EFFECTS OF RESISTANCE TRAINING ON EXERCISE TOLERANCE IN MARATHON RUNNERS

EFEITOS DO TREINAMENTO DE RESISTÊNCIA SOBRE A TOLERÂNCIA AO EXERCÍCIO EM CORREDORES DE MARATONA

EFECTOS DEL ENTRENAMIENTO DE RESISTENCIA SOBRE LA TOLERANCIA AL EJERCICIO EN CORREDORES DE MARATÓN

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ABSTRACT

Introduction: A high index of exercise tolerance is fundamental for marathon runners, indicating a good capacity to perform the exercises considering their maximum duration and workload. Objective: Evaluate the effects of resistance training with different loads on exercise tolerance of marathon runners. Methods: 120 professional long-distance runners were selected as volunteers for the experiment. Divided into experimental groups A, B and Control, the intervention had a 9-week period. The experimental groups A and B received resistance training with different loads, while the Control group did not undergo training intervention. Results: Upper limb muscle mass increased from 3.38 ± 0.18 to 3.75 ± 0.37 in group A; from 3.40 ± 0.15 to 3.66 ± 0.31 in group B; peak biceps brachii moment increased from 53.60 ± 6.27 to 62.97 ± 8.87 in group A; from 53.67 ± 5.68 to 58.48 ± 6.16 in group B; from 5. 37 ± 2.16 to 5.73 ± 2.67 in group A; from 7.21 ± 2.62 to 6.76 ± 4.36 in group B; and from 154.86 ± 19.69 to 108.30 ± 31.75 in group A; group B presented a reduction from 156.97 ± 46.13 to 116.45 ± 39.09, and the data from the control group did not change significantly. Conclusion: Resistance training with different loads in daily training can effectively improve the endurance of long-distance runners. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Training, Endurance; Marathon Running; Athletes; Exercise Tolerance.

RESUMO

Introdução: Um índice elevado de tolerância ao exercício é fundamental para corredores de maratona, sinalizando uma boa capacidade para a realização dos exercícios considerando sua duração máxima e carga de trabalho. Objetivo: Avaliar os efeitos do treinamento de resistência com distintas cargas sobre a tolerância ao exercício dos corredores de maratona. Métodos: Foram selecionados 120 corredores profissionais de longa distância como voluntários para o experimento. Divididos em grupo experimental A, B e Controle, a intervenção teve um período de 9 semanas. Os grupos experimentais A e B receberam treinamento de resistência com cargas diferentes, enquanto o grupo Controle não sofreu intervenção de treinamento. Resultados: A massa muscular dos membros superiores elevou-se de 3,38 ± 0,18 para 3,75 ± 0,37 no grupo A; de 3,40 ± 0,15 para 3,66 ± 0,31 no grupo B; o momento de pico do bíceps braquial aumentou de 53,60 ± 6,27 para 62,97 ± 8,87 no grupo A; de 53,67 ± 5,68 para 58,48 ± 6,16 no grupo B; de 5. 37 ± 2,16 para 5,73 ± 2,67 no grupo A; de 7,21 ± 2,62 para 6,76 ± 4,36 no grupo B; e de 154,86 ± 19,69 para 108,30 ± 31,75 no grupo A; o grupo B apresentou redução de 156,97 ± 46,13 para 116,45 ± 39,09, e os dados do grupo de controle não sofreram alterações significativas. Conclusão: O treinamento de resistência com diferentes cargas no treinamento diário pode efetivamente melhorar a resistência dos corredores de longa distância. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Treinamento de Resistência; Corrida de Maratona; Atletas; Tolerância ao Exercício.*

RESUMEN

Introducción: Un alto índice de tolerancia al ejercicio es fundamental para los corredores de maratón, indicando una buena capacidad para realizar los ejercicios, considerando su máxima duración y carga de trabajo. Objetivo: Evaluar los efectos del entrenamiento de resistencia con diferentes cargas sobre la tolerancia al ejercicio de corredores de maratón. Métodos: 120 corredores profesionales de larga distancia fueron seleccionados como voluntarios para el experimento. Divididos en los grupos experimentales A, B y Control, la intervención tuvo una duración de 9 semanas. Los grupos experimentales A y B recibieron entrenamiento de resistencia con diferentes cargas, mientras que el grupo Control no se sometió a intervención de entrenamiento. Resultados: La masa muscular del miembro superior aumentó de 3,38 ± 0,18 a 3,75 ± 0,37 en el grupo A; de 3,40 ± 0,15 a 3,66 ± 0,31 en el grupo B; el momento máximo del bíceps braquial aumentó de 53,60 ± 6,27 a 62,97 ± 8,87 en el grupo A; de 53,67 ± 5,68 a 58,48 ± 6,16 en el grupo B; de 5. 37 ± 2,16 a 5,73 ± 2,67 en el grupo A; de 7,21 ± 2,62 a 6,76 ± 4,36 en el grupo B; y de 154,86 ± 19,69 a 108,30 ± 31,75 en el grupo A; el grupo B presentó una reducción de 156,97 ± 46,13 a 116,45 ± 39,09, y los datos *del grupo control no sufrieron cambios significativos. Conclusión: El entrenamiento de resistencia con diferentes cargas en el entrenamiento diario puede mejorar eficazmente la resistencia de los corredores de fondo.* ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Entrenamiento de Resistencia; Carrera de Maratón; Atletas; Tolerancia al Ejercicio.*

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INTRODUCTION

Resistance training is often referred to as strength training. Resistance training with different loads usually refers to a process in which the body overcomes the resistance of body muscles to achieve muscle increase and strength enhancement after exercise.[1] Resistance training has gradually evolved into one of the main training methods for people's daily exercise and exercise fitness. Because the tools for measuring resistance training energy consumption are relatively expensive and mostly limited to laboratories, the development of immediate evaluation of general fitness effects is limited.[2] At present, China has not paid enough attention to the research on the impact of resistance training on the sports endurance of long-distance runners, and there is not enough research on resistance training and sports endurance training, so it is necessary to conduct further research.[3] Long distance running is the most common cycle endurance sport, which requires high endurance and perseverance of athletes. For most long-distance runners, they need not only the speed training of sprinters, but also long-term and strict endurance training.[4] At the same time, they need to increase their exercise volume and weight to reach a better sports level. With the development of China's economy and the proposal of the sports power strategy, China's overall sports ability has improved significantly. In recent years, in international competitions, it is often seen that Chinese athletes have won and stood proudly on the podium.[5] Although Chinese athletes have made outstanding achievements in many sports, there is still a huge gap between Chinese and foreign athletes in track and field. Among them, long-distance running is a difficult challenge for many athletes.[6] It not only needs to beat the opponent in speed, but also a severe challenge for the endurance of athletes. Because in the process of long-distance running training, we should pay attention to and improve the shortcomings of athletes' endurance training methods, and use scientific and reasonable methods to conduct effective endurance quality training for long-distance runners.[7] Therefore, this paper uses resistance training with different loads to explore the impact on the endurance of long-distance runners.

METHOD

Research object

The experimental subjects in this paper are 120 professional long-distance runners. There is no significant difference in the physical indicators of these selected experimental subjects. The study and all the participants were reviewed and approved by Ethics Committee of Ningbo University (NO.NBUST20F092). The age distribution is about 22 years old, the height is more than 175cm, the weight is more than 75kg, and the BMI value is more than 24. See Table 1 for details. During the experiment, 120 professional long-distance runners were divided into three groups, including the control group, experimental group A and experimental group B, and the experimental group A and experimental group B were given intervention training for 9 weeks, while the control group did not carry out any load resistance training, but only routine related long-distance running training. In the 9-week experiment, the subjects kept normal work and rest and diet, so as to further study the impact of resistance training with different loads on the endurance of long-distance runners.

Table 1. Basic information of the subject.

Group	Control group	Experimental group A	Experimental group B	P
Age (y)	22.25±1.623	22.58±1.533	22.79±1.463	P>0.05
Height (cm)	178.23±4.739	175.44±4.358	178.76±4.729	P>0.05
Weight (kg)	77.72±2.589	76.49±4.499	76.02±4.932	P>0.05
BMI	24.00±2.025	25.12±2.095	24.99±2.293	P>0.05

Experimental methods

Before the experiment, 120 subjects were measured for various physical indicators, and these measured data passed the independence experiment, with P values higher than 0.05. During the experiment, the athletes in the experimental group were further divided into group A and group B according to their different physical qualities, and load resistance training was carried out at different levels. The control group only carried out daily training and did not participate in load resistance training. For group A with good physical quality, load resistance training of medium and high intensity was carried out, and for group B with general physical quality, load resistance training of primary intensity was carried out. During the nine week experimental period, the changes of various indicators of long-distance runners were recorded through professional equipment, including the changes of upper limb muscle mass, peak torque of biceps brachii, changes of blood lactic acid after long-distance running, and changes of creatine kinase after long-distance running recovery, and information was summarized every three weeks. In the course of the experiment, the total amount of load resistance training should be increased appropriately by means of gradual training and periodic recording of data, so as to achieve the required training effect. At the same time, it can also avoid irreversible injuries to athletes caused by excessive load resistance training. At the end of the experiment, the data of the control group, experimental group A and experimental group B were analyzed and compared, and then the impact of different load resistance training on the endurance of long-distance runners was analyzed.

Experimental location

The experiment was carried out in the track and field. Before the experiment, the safety performance of the infrastructure in the track and field was tested to avoid unnecessary sports injuries to the long-distance runners participating in the experiment during the training process. Finally, all data tests were in line with the safety standards.

RESULTS

Effect of resistance training with different loads on upper limb muscle volume of long-distance runners

Through 9 weeks of load resistance training for 3 groups of long--distance runners, the changes of upper limb muscle mass of athletes are shown in Table 2.

Through the comparison and analysis of the upper limb muscle mass data of the three groups of experimental subjects, it can be clearly seen that the upper limb muscle mass of the long-distance runners in Group

A and Group B of the experiment has significantly increased, and the upper limb muscle mass of the long-distance runners has continuously increased, while the upper limb muscle mass of the long-distance runners in the control group has not changed much, and even has a decreasing trend, and the change of the data in Group A of the experiment is greater than that in Group B.

Changes of peak torque of biceps brachii in long-distance runners under different load resistance training

After 9 weeks of resistance training with different levels of load, the changes of peak torque of biceps brachii of three groups of long-distance runners are shown in Table 3.

After 9 weeks of load resistance training, the peak torque of biceps brachii of long-distance runners in Group A and Group B of the experiment has changed significantly, and the peak torque of biceps brachii continues to increase, and the change degree of the peak torque of biceps brachii of long-distance runners in Group A of the experiment is significantly higher than that of Group B of the experiment, while the data of the peak torque of biceps brachii of long-distance runners in the control group who only carry out daily training have not changed significantly before and after, And the peak torque of biceps brachii decreased.

Effect of resistance training with different loads on blood lactic acid of long-distance runners after long-distance running

After 9 weeks of load resistance training for 3 groups of long-distance runners, the changes of blood lactic acid after long-distance running are shown in Table 4.

By comparing the changes of blood lactic acid data of long-distance runners after the completion of long-distance running in the 9-week experiment, it can be seen that the changes of blood lactic acid of experimental subjects in Group A and Group B are more obvious after the completion of long-distance running, and the values of blood lactic acid of the three groups of experimental subjects after the completion of long-distance running are reduced in the sixth week, while the changes of the control group without load resistance training are not significant.

Table 2. Effect of Resistance Training with Different Loads on Muscle Mass of Long distance Runners' Upper Limbs.

Measurement index	Control group	Experimental group A	Experimental group B
Week 0	3.37±0.151	3.38±0.189	3.40±0.152
Week 3	3.51±0.130	3.48±0.189	3.50±0.141
Week 6	3.54±0.169	3.59±0.295	3.51±0.213
Week 9	3.52±0.203	3.75±0.379	3.66±0.318

Table 3. Changes of peak torque of biceps brachii in long-distance runners with different load resistance training.

Measurement index	Control group	Experimental group A	Experimental group B
Week 0	53.87±6.523	53.60±6.273	53.67±5.688
Week 3	56.71±6.235	56.75±7.743	54.85±5.253
Week 6	59.49±7.069	58.86±8.268	55.59±5.155
Week 9	57.75±5.681	62.97±8.879	58.48±6.165

Table 4. Effect of Resistance Training with Different Loads on Blood Lactic Acid of Long distance Runners after Long distance Running.

Measurement index	Control group	Experimental group A	Experimental group B
Week 0	5.12±2.369	5.37±2.161	7.21±2.620
Week 3	4.86±2.055	5.48±2.621	7.74±3.529
Week 6	4.32±2.001	5.44±2.539	6.80±3.787
Week 9	5.29±2.866	5.73±2.674	6.76±4.368

Changes of creatine kinase in long-distance runners after long-distance running recovery after resistance training with different loads

After 9 weeks of load resistance training for 3 groups of long-distance runners, the changes of creatine kinase of 3 groups of long-distance runners after long-distance running recovery are shown in Table 5.

By comparing the changes of creatine kinase values of 120 subjects before and after the experiment, it can be concluded that after carrying out different levels of load resistance training, the long-distance runners' creatine kinase values change significantly after the recovery of long-distance running. The initial creatine kinase indicators of Group A and Group B and the measured creatine kinase value indicators after the completion of the experiment for 9 weeks are both greater than 40 before and after the change, but only for daily training, The data of the control group without load resistance training intervention did not change significantly.

DISCUSSION

Whether it is resistance training with low strength load of single action or resistance training with medium strength load, all movement resistance training of metabolism can reach the level of medium intensity sports activities recommended by the American Sports Medical Association for 3-6 METs daily exercise. Among them, the metabolism of dumbbell squatting with medium strength load even reached the level of high intensity physical activity. In addition, the resistance training of combined movements with medium strength load also reached the level of high intensity physical activity. At present, long-term exercise can significantly improve the basic metabolic state of the human body. Systematic resistance training can increase exercise endurance, thus improving the resting metabolic rate of the human body. During the 24-hour recovery period after resistance training, the athletes' sports endurance will be significantly improved. During this period, the human body will use more energy to complete the physical recovery. This stage is mainly based on the fat energy supply in the human body. Resistance training can effectively promote the decomposition of fat, achieve the goal of weight gain, and effectively improve the composition of body muscles. In addition, with the deepening of resistance training research in recent years, some studies believe that resistance training with different loads has a significantly higher effect on the endurance of long-distance runners than aerobic exercise.

The environment has obvious influence on the movement process of human body. Environmental factors include temperature, weather, climate, terrain and other external factors. In addition to the above environmental factors, the factors of long-distance runners' own activities are very important. The athletes themselves include endurance, central nervous system function, maximum oxygen intake, speed reserve, energy reserve, and the number of red muscle fibers. Therefore, endurance training is very important in the process of sports mobilization training. The endurance of athletes depends on long-term training, that is, the length of time required to tolerate drastic changes in the body. If athletes cannot tolerate this threshold, it is difficult to develop

Table 5. Changes of Creatine Kinase in Long distance Runners after Long distance Running Recovery by Resistance Training with Different Loads.

Measurement index	Control group	Experimental group A	Experimental group B
Week 0	153.64±13.017	154.86±19.695	156.97±46.132
Week 3	151.90±37.173	131.43±41.812	145.24±31.619
Week 6	148.22±41.321	116.73±12.594	133.02±23.960
Week 9	143.13±36.659	108.30±31.756	116.45±39.092

endurance training downward. Secondly, the function of the central nervous system of long-distance runners and the number of red muscle fibers are enough to keep the nervous system excited or disordered for a long time, and the number of red muscle fibers in the muscles is enough to ensure the smooth progress of aerobic respiration, which is a good basis for endurance quality training of long-distance runners. Finally, the athletes' speed and energy reserve can respectively affect the stable time and speed burst in the early and late stages by ensuring the perfect connection of the athletes' entire training process.

CONCLUSION

Through the further analysis of the experimental data of the experimental results in this paper, it can be concluded that in the daily training process of long-distance runners, increasing a certain degree of load resistance training is conducive to increasing the upper limb muscle mass of long-distance runners. The changes in the upper limb muscle mass of the two group leaders who have undergone load resistance training have increased from the original 3.38 ± 0.189 to 3.75 ± 0.379, 3.40 ± 0.152 to 3.66 ± 0.318, respectively. The peak torque of biceps brachii of the experimental subjects also increased. The peak torque of biceps brachii of long-distance runners in the two groups who received overload resistance training increased from 53.60 ± 6.273 to 62.97 ± 8.879, 53.67 ± 5.688 to 58.48 ± 6.165, respectively. In addition, the blood lactic acid value of the experimental subjects after the completion of long-distance running and the creatine kinase value after the recovery of long-distance running were also significantly changed. The experimental data of four groups of different measurement indicators had significant changes, while no load resistance training was carried out, and the number of indicators of the control group that only carried out daily training did not change significantly. Therefore, it can be further concluded that increasing load resistance training is conducive to increasing the endurance of long-distance runners.

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