EFFECTS OF PROGRESSIVE LOAD TRAINING ON SPRINTERS' CARDIORESPIRATORY ENDURANCE

EFEITOS DO TREINAMENTO COM CARGAS PROGRESSIVAS NA RESISTÊNCIA CARDIORRESPIRATÓRIA DE VELOCISTAS

EFECTOS DEL ENTRENAMIENTO CON CARGAS PROGRESIVAS EN LA RESISTENCIA CARDIORRESPIRATORIA DE VELOCISTAS

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ABSTRACT

Introduction: The most evident change during exercise is the increase in oxygen demand, and prolonged high-intensity exercises may impact this even more on this demand. Physical training with progressive loads is a method that aims to reach the training goals by adjusting factors such as initial load, stage load, and a load of the athletes and can be a monitor of the aerobic and anaerobic exercise on the athlete with potential benefits for the high demand of oxygenation. Objective: Study the changes in heart rate and indexes of cardiorespiratory endurance of sprinters under training with progressive loads. Methods: By random sampling, the study subjects were 15 male sprinters and 15 non-sportsmen as research volunteers. The study subjects performed a protocol with progressive load training on a platform. All subjects underwent the Italian Kosmai cardiopulmonary function test before and after training. Results: The subjects who did not practice the sport showed VO2 max values at an exercise intensity of 13 km/h. The VO2 max maximum for sprinters was 15 km/h. Individuals who were not sprinters generally showed lower VT levels than sprinters (P <0.05). Average non-speeder individuals demonstrated higher MET scores than sprinters. Conclusion: Cardiopulmonary endurance and energy metabolism levels are strongly related to long-term participation in physical activity and exercise intensity. Incremental load training improved cardiorespiratory fitness in sprinters. The results may provide a specific theoretical basis for the daily training of sprinters in the future. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Exercise; Physical Fitness; Running; Athletes.

RESUMO

Introdução: A alteração mais evidente durante o exercício é o aumento da demanda de oxigênio e os exercícios prolongados de alta intensidade podem impactar ainda mais nessa demanda. O treinamento físico com cargas progressivas é um método que visa atingir as metas de treinamento ajustando fatores como carga inicial, carga de estágio e uma carga dos atletas e pode ser um monitor do exercício aeróbico e anaeróbico sobre o atleta com potenciais benefícios para a alta demanda de oxigenação. Objetivo: Estudar as alterações na frequência cardíaca e nos índices de resistência cardiorrespiratória de velocistas sob treinamento com cargas progressivas. Métodos: Selecionou-se 15 velocistas do sexo masculino e 15 homens que não praticavam o esporte como voluntários de pesquisa por amostragem aleatória. Os sujeitos do estudo realizaram um protocolo com treinamento de cargas progressivas em plataforma. Todos os indivíduos foram submetidos ao teste de função cardiopulmonar Italian Kosmai antes e após o treinamento. Resultados: Os indivíduos que não praticavam o esporte apresentaram valores de VO2max em uma intensidade de exercício de 13 km/h. O VO2max máximo para velocistas foi de 15 km/h. Indivíduos que não eram velocistas em geral apresentaram níveis de VT mais baixos do que os velocistas (P <0,05). Os não velocistas médios demonstraram pontuações MET mais altas do que os velocistas. Conclusão: A resistência cardiopulmonar e os níveis de metabolismo energético estão fortemente relacionados com a participação a longo prazo na atividade física e intensidade do exercício. O treinamento de carga incremental melhorou a aptidão cardiorrespiratória em velocistas. Os resultados podem fornecer uma base teórica específica para o treinamento diário de velocistas no futuro. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Exercício Físico; Aptidão Física; Corrida; Atletas.*

RESUMEN

Introducción: La alteración más evidente durante el ejercicio es el aumento de la demanda de oxígeno y los ejercicios prolongados de alta intensidad pueden incidir aún más en esta demanda. El entrenamiento físico con cargas progresivas es un método que pretende alcanzar los objetivos de entrenamiento ajustando factores como la carga inicial, la carga por etapas y la carga de los atletas y puede ser un monitor del ejercicio aeróbico y anaeróbico en el atleta con beneficios potenciales para la alta demanda de oxigenación. Objetivo: Estudiar las alteraciones en la frecuencia cardíaca y en los índices de resistencia cardiorrespiratoria de los velocistas bajo tratamiento con cargas progresivas. Métodos: Seleccionamos a 15 velocistas masculinos y a 15 hombres no practicantes como voluntarios

de la investigación mediante un muestreo aleatorio. Los sujetos se sometieron a un protocolo con entrenamiento de carga progresiva en plataforma. Todos los sujetos fueron sometidos a la prueba de función cardiopulmonar de Kosmai italiano antes y después del entrenamiento. Resultados: Los sujetos que no practicaban el deporte presentaron valores de VO2máx a una intensidad de ejercicio de 13 km/h. El VO2máx de los velocistas era de 15 km/h. Los individuos que no eran velocistas en general mostraron niveles de VT más bajos que los velocistas (P <0,05). La media de los no-principiantes mostró mayores puntuaciones MET que los velocistas. Conclusión: Los niveles de resistencia cardiopulmonar y de metabolismo energético están fuertemente relacionados con la participación a largo plazo en la actividad física y la intensidad del ejercicio. El entrenamiento de carga incremental mejoró la aptitud cardiorrespiratoria de los velocistas. Los resultados pueden proporcionar una base teórica específica para el entrenamiento diario de los velocistas en el futuro. Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.

Descriptores: *Ejercicio Físico; Aptitud Física; Carrera; Atletas.*

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INTRODUCTION

Cardiorespiratory endurance is a critical factor in measuring physical fitness. It is pumped by the heart and ventilated by the lungs to drive blood circulation and deliver nutrients and oxygen to the body. In this way, it can meet various physiological functions and energy metabolism needs of the human body. Cardiopulmonary function and ventilation, body temperature, pulse, and blood pressure were the five significant vital signs. Sprinting is an endurance, periodic sport.[1] An essential metabolic mode of sprinting exercise is aerobic metabolism. In recent years, Chinese sprinting performance has not been good. Improving the century ranking of sprinters has become an urgent problem for domestic sports workers and coaches.

Previous surveys have shown that load training can improve an athlete's aerobic metabolism. This training method can improve performance, such as VO2 max, hemoglobin, and lactate tolerance. However, improper load training can also reduce the athletic ability of athletes. Incremental load training is a training plan that adjusts initial and stages load parameters to achieve the best training effect. At present, the theory of incremental load training is relatively complete. This training method can provide scientific references for athletes' aerobic and anaerobic detection.[2] This training method can better grasp the physical fitness of sprinters. This paper randomly selected 15 male sprinters and 15 non-sports professional men as research objects. This study investigated the changes in heart rate and cardiorespiratory endurance indicators of sprinters under increasing load training. The results can provide a specific theoretical basis for the daily training of sprinters in the future.

METHOD

Research objects

This paper randomly selected 15 male sprinters and 15 non-sports professional men as research objects. The subjects had no cardiovascular, chronic, metabolic, etc. The subjects' blood pressure was checked before the experiment, and it was found that their blood pressure of the subjects was within the normal range. Table 1 shows the basic information about the subjects.

Table 1. Basic information on objects.

Group	Sprint professional	General professional
N	15	15
Age	20.94±2.19	21.04±1.46
Height/cm	182.92±1.35	181.56±1.67
Weight/kg	71.15±1.15	71.04±1.77
BMI (kg·m^{-2})	23.07±2.6	23.39±2.42
Systolic blood pressure (mmHg)	123.75±9.69	127.81±8.85
Diastolic blood pressure (mmHg)	81.56±7.81	84.69±8.54

Test plan

Each participant was informed of the trial proceedings before the trial. The experimental subjects wore Polar heart rate belts and other equipment to monitor heart rate and cardiorespiratory endurance (CRE) indicators (spiritual capacity, absolute value of maximum oxygen uptake, tidal volume and minute ventilation, and other indicators). The conditions for ending the training are as follows: 1) The heart rate exceeds the maximum heart rate (maximum heart rate = 220-age). 2) The subjects experienced ventilation disturbance, dizziness, extreme fatigue, paleness, etc. 3) Terminate the test when the subject reaches the exercise limit.

Mathematical modeling of 3D motion capture data

The characteristic of dynamic behavior indicates that the body segment should be in motion at the moment. This paper analyzes whether it exceeds the critical point by measuring the displacement between it and the adjacent poses.[3] This feature mainly refers to the movement of the limbs and the whole body.

$$g_k(d^i) = | d_k^i - d_k^{i-1} | > \mu_1 \quad (1)$$

Relative position describes the relative position between the limbs, for example, in the front or back of the body. The action happens before the feature is 1; otherwise, it is 0. This feature can describe the location of various parts of the human body. This method is mainly used to define the main features of body movement. Orientation information indicates the body's orientation has changed significantly compared to the initial pose.[4] This characteristic can describe movement steering, etc. The orientation information at this time has changed.

$$g_k(d^i) = | star(d_k^i - star(d_k^0) | > \theta_1 \quad (2)$$

From the inter-limb contact information, it is possible to calculate whether each leg is in contact. At this point, this article can analyze whether the distance between the two legs is smaller than the critical point.[5] The separation and fusion of the left and right arms can more accurately tell what is happening with the movement.

$$g_k(d^i) = | dis(d_{k1}^i) - dis(d_{k2}^i) | > \mu_2 \quad (3)$$

The angle information can calculate the angle of the limb to the body. For example, the angle of thigh and calf, upper body, and lower

body. This article can judge whether a person is standing or squatting according to this angle.

$$g_k(d^i) = |angle(d^i_{k1}, d^i_{k2})| < \theta_2 \quad (4)$$

In addition, there are center displacement, the center of gravity offset, support point and other characteristics. This method analyzes the distance ratio between the current pose and the previous Δ frame segment. This way, whether the motion trajectory of the position is a straight line or a curve is obtained.

$$g_k(d^i) = \frac{\sum_{i=i-\Delta}^{i} |d^i_k - d^i_k|}{|d^i_k - d^{i-\Delta}_k|} > \mu_3 \quad (5)$$

Data processing

This paper uses SPSS20.0 to process the data obtained from the experiment. All data are expressed as mean ± standard deviation. This paper used the independent t-test to analyze the indicators between groups.[6] This paper used the paired sampling t-test to compare the indicators between groups before and after training. In this paper, α=0.05 is used to represent the inspection level.

Ethical Compliance

Research experiments conducted in this article with animals or humans were approved by the Ethical Committee and responsible authorities of Hebei Professional College of Political Science and Law, Shijiazhuang University of Applied Technology and Hebei vocational college of rail trainsportation following all guidelines, regulations, legal, and ethical standards as required for humans or animals.

RESULTS

Heart rate changes of athletes in different groups during incremental load training

It can be seen from Table 2 that in the incremental load training experiment, ordinary subjects stopped exercising when the average heart rate reached 198.44±10.73 beats/min at the fourth level.[7] There was an increasing trend in heart rate ratios in increasing-load exercise in sprint professional and general subjects. Compared with sprinters, there was a significant difference in the heart rate level of ordinary subjects (P<0.05).

Changes in maximum oxygen uptake (VO2max) in different groups during incremental load training

As shown in Table 3, there were differences in the incremental load exercise test's VO2max values of each subject. The greater the exercise intensity, the higher the VO2max. Normal subjects had the highest VO2max at an exercise intensity of 13 km/h. The maximum VO2max for sprinters is 15 km/h. Sprinters had higher VO2max values than normal subjects.[8] There was a significant difference in the mean level of VO2max between sprint professional and ordinary subjects (P<0.05)

Table 2. Heart Rate Changes in Sprinters and Normal Subjects.

Category	Sprint professional	General professional
Quiet	74.27±3.23	81.46±4.79
Level 1	123.23±10.73	136.04±12.08
Level 2	140.94±12.6	153.65±13.75
Level 3	155.94±14.69	167.29±13.02
Level 4	183.85±10.73	197.71±5.1
Level 5	198.44±10.73	-

Changes in tidal volume (VT) of athletes in different groups during incremental load training

It can be seen from Table 4 that there are differences in the VT values of sprinters and ordinary subjects.[9] With the increase in exercise intensity, the VT value showed an upward trend, among which the VT in grades 2 and 3 increased significantly. In contrast, the VT of ordinary subjects increased more at the grade 3 level. Compared with sprinters, the VT level of common subjects was significantly different (P<0.05).

Changes in average breathing rate (VE) of athletes in different groups during incremental load training

It can be seen from Table 5 that the VE of sprinters and ordinary subjects increases with the increase of exercise intensity. Levels 4 and 5 VE saw the most significant increase in sprinting majors. Normal subjects have an even more significant increase in VE at level 4. Compared with sprinters, the VE level of common subjects was significantly different (P<0.01).

Changes in energy metabolism (MET) of athletes during incremental load training

It can be seen from Table 6 that the MET level of ordinary subjects was significantly higher than that of sprinters under quiet conditions (P<0.05). The MET values of the sprint and normal subjects increased with increasing load intensity. Sprinters and general subjects had significant increases in MET levels at Grade 4. Normal subjects had higher MET levels than sprinters. There was a significant difference (P<0.05) between the mean and sprinters at stages 2, 3, and 4.

DISCUSSION

The athletes' maximum oxygen uptake, VO2/HR, VO2max heart rate, and other aspects significantly improved after increasing load training. The VO2max value is an objective index to measure the overall reserve of cardiopulmonary function and the highest aerobic exercise metabolic power. The relative oxygen uptake is the maximum per kilogram of body

Table 3. Changes in absolute values of VO2max between sprinters and normal subjects (L/min).

Category	Sprint professional	General professional
Level 1	3.68±0.32	3.15±0.29
Level 2	3.82±0.23	3.33±0.84
Level 3	4.06±0.85	3.66±0.13
Level 4	4.51±0.55	3.81±0.35
Level 5	4.58±0.35	-

Table 4. Comparison of VT value changes between sprinters and ordinary subjects (L).

Category	Sprint professional	General professional
Quiet	3.34±0.31	2.74±0.19
Level 1	3.68±0.32	3.15±0.29
Level 2	3.82±0.23	3.33±0.84
Level 3	4.06±0.85	3.66±0.13
Level 4	4.51±0.55	3.81±0.35
Level 5	4.58±0.35	-

Table 5. Comparison of VE changes in sprinters and normal subjects (L/min).

Category	Sprint professional	General professional
Quiet	14.8±0.22	13.66±0.48
Level 1	20.13±0.41	18.04±0.53
Level 2	26.83±0.36	24.43±0.08
Level 3	32.63±0.3	29.66±0.39
Level 4	44.85±0.74	38.2±0.36
Level 5	57.39±0.18	-

Table 6. Changes in MET levels in sprinters and normal subjects.

Category	Sprint professional	General professional
Quiet	1.75±0.43	2.83±0.42
Level 1	3.56±0.26	3.91±0.28
Level 2	4.69±0.34	5.67±0.2
Level 3	5.54±0.2	6.68±0.22
Level 4	8.5±0.27	10.54±0.11
Level 5	9.55±0.32	-

mass. The athlete's heart rate, VE, and O2-pulse gradually increase to meet the needs of high metabolism. Oxygen pulse is a comprehensive index to measure cardiopulmonary function, which refers to the amount of blood oxygen the heart muscle provides with each heartbeat.

The anaerobic threshold is an important indicator reflecting the power of a skeletal muscle to use oxygen. The later the anaerobic threshold is generated, the higher the oxygen utilization rate in the body. Compared with VO2max, the anaerobic threshold can better reflect the body's aerobic endurance. Sprinting is a classic aerobic endurance sub-maximum suitable for exercise. Athletes have to perform below VO-2max to a certain extent. This is the basis for us to formulate incremental load training. The anaerobic threshold test of sprinters in this paper can help determine the physical state of the runners. At the same time, it helps the coaches analyze and judge whether the training method is effective. After the incremental load training, the anaerobic threshold of the players is extended by 0.4 minutes, which means that the players' aerobic metabolism strength, brain cell tolerance strength, and plasma buffer against lactic acid are Strength is increased.

CONCLUSION

Incremental load training can improve the cardiorespiratory fitness of the players, increase the body's oxygen uptake and transport power, and enhance the aerobic metabolism power of the players. Incremental load training can be performed before the competition to improve an athlete's athletic performance. It is recommended to detect aerobic strength indices such as maximum oxygen uptake, anaerobic threshold, and oxygen pulse before and after incremental load training. This helps coaches understand the impact of sprinters' exercise on aerobic capacity.

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