# IMPROVEMENT OF SWIMMERS' PHYSICAL COORDINATION BASED ON ANAEROBIC ENDURANCE TRAINING

*APRIMORAMENTO DA COORDENAÇÃO FÍSICA DOS NADADORES BASEADO NO TREINAMENTO DE RESISTÊNCIA ANAERÓBICA*

*PERFECCIONAMIENTO DE LA COORDINACIÓN FÍSICA DE LOS NADADORES BASADO EN EL ENTRENAMIENTO DE LA RESISTENCIA ANAERÓBICA*

**Original Article**
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Xinhua Li[1]
(Physical Education Teaching and Training)
Haiyan Wang[1]
(Physical Education Teaching and Training)

1. Guangdong Ocean University, Zhanjiang, Guangdong, China.

**Correspondence:**
Haiyan Wang
Guangdong, China. 524088.
haiyanw1997@gdou.edu.cn

## ABSTRACT

Introduction: Anaerobic exercise is a critical factor in swimming training. Coaches who monitor an athlete's anaerobic capacity can use this tool to improve competitive performance. Objective: Analyze the effect of the anaerobic function test on swimmers' training. Methods: We examined the anaerobic exercise capacity of swimmers the relationship between human body composition and anaerobic work capacity. For this purpose, 14 swimmers were selected by random sampling. Individual anaerobic threshold, serum testosterone and serum cortisol of the athletes at different periods were measured. Results: Individual anaerobic thresholds were significantly lower in male and female athletes after training. The difference was statistically significant (P<0.05). The plasma testosterone/cortisol content of female swimmers after six weeks of anaerobic endurance training was significantly lower than the pre-training mean (P<0.05). After six weeks of anaerobic endurance training, the plasma testosterone/cortisol content of the male swimmers was lower than that of the standard group (P<0.05). Conclusion: The swimmers' bodies were impacted after anaerobic endurance training. The importance of attention by the coach to consider the differences between male and female athletes when conducting dedicated anaerobic threshold training is emphasized. ***Level of evidence II; Therapeutic studies - investigating treatment outcomes.***

**Keywords:** Swimming; Anaerobic Threshold; Physical Conditioning, Human; Athletes.

## *RESUMO*

*Introdução: O exercício anaeróbico é um fator crítico no treinamento de natação. Os treinadores que monitoram a capacidade anaeróbica de um atleta podem utilizar essa ferramenta para melhorar o desempenho competitivo. Objetivo: Analisar o efeito do teste de função anaeróbica sobre o treinamento dos nadadores. Métodos: Examinou-se a capacidade de exercício anaeróbico dos nadadores, a relação entre a composição do corpo humano e a capacidade de trabalho anaeróbico. Para isso, foram selecionados 14 nadadores por amostragem aleatória. Foram mensurados o limiar anaeróbico individual, testosterona sérica e cortisol sérico dos atletas em diferentes períodos. Resultados: Os limiares anaeróbicos individuais foram significativamente menores em atletas do sexo masculino e feminino após o treinamento. A diferença foi estatisticamente significativa (P<0,05). O conteúdo de testosterona/cortisol plasmático das nadadoras após seis semanas de treinamento anaeróbico de resistência foi significativamente menor do que a média de pré-treinamento (P<0,05). Após seis semanas de treinamento de resistência anaeróbica, o conteúdo de testosterona/cortisol plasmático dos nadadores masculinos era menor do que o do grupo padrão (P<0,05). Conclusão: Os corpos dos nadadores foram impactados após o treinamento de resistência anaeróbica. Ressalta-se a importância da atenção pelo treinador em considerar as diferenças entre os atletas masculinos e femininos quando realizar um treinamento do limiar anaeróbico dedicado.* ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

***Descritores:*** *Natação; Limiar Anaeróbico; Condicionamento Físico Humano; Atletas.*

## *RESUMEN*

*Introducción: El ejercicio anaeróbico es un factor crítico en el entrenamiento de la natación. Los entrenadores que controlan la capacidad anaeróbica de un atleta pueden utilizar esta herramienta para mejorar el rendimiento competitivo. Objetivo: Analizar el efecto de la prueba de función anaeróbica en el entrenamiento de los nadadores. Métodos: Examinamos la capacidad de ejercicio anaeróbico de los nadadores, la relación entre la composición corporal humana y la capacidad de trabajo anaeróbico. Para ello, se seleccionaron 14 nadadores por muestreo aleatorio. Se midieron el umbral anaeróbico individual, la testosterona sérica y el cortisol sérico de los atletas en diferentes períodos. Resultados: Los umbrales anaeróbicos individuales fueron significativamente más bajos en los atletas masculinos y femeninos después del entrenamiento. La diferencia fue estadísticamente significativa (P<0,05). El contenido de testosterona/cortisol en plasma de las nadadoras después de seis semanas de entrenamiento de resistencia anaeróbica fue significativamente inferior a la media previa al entrenamiento (P<0,05). Después de seis semanas de entrenamiento de resistencia anaeróbica, el contenido de testosterona/cortisol en plasma de los nadadores masculinos fue inferior al del* *grupo estándar (P<0,05). Conclusión: Los cuerpos de los nadadores sufrieron un impacto después del entrenamiento de resistencia anaeróbica. Se destaca la importancia de que el entrenador tenga en cuenta las diferencias entre los atletas masculinos y femeninos a la hora de realizar un entrenamiento dedicado al umbral anaeróbico.* ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

***Descriptores*****:** *Natación; Umbral Anaerobio; Acondicionamiento Físico Humano; Atletas.*

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## INTRODUCTION

The personal anaerobic threshold is an essential biochemical indicator. It can be used to judge the aerobic level of a swimmer. Serum testosterone and blood cortisol are two specific steroid hormones. The former is a measure of the physical state of an athlete in stages, and it also indirectly reflects the degree of adaptation to training intensity.[1] In this paper, anaerobic endurance training is carried out for high-level swimmers. At the same time, we measured serum testosterone, serum cortisol value, and personal anaerobic threshold and studied their dynamic changes. The research conclusions of this paper provide a reference for the reasonable arrangement of anaerobic endurance training for elite athletes.

## METHOD

### Subjects

This paper takes 14 swimmers as the research object.[2] The average age of athletes is 20-25 years old. There were no statistical differences in age, years of training, or physical fitness of the athletes.

### Investigation method

When the anaerobic metabolism approaches or reaches the limit, this paper generally uses a blood lactate swimming rate of 12 mmol/L to improve the anaerobic endurance of athletes.[3] This article sets out the intensity of anaerobic endurance training for every excellent swimmer.

A load of exercise. Athletes have six training sessions per week. Each class focuses on anaerobic energy metabolism[4]—for about two hours. Athletes should strictly control the appropriate training intensity during anaerobic endurance training. Such a load training program is six weeks.

This paper measures an athlete's anaerobic threshold before starting the training cycle. From 7:00 to 8:00 in the morning, the athletes used radioimmunoassay to detect testosterone and plasma cortisol plasma.[5] This article measured the athletes' anaerobic thresholds, serum testosterone, and cortisol during six weeks of anaerobic endurance training.

The relationship between swimming intensity and physical fatigue

This paper presents a sample set $(a_i, b_i)$ of training intensities for swimmers. $a_i$ is used to describe the intensity of the action. $b_i$ is used to describe physical fatigue. The problem to be solved at present is how to find an optimal hyperplane under a certain precision.[6] All sample points will not be more than $\varepsilon$ from the optimal hyperplane. This paper transforms the current optimization problem into a minimal model complexity. This is equivalent to transforming it into the corresponding quadratic programming problem.

$$\begin{cases} y = \min \frac{1}{2} \| a-b \|^2 \\ \begin{cases} b_i - (a-b)\cdot x - b \le \varepsilon \\ (a-b)\cdot x + b - a \le \varepsilon \end{cases} \end{cases} \tag{1}$$

Because there is fault tolerance in the formula, this paper can introduce a relaxation variable $\xi$ adapted to the penalty factor $C$, and the corresponding quadratic programming problem can be described as (2)

$$\begin{cases} y = \min \frac{1}{2} \| a-b \|^2 + C\sum_{i=1}^{n} \xi_i \\ \begin{cases} b_i - (a-b)\cdot x - b \le \varepsilon + \xi_i \\ (a-b)\cdot x + b - a \le \varepsilon + \xi_i \end{cases} \end{cases} \tag{2}$$

In this paper, the above problem is transformed into a dual problem, and then the optimal regression equation is solved:

$$f(x) = ((a-b)\cdot x) + b = \sum_{i=1}^{n} (\alpha_i - a_i^*)(x \cdot x_i) + b \tag{3}$$

$0 \le \alpha_i,\ a^*_i \le C$ differs from the classification problem in that there is only a small number of sample support vectors $\alpha_i,\ a^*_i$ .

### Data processing

In this paper, SPSS statistical software was used to process the data. The results show that P<0.05 is more significant.[7] Test results are expressed as mean + standard deviation.

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

## RESULTS

Before starting the anaerobic endurance training cycle, the individual's anaerobic threshold, serum testosterone, and cortisol values were maintained at a relatively stable level.[8] Changes in individuals' anaerobic threshold, serum testosterone/serum cortisol, after an anaerobic endurance training cycle (Table 1 and 2).

It can be seen from Table 1 that in the second week of anaerobic endurance training, the individual anaerobic thresholds of male and female athletes were lower than those before training. There are apparent differences between the different genders.[9] The results showed that after four weeks of anaerobic endurance training, the individual anaerobic

**Table 1.** Changes in individual anaerobic thresholds of swimmers during anaerobic endurance training.

| Time | Individual anaerobic threshold (m/s) | |
|---|---|---|
| | Male | Female |
| before cycle | 1.87±0.41 | 1.8±0.25 |
| Two weeks later | 1.83±0.2 | 1.78±0.29 |
| Four weeks later | 1.79±0.25 | 1.75±0.12 |
| After six weeks | 1.78±0.14 | 1.75±0.23 |

**Table 2.** Changes in plasma cortisol/testosterone levels in swimmers during anaerobic endurance training.

| Time | Serum testosterone (ng/dl)/serum cortisol (µg/dl) | |
|---|---|---|
| | Male | Female |
| before cycle | 33.67±12.79 | 3.77±0.68 |
| Two weeks later | 39.68±9.97 | 3.51±0.51 |
| Four weeks later | 34.22±14.93 | 3.37±0.1 |
| after six weeks | 28.42±7.84 | 2.3±0.79 |

thresholds of male and female athletes were lower than those before training, and the difference was statistically significant ($P<0.01$). After six weeks of anaerobic endurance training, the anaerobic thresholds of male and female athletes decreased by -0.08 m/s and -0.05 m/s, respectively.

It can be seen from Table 2 that the serum testosterone/cortisol content of male swimmers after two weeks of anaerobic endurance training is higher than that of the standard group. There were no significant differences in serum testosterone/cortisol levels among athletes after four weeks of anaerobic endurance training.[10] After six weeks of anaerobic endurance training, athletes had a 15.6% reduction in plasma testosterone/cortisol levels. Female swimmers' serum testosterone/cortisol levels after 2 and 4 weeks of anaerobic endurance training were not significantly different from the mean levels before the start of the training cycle. After six weeks of anaerobic endurance training, serum testosterone/cortisol levels were significantly lower in athletes.

## DISCUSSION

Serum testosterone and plasma cortisol are two specific steroid hormones. It inhibits muscle glycogenolysis, activates glycogen synthesis, promotes erythropoiesis, and synthesizes proteins. Serum testosterone also plays a nutritional role in neuro-muscle conduction. The primary function of plasma cortisol is to break down proteins into sugars and facilitate the breakdown and redistribution of fats.[11] At the same time, cortisol in plasma also has weak sodium retention and potassium excretion effect. This increases the kidneys' ability to filter free water and reduces its reabsorption capacity. Under normal physiological conditions, serum cortisol and testosterone metabolism are balanced and coordinated. Plasma concentrations of anatomical and synthetic hormones were unchanged. After short-term high-intensity exercise, two hormones, plasma cortisol, and blood testosterone, showed a synchronous upward trend. The changes in the two hormones show opposite trends during long-term, high-intensity physical activity. Plasma cortisol levels rise while serum testosterone levels fall.

After two weeks of anaerobic endurance training, blood cortisol levels were significantly higher in both male and female athletes. Both anabolism and catabolism are enhanced in athletes during high-intensity training. Male and female athletes had similar increases in serum testosterone levels under the same load, while male and female serum cortisol levels differed. After two weeks of anaerobic endurance training, serum testosterone/cortisol levels in female athletes were comparable to levels before the training cycle. Physical stimulation of female athletes was greater than that of male athletes after two weeks of exercise load training. Male athletes showed better physical fitness than female athletes after two weeks of anaerobic endurance exercise.

The levels of catabolism in male swimmers increased significantly after four weeks of anaerobic endurance training. Anabolic levels were significantly reduced. There was no statistically significant difference in testosterone/cortisol levels. After six weeks of anaerobic endurance training, testosterone levels dropped significantly in both men and women. Serum cortisol levels were significantly higher in men and women. High serum testosterone helps promote muscle protein synthesis and inhibits muscle glycogen breakdown. High levels of plasma cortisol can lead to the breakdown and metabolism of proteins that affect the development of exercise capacity. Both anabolism and catabolism improved in athletes after six weeks of anaerobic endurance training. Plasma testosterone/cortisol levels were significantly lower than the individual anaerobic thresholds for the corresponding period.

The anaerobic energy supply system includes a phosphoric acid source and a lactic acid energy system. The phosphagen system is a combination of ATP and CP. ATP is stored in muscles. The content of CP in muscle is 3 to 5 times that of ATP. Through the rate of ATP degradation, CP can most directly resynthesize it. Because both are high-energy phosphate compounds, they are called phosphate systems. During high-intensity exercise, the content of CP in muscle decreased sharply, but the content of ATP did not change significantly. It has the advantages of less total energy, short duration, maximum output power, no oxygen, no lactic acid, etc.

The lactic acid system is an energy system. It is produced by the anaerobic degradation of glycogen or glucose within cells. Because its final product is lactic acid, we call it the lactic acid system. Lactic acid is an acidic substance. Once accumulated to a certain extent, it will destroy the pH balance in the human body and inhibit the anaerobic glycolysis of sugar. This will affect the synthesis of ATP and cause fatigue in the body. There are many ways to assess anaerobic exercise capacity. The contents include Wingate anaerobic test, Margarita step test, critical power test, etc. The Wingate test is a method widely used in clinical practice to evaluate anaerobic exercise capacity. Average power is a measure of the sustained ability of a muscle to withstand greater power. Its size is related to the highest decomposition rate of ATP and the highest synthesis rate of CP and carbohydrates within 30 seconds. The human body's anaerobic enzymatic hydrolysis capacity, lactic acid buffering capacity, and the ability of brain cells to withstand blood pH are essential indicators that determine the body's anaerobic endurance.

During exercise, we usually use anaerobic average power and fatigue index to evaluate the exercise capacity of the body comprehensively. The fatigue index is the maximum fast muscle fiber accumulation and deaccumulation value. It is an essential indicator of rapid muscle fiber accumulation and deaccumulation. Too high indicates that the subject's anaerobic endurance is poor. A tiredness index that's too low means they're not doing the test as hard as possible. The fatigue index refers to the athlete's ability to maintain maximum anaerobic capacity. If the skill is more powerful, it will be faster. There was no significant difference in fatigue index compared with before exercise, but there were different degrees of reduction. This suggests that pre-competition staged training can help improve an athlete's anaerobic endurance.

## CONCLUSION

After six weeks of anaerobic endurance training, the hypoxic threshold was significantly lower in male and female athletes. This shows that elite athletes are subject to a specific load under such a high load state. After six weeks of anaerobic endurance training, serum testosterone/cortisol levels were significantly lower in female swimmers. Female swimmers' bodies are much more stressed. When conducting anaerobic endurance training, coaches should consider the different genders of male and female athletes.


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