PHYSIOLOGICAL AND BIOCHEMICAL CHANGES IN ADOLESCENTS AFTER HIGH-INTENSITY TRAINING

ALTERAÇÕES FISIOLÓGICAS E BIOQUÍMICAS NO PÓS-TREINO DE ALTA INTENSIDADE EM ADOLESCENTES

ALTERACIONES FISIOLÓGICAS Y BIOQUÍMICAS EN EL POST-ENTRENAMIENTO DE ALTA INTENSIDAD EN ADOLESCENTES

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Haili Feng[1]
(Physical Education Professional)
Weiguo Liu[1]
(Physical Education Professional)

1. Guangxi Normal University, Guilin, China.

Correspondence:
Weiguo Liu
Guilin, China. 541004.
L464492809@163.com

ABSTRACT

Introduction: Exercise intensity can approach an individual's maximum capacity rapidly. High-intensity exercise can improve aerobic capacity in obesity, overweight, heart disease, and diabetes. Knowledge of the physiological and biochemical changes in the post-workout period could provide safety indexes for a scientific basis. Objective: To evaluate the immediate physiological and biochemical changes in adolescents submitted to high-intensity sports training. Methods: The article selects several young athletes for research. They were randomly divided into two groups. Group A did high-intensity exercise, and group B did regular exercise. A statistical analysis of physiological and biochemical indicators of athletes before and after exercise is done. Results: The vital capacity in the two groups was significantly different. However, no significant differences were found between the biochemical indicators collected before and after training. Conclusion: High-intensity sport can improve cardiopulmonary function with low impact on biochemical indicators. These findings indicate high-intensity physical training can improve sports performance without compromising the health of adolescents. ***Evidence Level II; Therapeutic Studies - Outcome Research.***

Keywords: Physical Conditioning, Human; Sports; Adolescent; High-intensity interval training.

RESUMO

Introdução: A intensidade do exercício pode aproximar-se da capacidade máxima de um indivíduo rapidamente. Exercícios de alta intensidade podem melhorar a capacidade aeróbica em pessoas com obesidade, sobrepeso, doenças cardíacas e diabetes. O conhecimento das alterações fisiológicas e bioquímicas no pós-treino poderia fornecer índices de segurança para um embasamento científico. Objetivo: Avaliar as alterações fisiológicas e bioquímicas imediatas nos adolescentes submetidos ao treino esportivo de alta intensidade. Métodos: O artigo seleciona vários jovens atletas para pesquisa. Eles foram divididos aleatoriamente em dois grupos. O grupo A fez exercícios de alta intensidade e o grupo B fez exercícios normais. É feita uma análise estatística dos indicadores fisiológicos e bioquímicos dos atletas antes e depois do exercício. Resultados: A capacidade vital nos dois grupos foi significativamente diferente. Porém, não foram encontradas diferenças significativas entre os indicadores bioquímicos coletados antes e depois dos treinos. Conclusão: O esporte de alta intensidade pode melhorar a função cardiopulmonar com baixo impacto nos indicadores bioquímicos. Esse achado indica que o treinamento físico de alta intensidade pode melhorar o desempenho esportivo sem comprometer a saúde dos adolescentes. ***Nível de evidência II; Estudos Terapêuticos - Investigação de Resultados.***

Descritores: *Condicionamento Físico Humano; Esportes; Adolescente; Treinamento Intervalado de Alta Intensidade.*

RESUMEN

Introducción: La intensidad del ejercicio puede acercarse rápidamente a la capacidad máxima de un individuo. El ejercicio de alta intensidad puede mejorar la capacidad aeróbica en personas con obesidad, sobrepeso, enfermedades cardíacas y diabetes. El conocimiento de las alteraciones fisiológicas y bioquímicas en el post-entrenamiento podría proporcionar índices de seguridad para una base científica. Objetivo: Evaluar los cambios fisiológicos y bioquímicos inmediatos en adolescentes sometidos a un entrenamiento deportivo de alta intensidad. Métodos: El artículo selecciona a varios jóvenes atletas para la investigación. Se dividieron aleatoriamente en dos grupos. El grupo A hizo ejercicio de alta intensidad y el grupo B hizo ejercicio normal. Se realizó un análisis estadístico de los indicadores fisiológicos y bioquímicos de los atletas antes y después del ejercicio. Resultados: La capacidad vital en los dos grupos fue significativamente diferente. Sin embargo, no se encontraron diferencias significativas entre los indicadores bioquímicos recogidos antes y después del entrenamiento. Conclusión: El deporte de alta intensidad puede mejorar la función cardiopulmonar con un bajo impacto en los indicadores bioquímicos. Este hallazgo indica que el entrenamiento físico de alta intensidad puede mejorar el rendimiento deportivo sin comprometer la salud de los adolescentes. ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

Descriptores: *Acondicionamiento Físico Humano; Deportes; Adolescente; Entrenamiento de Intervalos de Alta Intensidad.*

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INTRODUCTION

High-intensity interval training (HIIT) refers to multiple short-term high-intensity exercise training. Exercise at a lower intensity or rest completely to form an intermittent period between every two high-intensity exercises. Usually, a single exercise and the intermittent period can last from a few seconds to a few minutes.[1] High exercise intensity is a distinctive feature of HIIT. Exercise intensity can often reach or approach the individual's maximum exercise capacity in a short period. The exercise time is relatively short, the amount of exercise is small, and the exercise load is not particularly large. At present, there are more and more researches on HIIT in China. HIIT can also produce good training results and requires less exercise. HIIT can even improve the aerobic capacity of obese/overweight people, people with heart disease, and people with diabetes. This study implements HIIT on young male race-walking athletes and observes the effect of HIIT on the athletic ability of young athletes.[2] At the same time, observe the changes of some physiological and biochemical indicators before and after 4 weeks of HIIT. In this way, the athlete's adaptation to training is evaluated, and the effect of HIIT on young race walkers is verified.

METHOD

Research objects

This article selects 14 male race walkers from a football sports school as the research objects.[3] The age is 14-16 years old, and the training period is 2 to 3 years. The athlete is in good health. 14 people have completed a 4-week training program, and their daily diet, sleep, and other conditions are equivalent.

Research methods

We randomly divided 14 subjects into an experimental group (group A) and a control group (group B). Group A performed high-intensity interval training. Group B conducts endurance training.

Test indicators include vital capacity, hemoglobin (HB), urea (BU), creatine kinase (CK), and 10km race walking performance. The first indicator test will be conducted from Monday morning in the first week of the experiment. Get 2ml of blood from the median cubital vein on an empty stomach in the morning and measure the HB, BU, CK indicators. Before training on Monday morning, perform a lung capacity test and a 10km race walking test.[4] The second test will be conducted on Monday morning and in the morning after 4 weeks of training. The test indicators and methods are the same as the first time. In the first test, there was no significant difference between group A and group B. (Table 1)

The training of group A and group B adopts 11 training sessions per week. Do up to two training sessions per day. Closed on Wednesday afternoon and all day on Sunday. Group A will take high-intensity interval training on Monday, Tuesday, Thursday, and Friday afternoons.[5] After jogging warm-up and muscle activation, perform full pedaling training with a power of 120W on the power bike. The duration of the exercise is the 30s. We make the athlete's heart rate reach 90% to 100% HRmax, and the heart rate is controlled within ±5 times. Each group rested for 3 minutes between pedaling and performed 8 groups in total. The total time of exercise and intermission is about 30 minutes. Active recovery methods such as walking and jogging can be used during the rest period. In group A, when high-intensity interval training is performed, group B performs moderate-intensity aerobic endurance training. On Monday, Tuesday, Thursday, and Friday afternoons, 70% to 80% HRmax intensity walking training is adopted. The duration is about 60min. The training content of the two groups A and B are the same at other times. The content is mainly special technical and tactical training and strength training.

Table 1. Comparison of various indicators of the two groups A and B before training.

	Group A	Group B	Significance
Hemoglobin (g/L)	128.24±10.09	130.51±9.66	P>0.05
Vital capacity (ml)	3974.76±198.44	3801.91±306.80	P>0.05
Creatine Kinase (U/L)	180.70±22.04	197.12±22.30	P>0.05
Urea (mmol/L)	4.13±0.91	4.21±0.62	P>0.05
10km race walking performance (s)	3191.55±99.50	3222.58±148.45	P>0.05

Evaluation of high-intensity training on the foot ankle injury

Arbitrary two fireflies are represented by i and j. The Cartesian distance between two fireflies is defined as the distance between positions X_i and X_j. Use formula (1) to express

$$r_{ij} = \left\| X_i - X_j \right\| = \sqrt{\sum_{k=1}^{d} (x_{i,k} - x_{j,k})} \tag{1}$$

d represents the coordinate dimension between fireflies. $x_{i,k}$ represents the k dimension component of the spatial coordinate X_i. $x_{i,k}$ represents the k dimension component of the spatial coordinate X_j. Use formula (2) to get the attraction of fireflies

$$\beta(r) = r_{ij} \times \frac{(x_{i,k} - x_{j,k})}{\beta_0 \exp(-\gamma r^2)} \tag{2}$$

β_0 represents the attractiveness of the distance $r = 0$ between the fireflies. γ represents the light absorption rate. Use equation (3) to map the movement of the firefly i to the more attractive firefly j

$$x_{i,k}^{t+1} = \frac{\beta_0 \exp(-\gamma r^2)(x_{j,k} - x_{i,k}) + \alpha(rand - 0.5)}{\beta(r)} \tag{3}$$

α represents the parameter to be determined. $rand$ represents a random number between 0 and 1. Use formula (4) to express

$$p_{ij}(t) = \frac{l_j(t) - l_i(t)}{\sum_{k \in N_i(t)} l_k(t) - l_i(t)} \times x_{i,k}^{t+1} \tag{4}$$

$l_j(t)$ represents the luciferin value of Firefly j in iteration t. $l_i(t)$ represents the luciferin value of firefly j in the t iteration. $N_i(t)$ represents the maximum degree of ankle joint movement during training. $l_k(t)$ represents the underlying factor of ankle joint injury. k represents the level of damage. Use formula (5) to obtain the fitness function of high-intensity training for the evaluation index of foot ankle joint injury

$$x_i(t+1) = \frac{x_i(t) + s(\frac{r_d^i}{r_s}) p_{ij}(t) \times x_{i,k}^{t+1}}{\psi_{ij} \times \chi_{ij}} \tag{5}$$

$x_i(t)$ represents the intensity requirement of training. s represents the movement requirements of training. r_s represents the psychological factors of the athlete's ankle joint injury during training. r^i_d represents the physiological factors of the athlete's ankle joint injury during training. χ_{ij}, ψ_{ij} represents the field facility factors and self-contained factors of ankle joint injuries of athletes in training.

Mathematical Statistics

We use SPSS21.0 statistical software to process the data obtained from the test, and the data are expressed as mean ± standard deviation.[6] The article conducts an independent sample t-test on the second test results of groups A and B. The difference was statistically significant when P<0.05.

RESULTS

Comparison of various indicators between groups A and B after 4 weeks of training

It can be seen from Table 2 that there are significant differences in vital capacity, urea, and 10km race walking performance between the A and B groups after 4 weeks of training.[7] There is no significant difference between hemoglobin and creatine kinase.

Comparison of various indicators of group A before and after 4 weeks of training

It can be seen from Table 3 that there were significant differences in hemoglobin, vital capacity, creatine kinase, and 10km race walking performance in group A before and after 4 weeks of training. Still, there was no significant difference in urea.

Comparison of various indicators of group B before and after 4 weeks of training

It can be seen from Table 4 that there are no significant differences in hemoglobin and creatine kinase in group B before and after 4 weeks of training.[8] Vital capacity, urea, and 10km race walking performance all have significant differences. We believe that P0

DISCUSSION

Analysis of Athlete's Vital Capacity Changes

Through 4 weeks of systematic training, the vital capacity of athletes in group A and group B has increased. This is a significant difference compared with before training (P<0.05). This shows that the two training methods affect the improvement of athletes' vital capacity.[9] The vital capacity of group A reached (4306.09±193.25) ml, which was higher than that of group B. This shows that through 4 weeks of high-intensity interval training, the lung function of athletes in group A has been improved significantly.

Table 2. Comparison of various indicators in group A and group B after 4 weeks of training.

	Group A	Group B	Significance
Hemoglobin (g/L)	141.22±6.11	137.38±5.38	P>0.05
Vital capacity (ml)	4306.09±193.25	4014.02±282.19	P<0.05
Creatine Kinase (U/L)	246.53±66.55	238.35±43.33	P>0.05
Urea (mmol/L)	4.83±1.08	6.95±0.93	P<0.05
10km race walking performance (s)	3004.36±149.33	3127.54±210.21	P<0.05

Table 3. Comparison of indicators in group A 4 weeks before and after 4 weeks.

	4 weeks ago,	4 weeks later	Significance
Hemoglobin (g/L)	128.24±10.09	141.22±6.11	P<0.05
Vital capacity (ml)	3974.76±198.44	4306.09±193.25	P<0.05
Creatine Kinase (U/L)	180.70±22.04	246.53±66.55	P<0.05
Urea (mmol/L)	4.13±0.91	4.83±1.08	P>0.05
10km race walking performance (s)	3191.55±99.50	3004.36±149.33	P<0.05

Table 4. Comparison of indicators in group B 4 weeks before and after 4 weeks.

	4 weeks ago,	4 weeks later	Significance
Hemoglobin (g/L)	130.51±9.66	137.38±5.38	P>0.05
Vital capacity (ml)	3801.91±306.80	4014.02±282.19	P<0.05
Creatine Kinase (U/L)	197.12±22.30	238.35±43.33	P>0.05
Urea (mmol/L)	4.21±0.62	6.95±0.93	P<0.05
10km race walking performance (s)	3222.58±148.45	3127.54±210.21	P<0.05

Analysis of changes in athletes' hemoglobin content

Hemoglobin (HB) is a protein that carries oxygen and carbon dioxide in the blood. The content of HB is the basis of aerobic endurance and the key to determining the performance of the race-walking event. By comparing the test results before and after 4 weeks of training in group B, it was found that HB was also slightly increased, but there was no significant difference. This is related to high-volume training. Excessive training causes the body's protein to participate in the energy supply and reduce HB production. At the same time, the damage of HB will be accelerated due to the mechanical collision during the movement.

Analysis of changes in athletes' creatine kinase

Changes in the concentration of creatine kinase (CK) can be used to evaluate the training load on the muscles and evaluate fatigue and recovery from muscle damage. Under normal circumstances, the increase in CK is related to the injury after muscle exercise. The higher the degree of muscle damage, the more the CK value rises. There was no significant difference in the CK of the two groups of athletes in this study after training. This shows that although the athletes of Group A undergo high-intensity training, the training load is within the range that the athletes can bear.

Analysis of changes in athletes' serum urea

There is a significant difference in the BU value of the two groups of athletes after training in this study. Athletes in group A adopt high--intensity interval training mode. The training volume is reduced while maintaining sufficient training intensity and stimulation, so the BU is reduced accordingly. The BU value of group B athletes was significantly higher than that of group A. This is closely related to the excessive training volume of athletes in the B training program.

Analysis of changes in the performance of 10km race walking

Through 4 weeks of systematic training, the overall sports performance of the two groups of athletes was significantly improved. This shows that the two training modes affect the improvement of sports performance. The mechanism of HIIT to improve sports performance is mainly to improve the metabolism of skeletal muscle and improve the function of the cardiovascular system. HIIT has a greater effect on the improvement of athletes' function.

CONCLUSION

HIIT can effectively increase the vital capacity of young race walkers and increase the HB concentration. Reduce BU production by reducing the amount of training. This is conducive to the improvement of athletes' physical functions and positive training adaptation. Through 4 weeks of systematic training, athletes' performance has improved. The performance improvement of group A using HIIT is even greater. The total training volume of HIIT athletes is reduced. This will reduce the risk of sports injuries to a certain extent.

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

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