HIGH-INTENSITY TRAINING ON PULSE AND DICROTIC WAVEFORM IN CHRONIC DISEASES

TREINOS DE ALTA INTENSIDADE E O BATIMENTO CARDÍACO E ONDA DICRÓTICA EM DOENÇAS CRÔNICAS

ENTRENAMIENTOS DE ALTA INTENSIDAD, EL LATIDO CARDÍACO Y LA ONDA DICRÓTICA EN ENFERMEDADES CRÓNICAS

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ABSTRACT

Introduction: The formation and propagation of pulse waves are mainly accomplished by coordinating the heart and the vascular system. The contraction and relaxation of the heart are the sources of pulse waves. The aorta vibrates regularly as the heart contracts. This vibration propagates forward along the elastic blood vessel to form a pulse wave. The pulse wave contains very rich physiological and pathological information about the cardiovascular system. If there is a problem with the heart's structure, it can cause abnormal pulse waveforms. Objective: This article analyzes pulse waveform changes and blood flow during high-intensity interval training. It combines the test results to guide the exercise rehabilitation treatment of patients with chronic diseases. Methods: Pulse waves were collected from subjects under different exercise loads and the characteristics of pulse wave parameters under intermittent exercise were studied. Results: An athlete's pulse wave response is different in the case of high-intensity intermittent exercise. There are differences in the cardiovascular response of patients with different body weights. Conclusion: High-intensity interval training can improve the cardiovascular function of patients with chronic diseases and affect their pulse waveform. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Pulse wave analyses; Sports; Cardiac rehabilitation.

RESUMO

Introdução: A formação e propagação de ondas dos batimentos cardíacos resultam principalmente da coordenação entre o coração e o sistema vascular. A contração e o relaxamento do coração produzem ondas de batimento cardíaco. A aorta vibra regularmente a medida em que o coração se contrai. A vibração se propaga no vaso sanguíneo elástico para formar uma onda de batimento cardíaco. Esta onda contém informações fisiológicas e patológicas muito ricas sobre o sistema cardiovascular. Se há algum problema com a estrutura cardíaca, ondas anormais podem resultar. Objetivo: Este estudo analisa as alterações em ondas de batimentos cardíacos e o fluxo sanguíneo durante treinos de intervalos de alta intensidade. Combina os resultados dos testes para orientar o tratamento de exercícios de reabilitação em pacientes com doenças crônicas. Métodos: Ondas de batimentos cardíacos foram coletadas de indivíduos praticando exercícios com cargas diferentes. As características dos parâmetros das ondas de batimento cardíaco relacionadas a exercícios intermitentes foram estudadas. Resultados: A resposta das ondas de batimentos de atletas é diferente em exercícios intermitentes de alta intensidade. Existem diferenças na resposta cardiovascular de pacientes com diferentes pesos corporais. Conclusão: O exercício de intervalos de alta intensidade pode melhorar a função cardiovascular de pacientes com doenças crônicas e afetar as ondas de batimentos cardíacos. ***Nível de evidência II; Estudos terapêuticos – investigação de resultados de tratamento.***

Descritores: *Análise de ondas de pulso; Esportes; Reabilitação cardíaca.*

RESUMEN

Introducción: La formación y propagación de ondas de los latidos cardíacos resultan principalmente de la coordinación entre el corazón y el sistema vascular. La contracción y el relajamiento del corazón producen ondas de latido cardíaco. La aorta vibra regularmente a la medida que el corazón se contrae. La vibración se propaga en el vaso sanguíneo elástico para formar una onda de latido cardíaco. Esta onda contiene informaciones fisiológicas y patológicas muy ricas sobre el sistema cardiovascular. Si hay algún problema con la estructura cardíaca, puede causar ondas anormales. Objetivo: Este estudio analiza las alteraciones en ondas de latidos cardíacos y el flujo sanguíneo durante entrenamientos de intervalos de alta intensidad. Combina los resultados de las pruebas para orientar el tratamiento de ejercicios de rehabilitación en pacientes con enfermedades crónicas. Métodos: Ondas de latidos cardíacos se recogieron de individuos practicando ejercicios con carga diferentes. Las características de los parámetros de las ondas de latido cardíaco relacionadas a ejercicios intermitentes se estudiaron. Resultados: La respuesta de las ondas de latidos de atletas es diferente en ejercicios intermitentes de alta intensidad. Existen diferencias en la respuesta cardiovascular de pacientes con diferentes pesos corporales. Conclusión: El ejercicio de intervalos de alta intensidad puede mejorar la función cardiovascular de pacientes con enfermedades crónicas y afectar las ondas de latidos cardíacos. ***Nivel de evidencia II; Estudios terapéuticos – investigación de resultados de tratamiento.***

Descriptores: *Análisis de la onda del pulso; Deportes; Rehabilitación cardiaca.*

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INTRODUCTION

The cardiovascular system is the powerful organ of human blood circulation, responsible for the blood supply and transportation of the human body. The pulse wave responds to the cyclical changes in pressure caused by the contraction and relaxation of the heart's ventricles to guide the blood flow in the arteries. Its waveform can reflect the body's cardiovascular function and blood circulation status.[1] Changes in cardiovascular physiology will cause pulse wave changes. Some scholars have proved that pulse wave characteristic parameters can be continuously and independently used as an important indicator for predicting cardiovascular disease. Some scholars conducted a 10-year follow-up survey of 492 Japanese Americans living in Hawaii and showed that pulse wave velocity could predict the mortality of cardiovascular diseases. Through experiments, some scholars have proved that aortic pulse wave velocity is an important indicator for predicting cardiovascular risk in patients with hypertension. Some scholars have proved that the aortic pulse wave velocity is an effective independent indicator for predicting diabetes and glucose tolerance test (GTT).

Long-term physical exercise can affect the human heart in terms of form and function. Engaging in physical exercise can effectively improve human cardiovascular function. Studying the changes in the cardiovascular function of people with different types of exercise is of great significance to the physical exercise and cardiovascular function health care of the general population.[2] This study analyzes the cardiovascular function of the human body by detecting the radial artery pulse wave analysis and parameter calculation of volunteers of different exercise types.

METHOD

Experimental equipment

The experimental equipment mainly includes a power car, a cuff-type electronic sphygmomanometer, a cardiovascular detection system under exercise load, and a computer.

Subjects

We choose volunteer subjects with normal cardiovascular function in a peaceful state to participate in the exercise load experiment. 60 subjects participated in the blood flow parameter detection experiment.[3] All of them are undergraduates, and their physical condition is good. According to the body mass index (BMI): BMI=kg/m^2, this index is grouped. BMI≥30 means obesity. We divided 60 subjects into the normal male group, normal female group, male obese group, and female obese. The basic information of each group is shown in Table 1.

Experimental method

The subject sits quietly on the power car to measure his blood pressure in a surprise state. Then began the exercise load test.[4] The subject pedaled a bicycle to enter the exercise load experiment. Male pedaling load power is five levels (50W, 75W, 100W, 125W, 150W), female and obese group pedaling load power is 4 levels (50W, 75W, 100W, 125W). Each step is pedaled for 1 min, and the pedaling speed is 60r/min. Take a rest every 1 minute and collect a pulse wave signal.

Table 1. The basic situation of each group.

Group	Height (cm)	Weight (kg)	BIM	Blood pressure at rest (mmHg)	
				Systolic blood pressure	Diastolic blood pressure
Boys normal group	177±8	60±10	19.59	120±6	79±6
Girls Normal Group	162±5	49±7	18.82	109±8	70±5
Boy obesity group	178±8	88±8	35.87	139±4	90±5
Girls obesity group	163±1	70±10	31.2	130±5	82±4

Gaussian fitting of pulse wave based on characteristic parameters

Several Gaussian functions can synthesize a cycle of peripheral arterial pulse waves. Each Gaussian function needs amplitude V, time T, and width U to determine. The total pulse wave $x(t)$ is expressed by the following formula:

$$x(t) = \sum_{i=1}^{n} V_i \exp\{-(t-T_i)^2 / U_i\} \quad (1)$$

T is the length of a cycle of pulse waves. The characteristic parameters used to evaluate the fitting effect in this article mainly include pulse wave waveform characteristic quantity K, systolic waveform area K_1, diastolic waveform area K_2, characteristic ratio K_1 / K_2, and reflection wave enhancement index AI These characteristic parameters can all reflect some important physiological and pathological information.[5] The pulse waveform characteristic quantity K value is extracted based on the area change of the pulse wave pattern. The calculation formula is:

$$K = \frac{P_m - P_d}{P_s - P_d} \quad (2)$$

$P_m = \frac{1}{T}\int_0^T P(t)dt$ is the mean arterial pressure. It is equal to the average value of pulse pressure $P(t)$ in a cardiac cycle. P_s and P_d are systolic blood pressure and diastolic blood pressure, respectively. Since the shape of the pulse wave diagram will be different when the value of K is the same, the boundary point of the systolic and diastolic periods is used to divide the area of the pulse wave diagram into the systolic area and the diastolic blood pressure.[6] The diastolic area is 2 parts. These pulse wave waveform periodic area characteristics are added in the process of evaluating the fitting effect. The systolic waveform area K_1, the diastolic waveform area K_2, and the characteristic ratio G. The calculation formula is:

$$K_1 = \frac{P_{m1} - P_d}{P_s - P_d}, P_{m1} = \frac{1}{t_1}\int_0^{t_1} P(t)dt \quad (3)$$

$$K_2 = \frac{P_{m2} - P_d}{P_s - P_d}, P_{m2} = \frac{1}{t_2}\int_{t_1}^{T} P(t)dt \quad (4)$$

$$\frac{K_1}{K_2} = \frac{P_{m1} - P_d}{P_{m2} - P_d} \quad (5)$$

P_s is the systolic blood pressure. P_d is the diastolic blood pressure. P_{m1} is the average systolic pressure. P_{m2} is the mean diastolic pressure.

Data processing

We use SPSS18 statistical software and excel software to compare the parameters of the same group of college students with different exercise loads using a t-test. Experiment and analyze the proportions of the principal components of each group under the same exercise load.[7] The difference was statistically significant when P<0.05.

RESULTS

Blood flow parameters of the same group of college students under different loads

1. See Table 2 to compare the differences in blood flow parameters of the obesity group.[8] The trend of the K value of the radial artery pulse

wave coefficient and the K value of the finger pulse wave coefficient in the obese group is shown in Figure 1.

The experimental results show that the heart rate HR of the obese college students in the exercise load experiment reaches the maximum when the power is 125W. This is a significant increase in power compared to 0W. Other blood flow parameters changed little during exercise. The changing trends of K and K' are opposite, and the data decrease is not significant. The subject's central stroke volume (SV) did not change much during the loading exercise. SV during exercise in a relatively peaceful state does not increase but decreases at 50W and 100W. The cardiac output does not increase much and increases slowly. The cardiac ejection force of obese college students is relatively weak. The subjects in this group are prone to heart fatigue during exercise.[9] They do not respond well to exercise. The adaptability and reserve capacity of the vascular system is relatively poor, and the body is not suitable for participating in strenuous exercise.

2. See Table 3 for the comparison of blood flow parameters in the normal group. The trend of normal group K and K' has shown in Figure 2. Compared with the obesity group, the heart rate HR changes of the normal group were not significantly different, while K and K' both decreased during exercise. This shows that the continuous increase in the blood supply of subjects in the normal group is mainly due to strong myocardial contractility and good muscle vasodilation during exercise.[10] This is not entirely dependent on an increase in heart rate. Therefore, compared with the obesity group, the cardiovascular function of this group is relatively normal, and the adaptability and reserve capacity of the cardiovascular system is also stronger than that of the obesity group.

Table 2. Differences of blood flow parameters in obesity group.

Exercise load power (W)	0	50	75	100	125	t	P
Pulse pressure DP	30	40	55	50	52	-3.256	0.07
Heart rate HR (times/min)	72	110	125	140	155	-5.721	0.01
Finger pulse K'	0.5	0.46	0.48	0.5	0.47	0.02	0.2
Radial artery K	0.42	0.45	0.42	0.42	0.36	1.257	0.11
Heart stroke volume SV (ml/beat)	38	35	38	35	36	0.563	0.1
Cardiac output CO (L/min)	2.5	3	5	4	7	-2.468	0.06

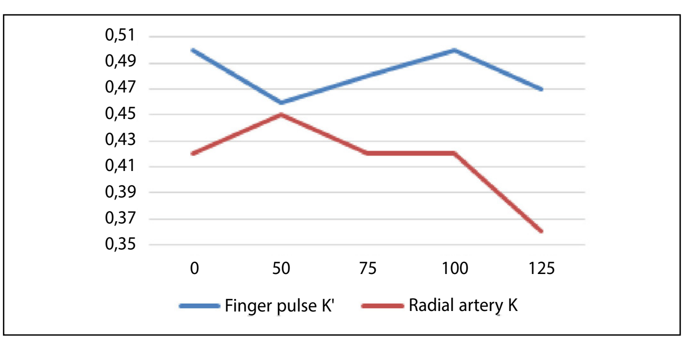

Figure 1. Obesity group K and K' trend graph.

Table 3. Differences of blood flow parameters in the normal group.

Exercise load power (W)	0	50	75	100	125	150	t	P
Pulse pressure DP	50	55	78	85	100	110	-6.348	0.02
Heart rate HR (times/min)	78	100	105	113	120	130	-8.462	0.05
Finger pulse K'	0.489	0.4	0.43	0.38	0.38	0.34	1.547	0.07
Radial artery K	0.35	0.3	0.29	0.31	0.3	0.33	0.246	0.07
Heart stroke volume SV (ml/beat)	100	120	152.7	133	154	143	8.397	0.01
Cardiac output CO (L/min)	7.1	9.2	14.3	13.8	18.6	16.9	2.498	0.01

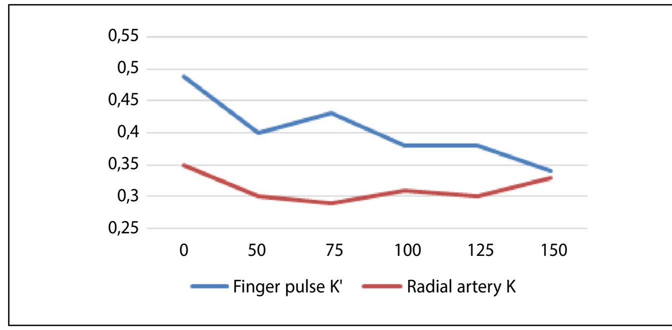

Figure 2. Trend chart of K and K'in normal group.

The proportion of principal components of each group under exercise load

Suppose the influence of a certain principal component on the stroke volume is a positive factor. In that case, it can cause the principal component to fall on the positive semi-axis when the stroke volume increases. If it is a negative impact factor, it will cause the principal component to fall on the negative semi-axis when the stroke volume is reduced. For example, when the load power is 50W, the K value is lower than when it is calm.[11] This means that the vasodilator component has a positive influence on the increase in stroke volume. An increase in pulse pressure is also a positive influencing factor. If the K value rises in a relatively peaceful state, this indicates that the blood vessel shrinks to a negative factor. If the pulse pressure difference decreases in a relatively peaceful state, it is also a negative factor. The increase in heart rate is a negative factor.

DISCUSSION

According to the pulse waveform parameters and blood flow parameters, we use pulse wave sensors in different incremental exercise programs to significantly reflect the subtle changes in the human body's blood vessels under different exercise load stimulation. This shows that the human cardiovascular system has a transient stress response to sports. Obese people and normal subjects have different stress responses to exercise under the same exercise load. The increase in the cardiac output depends entirely on the increase in heart rate, which has little to do with vasodilation. This shows that obese people (BMI>30) are more prone to fatigue and poor cardiovascular function. Those whose athletic ability is lower than normal indicate a serious lack of physical exercise. Boys and girls react differently to exercise under the same exercise load. The boys' group responds better to sports and is more suitable for high-intensity sports activities. And girls are suitable for light sports activities.

CONCLUSION

With the help of the pulse wave acquisition system, we can understand the subtle changes in the cardiovascular system of the human body when the human body is subjected to a certain exercise load. Through these tests, it is possible to judge the changes of the human cardiovascular system in sports and the tolerance to the intensity of sports training accurately. In this way, the signs of sports injuries can be detected early. This experiment shows that there are differences in cardiovascular function among people of different weights during physical exercise. This can provide a corresponding theoretical basis for future research in the field of sports weight loss. This plays a positive role in preventing serious sports injuries and even sudden sports deaths and provides a new research method for college students' physical education and enhancing their physical fitness.

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