aerobic capacity development stage, the special anaerobic capacity development stage, and the pre-competition adjustment stage. The latter two stages are more challenging to master and make a big difference in training success or performance.[1] High-intensity anaerobic training before competition is an essential topic in sports training. This paper studies the adaptive change characteristics of swimmers' energy metabolism and functional state.[2] Finally, this paper evaluates the effect of high-intensity training before competition in swimmers.

METHOD

Research objects

This paper selects eight outstanding men's long-distance freestyle swimmers as research objects. Table 1 lists the basic information about the athletes.

Research methods

Training plan

Athletes perform high-intensity training before competitions—three weeks as a cycle. Athletes do two weeks of heavy training for two weeks. The athlete then adjusts for one week.[3] The time is six cycles. The total length of weekly training is 50,000 to 60,000 meters, and the weekly training length is 30,000 meters.

Inspection before and after training

Before and after high-intensity training, the coaches performed an extreme load exercise test on the athletes' air generation and blood lactate homogeneity. 1) Extreme load exercise gas metabolism test: the athletes did not perform high-intensity exercise within two days of the start of the test. All physiological and biochemical indicators were within the normal range. First, the athlete is fully prepared and put on a respirator. The athlete swims 300 meters with maximum effort. 2) Anaerobic threshold test for homogeneity of blood lactate: athletes take off their breathing masks after completing the gas metabolism ability test. Athletes swim at a constant speed of 5x200 meters in 7 minutes. Start at 70% low intensity and increase speed by 3-4 seconds every 200 meters. The interval between stages is 1 minute and 30 seconds.[4] At this time, blood lactate concentration and heart rate were measured. Blood lactate gradually decreases at the initial low level. The fastest rate at which lactate rises again is called the anaerobic threshold. The rate of lactate production in the blood is then equal to the rate of clearance.

The athletes' hemoglobin (H b), serum creatine kinase (CK), blood urea (BU), testosterone (T), and cortisol (C) were measured before, during, and after training.

Table 1. Athlete Profile.

n	age	Height (m)	Weight (kg)	Training years
8	17.36±3.05	194.46±5.41	76.77±11.47	10.38±2.76

Model simulation of the relationship between human fatigue and swimming intensity

Assume that the capacity of the sampling point is n. The following formula can express the physical exertion in time t.

$$f_i(t) = \alpha_0 + \alpha_1 x_j^t + \cdots + \alpha_M x_j^t + \delta \quad (1)$$

$$\delta = \begin{pmatrix} \delta_1 \\ \delta_2 \\ \vdots \\ \delta_M \end{pmatrix}, \alpha = \begin{pmatrix} \alpha_0 \\ \alpha_1 \\ \vdots \\ \alpha_M \end{pmatrix} \quad (2)$$

Then the augmented matrix $(m, f(t))$ of exercise intensity and physical fatigue can be expressed as:

$$N = \begin{pmatrix} (m)'m & (m)\, f(t) \\ (f(t))'m & (f(t))\, f(t) \end{pmatrix} = \begin{pmatrix} N_{11} & N_{12} \\ N_{21} & N_{22} \end{pmatrix} \quad (3)$$

Least squares estimation can be used for regression coefficients

$$\hat{\alpha} = N(N_{11})^{-1} N_{12} \quad (4)$$

Statistical analysis of data

In this paper, SPSS 10.1 was used for statistical analysis of the test results.[5] The t-test was used to compare the changes in the two groups of patients in this paper.

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

RESULTS

Table 2 shows that the oxygen uptake, the relative value of oxygen uptake, and the respiratory rate of the athletes in the 300-meter full-speed swimming after six weeks of high-intensity training were significantly

Table 2. Changes in respiratory metabolism and related physiological indicators of athletes before and after high-intensity training six weeks before the competition.

Time	Before training	After training
n	8	8
Oxygen uptake (ml/min)	4420.08±478.48	4100.55±634.94
Relative value of oxygen uptake (ml/min/kg)	61.13±6.92	56.29±5.75
Respiratory entropy	0.99±0.09	1.11±0.06
Respiratory rate Rf (b/min)	48.46±11.1	44.96±7.25
Tidal volume VT(L)	2.61±0.45	2.77±0.36
Ventilation VE (L/min)	112.54±23.96	112.55±20.13
Immediate lactate (mmol/L)	7.94±2.7	10.02±1.83
Heart rate (bpm)	198±11.06	199.22±10.47
Grade(s)	3'45"12±17"11	3'24"12±13"25

decreased (P<0.001). Respiratory entropy, tidal volume, performance, and immediate blood lactate were significantly increased (P<0.001).

It can be seen from Table 3 that after high-intensity training six weeks before the competition, the athletes' anaerobic threshold speed, blood lactic acid, and heart rate at the anaerobic critical inflection point all increased slightly. Still, there was no significant difference (P>0.05).

Table 4 shows that the hemoglobin levels of the athletes decreased significantly after two weeks of high-intensity training, while their hemoglobin levels did not change significantly after high-intensity training.[6] The results showed that the serum creatine kinase index was different at each stage of the whole cycle. Blood urea index improved significantly after two weeks of high-intensity exercise. Compared with the eight weeks before training, the difference was statistically significant (P<0.05). Serum testosterone levels did not change significantly during training. It was significantly decreased in the middle of training (P<0.0.1) and increased significantly in the later stage of exercise (P<0.05).

DISCUSSION

From the perspective of energy metabolism, the energy supply capacity of phosphate and carbohydrate is an essential factor in determining the athletic performance of athletes.[7] With the gradual increase of exercise intensity, the transition stage of the human body's energy metabolism system from aerobic energy supply to anaerobic lactic acid supply is the anaerobic threshold. The general academic community uses the anaerobic threshold to assess the aerobic capacity of athletes. The intensity of exercise at this critical moment is called the anaerobic threshold. This is the most effective workout intensity for cardio training. Under normal circumstances, the coach will use the blood lactate value of 4 mmol/L as the anaerobic threshold.[8] Many athletes with high endurance levels have lactate levels below four mmol/L, while those with weaker endurance have blood lactate levels above four mmol/L. Traditional personal lactate threshold testing is based on analyzing measurements using dedicated software under continuously increasing loads. In recent years, the University of Otago in New Zealand has had an anaerobic threshold measurement called "blood lactate uniformity." It enables the trainer to obtain the anaerobic threshold with high operability directly.

Phosphate supply is the first to be activated from an energy metabolism perspective. It can last for 6-8 seconds. A glycolytic energy supply system can provide maximum energy in 30 seconds and maintain energy supply for longer.[9] Although the aerobic energy supply system has a late start, it is a suitable method for short-distance swimming. It can effectively remove lactic acid from the body. According to the characteristics of human energy metabolism, both short-range and long-range swimming have their particularities. There is no single energy supply system for every sport. Muscles can use a variety of energy sources. The 50-meter run takes about 23 seconds and is dominated by anaerobic energy. A 100-meter sprint takes 50 seconds. This has high requirements for the human body's anaerobic and aerobic metabolism. In short-range swimming events, 50-meter intensity training, 100-meter intensity training, 200-meter aerobic training, and 400-meter aerobic training are often used.

According to the Australian energy training grading method, endurance training for lactic acid tolerance is divided into 8-12 mmol/L and 10-18 mmol/L. The world's top high-level athletes choose distances of 50-100 meters for their glycolysis training. Coaches generally choose the most considerable movement and reduce rest periods.[10] The lactate concentration in the blood will be between 22-26 mmol/L, and the heart rate will be between 190-200 beats/min. According to a survey of American swimmers, the secret to winning in short-course training is as follows: In training, athletes increase the interval time and the number of times per set. In the 100-meter intensity training, the coach can increase the interval by using 2×10x100 m. The interval between each exercise was extended to 2 minutes to increase the intensity and lactate concentration of the training. Under the premise of maintaining swimming speed, athletes can shorten the number of training sets per set and increase the number of training sets.[11] The training intensity of the athletes was increased from 2×(10×100 m) to 3×(4×100 m). By adjusting the training method, the trainer maximizes the strength and volume of glycolysis. This allows the athlete to maximize the maximum amount of lactic acid. This will reduce the distance between you and the world's top-level athletes. In addition to maximizing blood lactate workouts, athletes also perform anti-lactate workouts.

Current studies have shown that 8x100 meters, intensity more significant than 90%, and 1-minute rest are the best combination to improve athletes' glycolytic energy tolerance to lactic acid. Athletes control the blood lactate concentration to 12 mmol/L during training.[12] Workout intensity is 90%. This article takes 50-200 meters as an interval. This improves the athlete's tolerance to lactic acid. Proper aerobic exercise is also essential for short-range swimmers. Improving an athlete's aerobic capacity can help increase muscle and muscle acid excretion rates. Aerobic exercise can accelerate lactate removal during exercise. This allows the body to perform high-intensity workouts better. This is very important for improving the anaerobic capacity of short-distance swimmers. A recent survey showed that 40%-50% of the energy in a 100-meter swim comes from the energy supply. Aerobic exercise occupies a large proportion of short-distance swimmers. They spend almost half of their time doing cardio.[13] The training method in Russia is based on the anaerobic threshold. Among them, the training content of athletes is 45% to 55% of the anaerobic threshold and 6% to 10% of VO2max. According to the requirements of energy classification training, they controlled the blood lactate value between 3 and 5 mmol/L, and the blood lactate value of VO2max training was between 4 and 8 mmol/L.

Table 3. Changes of anaerobic threshold and other related physiological indicators before and after high-intensity exercise 6 weeks before exercise.

Time	n	Anaerobic Threshold Velocity (s)	Anaerobic Threshold Lactic Acid (mmol/L)	Heart rate (b/min)
Before training	8	2'32"14±6"29	3.36±1.84	166.46±18.3
After training	8	2'32"54±8"14	3.43±0.89	169.4±18.37

Table 4. Changes in blood biochemical parameters of athletes before and after high-intensity training six weeks before the competition.

Time	Eight weeks before the game	Seven weeks before the game	Six weeks before the game	Three weeks before the game
Hb (g/dl)	172.04±4.16	-	170.06±6.35	170.72±7.11
CK (U/L)	207.9±159.01	190.96±139.79	190.96±139.79	220.88±95.01
BU (mmol/L)	5.79±0.35	5.39±1.53	5.39±1.53	7.19±1.58
T(ng/dl)	696.52±123.19	-	682±110.2	701.48±115.93
COR (ug/dl)	23.3±3.74	-	20.31±4.06	25.23±3.86
T/COR	0.03±0.01	-	0.04±0.01	0.03±0.01

CONCLUSION

The primary purpose of high-intensity anaerobic training before competition is to improve athletes' anaerobic capacity, maintain aerobic capacity and have good functional adaptability. This provides a reference for elite swimmers to perform high-intensity training before the competition. This paper proposes a new method to measure the gas metabolism capacity of swimming pools during extreme load exercise.

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