HIGH-INTENSITY EXERCISE IMPROVES THE CLINICAL RESPONSE OF ORGAN FUNCTION

MELHORIA NA RESPOSTA CLÍNICA DA FUNÇÃO DOS ÓRGÃOS CAUSADA POR EXERCÍCIO DE ALTA INTENSIDADE

MEJORÍA EN LA RESPUESTA CLÍNICA DE LA FUNCIÓN DE LOS ÓRGANOS CAUSADA POR EJERCICIO DE ALTA INTENSIDAD

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ABSTRACT

Introduction: Physical activity is accomplished by the coordination of various organ systems of the human body, and physical exercise can positively impact the activities of many of these systems. Because the impact of high-intensity sports on human organs is different according to the environmental temperature and exercise intensity, we must make more detailed observations and discussions. Objective: To analyze the changes in the body shape, function, and organ function of middle school students before and after high-intensity physical exercise through the study of human movement. Methods: Through the experimental research on the characteristics of metabolic gas exchanges in high-intensity incremental load exercise of college students. Results: There were statistically significant differences in the incidence of physiological reactions shown by the students who underwent high-intensity incremental load exercise, such as abdominal pain, dyspnea, tachycardia, nausea, dizziness, and muscle aches (P<0.05). Hypothermia was accompanied by a decrease in heart rate during exercise. Conclusion: Carrying out overload training can effectively mediate physiological functions. It is an important, in improving sports performance, to carry out warm-up activities in a low-temperature environment to increase body temperature. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Sports; Body temperature; Energy metabolism; Athletes.

RESUMO

Introdução: A atividade física acontece por meio coordenação de vários sistemas de órgãos do corpo humano, e os exercícios físicos podem ter impacto positivo nas atividades de vários desses sistemas. Uma vez que o impacto de esportes de alta intensidade nos órgãos humanos é diferente de acordo com a temperatura do ambiente e com a intensidade do exercício, é necessário realizar observações e discussões mais detalhadas. Objetivo: Analisar as mudanças de forma e função do corpo, e das funções dos órgãos de alunos universitários antes e depois de atividade física de alta intensidade, através do estudo do movimento humano. Métodos: Pesquisa experimental sobre as características da troca gasosa em exercícios de alta intensidade com aumento gradual de carga em alunos universitários. Resultados: Houve diferenças estatísticas significativas na incidência de reações fisiológicas dos estudantes que passaram pela atividade de alta intensidade com aumento gradual de carga, incluindo dores abdominais, dispneia, taquicardia, náusea, tonturas, e dores musculares (p<0,05). Na presença de hipotermia havia uma queda na frequência cardíaca durante os exercícios. Conclusão: Exercícios de sobrecarga podem mediar funções fisiológicas eficientemente. Para melhorar a performance esportiva em ambientes de baixa temperatura é importante realizar exercícios de aquecimento para aumentar a temperatura do corpo. ***Nível de evidência II; Estudos terapêuticos – investigação de resultados de tratamento.***

Descritores: *Esportes; Temperatura corporal; Metabolismo Energético; Atletas.*

RESUMEN

Introducción: La actividad física ocurre por medio de la coordinación de varios sistemas de órganos del cuerpo humano y los ejercicios físicos pueden tener impacto positivo en las actividades de varios de estos sistemas. Dado que el impacto de deportes de alta intensidad en los órganos humanos es diferente de acuerdo con la temperatura del ambiente y con la intensidad del ejercicio, es necesario realizar observaciones y discusiones más detalladas. Objetivo: Analizar los cambios de forma y función del cuerpo, y de las funciones de los órganos de alumnos universitarios antes y después de la actividad física de alta intensidad, a través del estudio del movimiento humano. Métodos: Investigación experimental sobre las características del intercambio de gases en ejercicios de alta intensidad con aumento gradual de carga en alumnos universitarios. Resultados: Hubo diferencias estadísticas significativas en la incidencia de reacciones fisiológicas de los estudiantes que pasaron por la actividad de alta intensidad con aumento gradual de carga, incluyendo dolores abdominales, disnea, taquicardia, náuseas, mareos y dolor muscular (p<0,05). En la presencia de hipotermia se produjo un descenso *cardíaco durante los ejercicios. Conclusión: Los ejercicios de sobrecarga pueden mediar las funciones fisiológicas eficientemente. Para mejorar el rendimiento deportivo en ambientes de baja temperatura es importante realizar ejercicios de calentamiento para aumentar la temperatura corporal.* ***Nivel de evidencia II; Estudios terapéuticos – investigación de resultados de tratamiento.***

Descriptores: *Deportes; Temperatura corporal; Metabolismo Energético; Atletas.*

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INTRODUCTION

Before the competition, athletes must warm up to improve their performance. An important factor in improving performance based on warm-up activities is increasing body temperature, which is cited by many examples. Because body temperature rise on sports performance is different according to the environmental temperature and exercise intensity, we must make more detailed observations and discussions.[1] The temperature of peripheral tissues such as muscle and skin exposed to a low-temperature environment is significantly lowered, and the contractile function of skeletal muscle changes accordingly. Its ability to resynthesize adenine nucleotides in the mitochondria is also reduced. The state of low muscle temperature will cause the maximum tension to be weakened, the muscle's viscous resistance, and so on. As a result, it is believed that the low body temperature in the low-temperature environment has various effects on muscle contraction and thus has a greater impact on sports performance. Therefore, it can be inferred that the warm-up activity before exercise in the low-temperature environment has an important effect on improving sports performance.[2] Therefore, this experiment discusses the influence of passive warming of body temperature before exercising at low temperature on the physiological response of subsequent high-intensity exercise. In this way, it is clearer whether the increase in body temperature affects the effect of warm-up preparation activities to improve performance.

METHOD

General information

We selected 5 young males in the physical education department on November 2, 2020. Age (25±2) years old, height (1.72±0.03) m, body weight (67.1±5.5) kg.

Experimental method

Set the exercise intensity of this experiment and measure the maximum oxygen uptake (VO2max) and lactate threshold.[3] Use the bicycle in an artificial room with a room temperature of 24°C and relative humidity of 40% to gradually increase the amount of exercise starting from 30W. Increase by 30W every 90s until fatigue. The number of laps of the pedaling bicycle is set to 60 laps/min. AN AUTOMATIC EXPIRATORY GAS ANALYZER MEASURES the VO2, VCO2, ventilation volume per minute, and respiratory exchange rate of the gas exchange parameters during exercise. At the same time, we use a pulse meter to measure the heartbeat. Before each exercise load intensity, blood was collected to measure the blood lactic acid concentration. We use fingertip blood sampling and analyze with a lactic acid analyzer. In the experiment, VO2 is on the horizontal axis, the lactic acid concentration is on the vertical axis, and the starting point when the blood lactic acid concentration rises non-linearly is defined as the lactic acid threshold.

The subjects wore shorts and performed all experiments in an artificial room at a room temperature of 16°C and relative humidity of 40%. Then sit still for 5 minutes and exercise. Sit for 35 minutes before exercise and then exercise.[4] The interval between the two experiments is at least 48h. We used a bicycle exercise with a maximum oxygen uptake of 75% higher than the lactic acid threshold of the subject, and the duration was 6 minutes.

Gas exchange parameters and heart rate were measured at the beginning of the two experiments and 15 minutes after the end of the exercise. Blood sampling was performed before exercise and 3, 5, 7, 9, 12, and 15 minutes. Body temperature is measured as rectal body temperature.[5] The subjective work intensity is measured as 1 time per minute during exercise.

Main observation indicators

Changes in VO2, VCO2, ventilation volume per minute, respiratory exchange ratio, lactate threshold, heart rate, and subjective work intensity before and after exercise.

Computer Simulation of Athlete's Dynamic Relationship

The analyzed kinematics parameters are converted to the human body motion simulation software Life Mod. We use the above method to build a human body model.[6] The vertical GRF of the two camera devices when the human body touches the landing pad is obtained through simulation and compared with the vertical GRF of the three-dimensional force plate. We use the multiple correlation coefficient (CMC) as an evaluation index to describe the similarity between the vertical GRF curves. The multiple correlation coefficient is defined as:

$$CMC = \sqrt{1 = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(x_{ij}-\bar{x}_j)^2 / n(m-1)}{\sum_{i=1}^{m}\sum_{j=1}^{n}(x_{ij}-\bar{x}_j)^2 /(nm-1)}} \quad (1)$$

m is the number of curves. n is the number of data contained in each curve. x_{ij} is the Eth data of the i curve. $\bar{x}_j$ is the average value of the j data of m curve. $\bar{x}$ is the overall mean of n data of m curve. The article uses a simple optimization algorithm to find the mechanical parameters of the landing mat. The method is to obtain the subject's ground reaction force and joint angle during the landing process through analysis [7]. The root-mean-square difference of the ground reaction force and the joint angle obtained during the landing process were respectively compared with the simulation. As shown in formula 2. When the minimum value of formula 3 appears, it means that the mechanical parameters of the landing mat in this state are the most suitable.

$$\Delta\delta = \sqrt{\frac{x_1^2 + x_2^2 + \cdots + x_m^2}{m} - \frac{y_1^2 + y_2^2 + \cdots + y_n^2}{n}} \quad (2)$$

$$S = [\Delta HGRF + \Delta VGRF + \frac{1}{4}\sum_{i=1}^{4}\Delta\alpha_i] \quad (3)$$

x and y represent experimental and simulated values respectively. $\Delta\delta$ represents the root mean square difference between the two. $\Delta HGRF$ and $\Delta VGRF$ are the root mean square error of GRF in the horizontal and vertical directions, respectively. $\Delta\alpha_i$ is the root mean square error of the angles of the shoulder, ankle, knee, and hip joints, respectively.

Statistical analysis

We use SPSS9.0 for data processing. The data were expressed as Mean ± standard deviation, and a t-test was performed.

RESULTS

Analysis of the number of participants

Five subjects were included, and they all entered the result analysis without falling out.

Analysis of experimental results

The changes of gas exchange parameters, lactate threshold, heart rate, and subjective work intensity in the low-temperature exposure experiment and passive heating experiment are shown in Table 1. The rectal body temperature of the athletes in the passive heating experiment 3 minutes before the start of exercise and 15 minutes after the end of the exercise was higher than that of the athletes in the low-temperature exposure experiment.

The results in Table 1 show no significant difference in the blood lactic acid concentration before exercise between the low-temperature exposure experiment and the passive heating experiment (P>0.05). The maximum blood lactic acid concentration after exercise in the passive warming experiment was lower than that in the low-temperature exposure experiment, and the difference was significant (P<0.05). In the gas exchange parameters, the maximum value of the breath exchange ratio in the passive heating experiment was lower than that in the low-temperature exposure experiment, and the difference was significant (P<0.05). However, VO2, VCO2, and ventilation volume per minute were not significantly different in the experiment (P>0.05). The average heart rate during exercise in the passive heating experiment was higher than that in the low-temperature exposure experiment, and the difference was significant (P<0.05). The average subjective work intensity during exercise in the passive heating experiment was lower than that in the low-temperature exposure experiment, and the difference was significant (P<0.05).

Table 1. Changes in gas exchange parameters, lactic acid threshold, heart rate, and subjective work intensity in low-temperature exposure and passive heating experiments.

	Quiet state	
State	**Low-temperature exposure**	**Passive heating**
VO2(mL/min)	292±48	273±48
VCO2(mL/min)	249±36	221±29
Breath exchange ratio	0.86±0.04	0.81±0.07
Air exchange rate (mL/min)	9.3±2.0	9.0±1.3
Lactic acid threshold (mmol/L)	1.3±0.2	1.3±0.4
Heart rate (n/min)	72±9	79±6
Subjective work intensity	-	-
	Motion state	
State	**Low-temperature exposure**	**Passive heating**
VO2(mL/min)	2079±274	2104±278
VCO2(mL/min)	2436±231	2391±231
Breath exchange ratio	1.15±0.08	1.11±0.07
Air exchange rate (mL/min)	78.1±8.2	72.6±8.9
Lactic acid threshold (mmol/L)	-	-
Heart rate (n /min)	153±6	159±8
Subjective work intensity	17±0	16±1
	Highest state	
State	**Low-temperature exposure**	**Passive heating**
VO2(mL/min)	2436±345	2500±353
VCO2(mL/min)	2911±309	2914±330
Breath exchange ratio	1.28±0.09	1.24±0.09
Air exchange rate (mL/min)	108.0±15.0	100.6±15.2
Lactic acid threshold (mmol/L)	13.8±2.5	12.8±1.9
Heart rate (n /min)	170±6	176±6
Subjective work intensity	20±1	18±2

Discussion

The results of this experiment show that the rectal body temperature changes over time from quiet time. Still, the passive warming experiment is higher than the low-temperature exposure experiment from 3 minutes before the start to the end of the exercise.[8] The difference is significant.

In this experiment, the maximum blood lactic acid concentration after exercise was lower in the passive heating experiment than in the low-temperature exposure experiment. The increase in blood lactic acid concentration is thought to reflect anaerobic energy metabolism. In the results of this experiment, the energy supply of the glycolytic sugar system is reduced compared to the passive heating experiment and the low-temperature exposure experiment. This will cause a decrease in oxygen glycolysis in peripheral tissues. We think this harms the energy supply. And as compensation, the degree of dependence on anaerobic energy supply will increase[9] as other anaerobic energy supplies may increase. This is the contraction properties of muscle fibers and changes in motor unit mobilization. Based on these factors, it can be inferred that the passive heating experiment of blood lactic acid concentration in this experiment is lower than the low-temperature exposure experiment.

No intentional difference was found between the passive heating experiment and the low-temperature exposure experiment in the oxygen uptake at rest in the gas exchange parameters due to the contraction of blood vessels in the skin in a low-temperature environment. When the deep body temperature becomes unable to maintain, it causes tremor and non-tremor heat generation and increases oxygen uptake. There are reports in previous studies that it will not cause tremor at an ambient temperature of 15°C. In this experiment, the passive heating experiment and the low-temperature exposure experiment did not find obvious tremors according to naked eye observation.[10] Therefore, it can be concluded from the results of oxygen uptake at rest that tremors accompany no increase in oxygen uptake more in the passive heating experiment and low-temperature exposure experiment.

The maximum value of the breath exchange ratio is lower in the passive heating experiment than in the low-temperature exposure experiment. From the results of blood lactic acid concentration and breath exchange ratio in this experiment, it can be seen that the lactic acid released during passive heating experiment exercise is less than that in low-temperature exposure experiment. In this experiment, the average value of the heart rate during exercise was higher in the passive heating experiment than in the low-temperature exposure experiment. The first study reported that hypothermia was accompanied by a decrease in heart rate during exercise. This is consistent with the results of this experiment. It can be inferred that the heart rate results are also different due to the difference in rectal body temperature rise.

CONCLUSION

This paper shows that the average subjective work intensity is lower in the passive heating experiment. This is because the person with a higher body temperature during high-intensity exercise in a low-temperature environment can reduce the mental burden and improve performance. Passive warming under a low-temperature environment and pre-researched exercise preparation activities also lower blood lactic acid concentration. Therefore, it is an important factor in improving sports performance to carry out warm-up activities in a low-temperature environment to increase body temperature.

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AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. Lin shao: writing; lin Luo: data analysis; Wei Shao: Formal analysis; Yu Zhang : article review.

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