RESTORATIVE EFFECT OF JOGGING ON LOWER LIMB MUSCLES

EFEITO REPARADOR DA CORRIDA MODERADA SOBRE A MUSCULATURA DOS MEMBROS INFERIORES

EFECTO RESTAURADOR DEL TROTE MODERADO SOBRE LOS MÚSCULOS DE LOS MIEMBROS INFERIORES

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ABSTRACT

Introduction: Jogging can be a great way to improve physical condition, boosting mind and body. Its method of movement is simple, and there are no sporting limitations as to age, gender, or training place. Jogging is believed to help repair muscle and joint injuries in the lower limbs. Objective: To explore the effects of running on recovering lower limb muscles. Methods: We surveyed 60 undergraduate students who took a 400-meter test at the same site. According to the test results, they were divided into low, medium, and high fitness levels. A questionnaire survey was also used with 20 undergraduate students from the Physical Education Department. Four groups of volunteers did some jogging exercises. Physiological, biochemical, and muscle strength measurements were performed after jogging. The data were statistically treated. Results: The magnitude of change in the sagittal angle of the knee and ankle joint did not increase significantly with increasing jogging rate. The changes in the sagittal angles of the hip, knee, and ankle joints were the same for the volunteers with different jogging rates. After 60 minutes of exercise, the low-fitness group showed faster breathing, an elevated heart rate, and a higher rate of lactate and creatinine in the blood. After 120 minutes of exercise training, all sedentary volunteers showed an increase in lactate, creatinine, respiratory rate, and heart rate ($P<0.05$). The test performance started to decrease at 400 meters. Conclusion: The maximal activation of different parts of the locomotor system changed under different rates of movement. Brief, controlled jogging may be beneficial to lower limb muscles. Still, long-term jogging may cause even more damage to the body and deleterious changes to rehabilitation in blood and biochemical parameters. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Jogging; Creatinine; Muscles; Exercise Therapy.

RESUMO

Introdução: A corrida moderada pode ser uma ótima maneira de melhorar a condição física, impulsionando mente e corpo. Seu método de movimento é simples e não há limitações esportivas quanto a idade, sexo ou local de treino. Acredita-se que a corrida moderada possa auxiliar no reparo de lesões musculares e articulares nos membros inferiores. Objetivo: Explorar os efeitos da corrida sobre a musculatura nos membros inferiores em recuperação. Métodos: Foram pesquisados 60 estudantes de graduação que fizeram um teste de 400 metros no mesmo local. De acordo com os resultados do teste, eles foram divididos em baixo, médio e alto nível de aptidão física. Também se utilizou uma pesquisa por questionário com 20 estudantes universitários do Departamento de Educação Física. Quatro grupos de voluntários fizeram alguns exercícios de corrida moderada. As medidas fisiológicas, bioquímicas e de força muscular foram realizadas após a corrida moderada. Os dados foram tratados estatisticamente. Resultados: A magnitude da mudança no ângulo sagital da articulação do joelho e tornozelo não aumentou significativamente com o aumento da taxa de corrida moderada. As mudanças nos ângulos sagitais das articulações do quadril, joelho e tornozelo foram as mesmas para os voluntários com diferentes taxas de corrida moderada. Após 60 minutos de exercício, o grupo de baixa condição física apresentou uma respiração mais rápida, um ritmo cardíaco elevado e uma taxa maior de lactato e creatinina no sangue. Após 120 minutos de treinamento físico, todos os voluntários sedentários apresentaram um aumento de lactato, creatinina, frequência respiratória e cardíaca ($P<0,05$). O desempenho do teste começou a diminuir aos 400 metros. Conclusão: A ativação máxima de diferentes partes do sistema locomotor alterou-se sob diferentes taxas de movimento. A corrida moderada breve e controlada pode ser benéfica a musculatura dos membros inferiores, porém a corrida moderada de longo prazo pode causar ainda mais danos ao corpo e mudanças deletérias à reabilitação nos parâmetros sanguíneos e bioquímicos. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Corrida Moderada; Creatinina; Músculos; Terapia por Exercício.*

RESUMEN

Introducción: El trote moderado puede ser una gran manera de mejorar la condición física, impulsando la mente y el cuerpo. Su método de movimiento es sencillo y no existen limitaciones deportivas en cuanto a edad, sexo o lugar de entrenamiento. Se cree que trotar puede ayudar a reparar las lesiones musculares y articulares de las extremidades inferiores. Objetivo: Explorar los efectos de la carrera en la recuperación de los músculos de las extremidades inferiores. Métodos: Se encuestó a 60 estudiantes universitarios que realizaron una prueba de 400 metros en el mismo

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lugar. Según los resultados de la prueba, se dividieron en nivel de aptitud bajo, medio y alto. También se utilizó una encuesta con 20 estudiantes de grado del Departamento de Educación Física. Cuatro grupos de voluntarios realizaron ejercicios de trote. Se realizaron mediciones fisiológicas, bioquímicas y de fuerza muscular después del trote moderado. Los datos fueron tratados estadísticamente. Resultados: La magnitud del cambio en el ángulo sagital de la articulación de la rodilla y el tobillo no aumentó significativamente con el aumento de la velocidad del trote. Los cambios en los ángulos sagitales de las articulaciones de la cadera, la rodilla y el tobillo fueron los mismos para los voluntarios con diferentes ritmos de trote. Después de 60 minutos de ejercicio, el grupo de baja forma física mostró una respiración más rápida, una frecuencia cardíaca elevada y un mayor índice de lactato y creatinina en la sangre. Tras 120 minutos de entrenamiento físico, todos los voluntarios sedentarios mostraron un aumento del lactato, la creatinina, la frecuencia respiratoria y la frecuencia cardíaca (P<0,05). El rendimiento de la prueba comenzó a disminuir a partir de los 400 metros. Conclusión: La activación máxima de diferentes partes del aparato locomotor cambió bajo diferentes ritmos de movimiento. El trote moderado y de forma controlada puede ser beneficioso para los músculos de las extremidades inferiores, pero trotar a largo plazo puede causar aún más daño al cuerpo y cambios nocivos para la rehabilitación en los parámetros sanguíneos y bioquímicos. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

***Descriptores*:** *Trote; Creatinina; Músculos; Terapia por Ejercicio.*

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INTRODUCTION

Jogging is a great way to improve your physical fitness. Jogging is a type of jogging that boosts the mind and body. Its movement method is simple and dangerous. The sport will not be interfered with by factors such as age, gender, environment, etc. Jogging can promote the body's self-regulation and improve the quality of life.[1] The speed of jogging will have a particular impact on the joints and muscles of the lower limbs. The above results have a particular guiding role in evaluating the exercise performance of the human body.

METHOD

General information

This article surveys 60 undergraduates in grades 1-4 in colleges and universities. Volunteers did a 400-meter test. According to the test results, the weaker physique group (>132 s), the regular physique group (83-132 s), and the better physique group (<83 s). Select 20 people from each group. Then this paper selects 20 volunteers from the physical education department of this school for testing.[2] There were no significant differences in height, weight, gender, age, and grade among the four groups.

Experimental method

All volunteers ran a 60-minute jog on the school's 400-meter track at a speed of 45-112 m/min. Students should take a blood test immediately after jogging.3 The experiment was repeated three times, with an interval of more than one week between each time. The 120-minute jogging test operates as above.

Observation indicators

In this paper, the respiration, heart rate, blood lactate, creatinine levels, and the results of the 400-meter run were compared between the two groups of volunteers before and after jogging.[4] At the same time, this paper adopts the dynamic capture technology to collect the primary EMG data of the lower limbs of volunteers. At the same time, the numerical simulation method was used to obtain the average rotation angles of the sagittal planes of the hip, knee, and ankle joints of volunteers at different jogging speeds.

Model simulation of jogger's movement muscle changes

θ indicates the time interval of jogging practice. ξ_γ means the human muscle system. Then this paper uses the formula (1) to deduce the movement characteristics of jogging from multiple perspectives

$$\Gamma(\tau)=\frac{\xi_\gamma}{\theta\times\alpha_I}*\frac{[G(L)+\iota(P)][G(L)-\iota(P)]g\rho}{\tau g\eta} \tag{1}$$

α_I indicates the muscle mechanics index after exercise. $G(L)$ is the physical and mechanical index of muscle load after exercise. $t(P)$ represents the sarcomere in the muscle fiber. τ is the energy generated by the muscles in different states of motion. γ represents the activation of the muscle. ρ represents the change in muscle density before and after exercise. u is the maximum exercise capacity of the volunteers' muscles before exercise. $q(x)$ represents the instantaneous length of muscle fibers. $\phi(L)$ represents the degree of muscle activity after exercise. δ stands for body musculature. Then this article uses formula (2) to get the main effect of jogging on muscles:

$$\gamma(k,q)=\frac{u\times q(x)}{\phi(L)\times\delta}\times\frac{[G(P)+F(x)][G(P)-F(x)]\times F(\delta)}{P\times\xi(\chi^*\gamma)} \tag{2}$$

$G(P)$ indicates the direction of muscle tension of the movement. $F(x)$ represents changes in $\rho a2$ + content in muscle segments. $F(\delta)$ represents the action state of muscles and bones at each stage. P represents the contraction mechanism of the muscle. χ is the maximum muscle tension at the optimal length. γ indicates the microstructure of the muscle. Γ is the sum of all muscle fiber strengths. I represents the restriction of biochemical factors on muscle strength. This paper uses formulas (3) and (4) to obtain the average value of muscle work and muscle torque in each training period.

$$L_{(U)}=\frac{\phi(\gamma)*\dfrac{\Gamma}{\rho(L)}\times\dfrac{T(G,Y)+\ell(I,G)}{T(G,Y)-\ell(I,G)}}{\dfrac{\Gamma(\xi)+\gamma(k,q)}{\Gamma(\xi)-\gamma(k,q)}} \tag{3}$$

$$L_{(P)}=\frac{\phi(B)*\dfrac{\Gamma}{\rho(L)}\times\dfrac{T(G,Y)+\ell(I,G)}{T(G,Y)-\ell(I,G)}}{\dfrac{\Gamma(\xi)+\gamma(k,q)}{\Gamma(\xi)-\gamma(k,q)}}*L_{(U)} \tag{4}$$

$\phi(B)$ and $\phi(\gamma)$ represent muscle fatigue and exercise volume during jogging, respectively. $T(G, Y)$ and $\ell(I, G)$ represent the response of each motor unit during low- or high-intensity training. $\Gamma(\xi)$ represents the adaptive capacity of bone under the excitation of high-load exercise. $\gamma(k, q)$ represents the correlation between EMG and muscle strength. In this paper, formula (5) is used to express the law of muscle biomechanical movement when volunteers are jogging:

$$\omega(g^* u) = \frac{\left[\gamma(k,q) + L_{(U)}\right]\Gamma(\xi)}{\gamma(k,q) - L_{(U)}} L_{(P)} * [\frac{R(\theta)+F(I)}{1-\gamma}] \quad (5)$$

$R(\theta)$ represents the correlation of the strength of bone contractions with the frequency of potential motor excitation at various loads. $F(I)$ represents the effect of exercise intensity on muscle fiber dynamics.

Data Analysis

This paper analyzes all the test results through SPSS16.0. Measurement data are expressed as mean ± standard deviation. We used paired sampling t-test for internal data processing.[5] After the homogeneity of variance test was performed, variance analysis was performed for each group. This paper uses chi-square analysis to transform the statistical data.

Ethical Compliance

Research experiments conducted in this article with animals or humans were approved by the Ethical Committee and responsible authorities of Jilin Police College and Boda College of Jilin Normal University following all guidelines, regulations, legal, and ethical standards as required for humans or animals.

RESULTS

Comparative study on various indicators of volunteers in four groups before and after 60 minutes of exercise

There were no significant changes in the four groups of students' respiration, heart rate, lactate, and creatinine concentrations before and after exercise.[6] There were no significant differences in the results recorded before the retest of 400 meters and before taking the test. (Table 1)

Comparative analysis of the indicators of the four groups before and after 120-minute jogging

There were no significant changes in the four groups of students' respiration, heart rate, lactate, and creatinine concentrations before and after exercise. One hundred twenty minutes after exercise, the heart rate was significantly increased (P<0.01), and the lactate and creatinine were significantly increased (P<0.01). The 400m test recorded a significant decrease in pre-exercise records (P<0.01). There were no significant changes in the indexes of respiration, heart rate, lactate, and creatinine in the professional sports group.[7] The 400m test was not significantly different from the pre-jogging test. (Table 2)

Table 1. Changes in physiological indicators before and after 60 minutes of jogging in the four groups.

Group	Poor physique group		Physically normal group	
	Before	After	Before	After
BR (beats/min)	26.32±4.11	32.63±6.11	24.21±4.21	25.26±3.89
HR (beats/min)	83.16±18.32	102.11±21.68	84.21±19.58	83.16±19.47
LA (mmol/L)	1.37±0.21	2.74±1.16	1.37±0.53	1.37±0.95
Src (mmol/L)	94.74±18.21	106.32±24.42	96.84±16.42	95.79±17.68
400-meter test (s)	171.58±32.53	208.42±44.95	109.47±22.42	108.42±24.74
Group	**Good fitness group**		**Professional group**	
	Before	**After**	**Before**	**After**
BR (beats/min)	26.32±3.89	26.32±4.32	24.21±2.84	25.26±3.16
HR (beats/min)	80±21.16	81.05±23.47	78.95±19.58	77.89±20.32
LA (mmol/L)	1.47±0.21	1.58±0.11	1.37±0.21	1.26±0.84
Src (mmol/L)	98.95±15.68	100±16	97.89±18.32	97.89±24.32
400-meter test (s)	74.74±12.84	75.79±10	53.68±3.79	55.79±5.37

Changes in muscle performance

This paper determined the changes in the activity of 8 major muscles under 5 different jogging speeds. The changing law of exercise intensity at each stage is the same. During a training cycle, the medial thigh, vastus medialis, rectus femoris, vastus lateralis, and semimembranosus semitendinosus were activated at a frequency of 1 time each.[8] The frequency of activation of the biceps femoris and the medial head of the gastrocnemius was two times. The anterior tibialis muscle, on the other hand, is often active. The changes in sagittal joint angles of the hip, knee, and ankle joints did not increase monotonically with jogging speed. The changes in sagittal joint angles of hip, knee, and ankle joints were the same at different jogging rates.

DISCUSSION

Academia regards serum lactate and creatinine values as essential measures to measure exercise and fatigue. Carbohydrates in the human body are produced by various organs such as red blood cells, striated muscles, and the brain. Some exercise situations or pathological hypoxic conditions can increase lactate levels in the body.[9] In addition, the increase in the decomposition rate of carbohydrate enzymes in the body, strenuous exercise, dehydration, etc., will also increase the body's lactic acid concentration. Serum creatinine is a substance produced by the metabolism of human muscle tissue. In the case of overload, local muscle tissue can be acutely damaged or dissolved to produce creatinine. This can cause a transient increase in the level of creatinine in the blood. Blood lactate and creatinine can accurately reflect exercise status and fatigue.

Jogging brings some physical changes to the human body. College students can strengthen the heart's function by jogging, improve the cardiovascular system's working performance and enhance the cardiovascular system's resistance. Moreover, it can also promote blood circulation in the human body, increase oxygen transport, and improve various body functions. Long-term jogging can improve the blood quality of the human body and reduce blood cholesterol and blood lipids.[10] College students can increase the body's ventilation by jogging to strengthen the respiratory muscles in the lungs. Jogging is a type of aerobic jogging. It removes excess oil from the body. College students can lose weight by jogging to remove body fat. Jogging increases bone density and strength, stiffness, and flexibility. Be prepared to warm up while jogging. College students should avoid muscle fatigue and joint fatigue.

The poor physique group experienced various physiological changes after 60 minutes. This means that the body has entered a hypoxic

Table 2. Various indicators of 4 groups before and after 120-minute jogging.

Group	Poor physique group		Physically normal group	
	Before	After	Before	After
BR (beats/min)	27.37±5.58	40±7.58	25.26±4.42	31.58±6.21
HR (beats/min)	84.21±15.68	127.37±28.11	82.11±17.79	108.42±18.53
LA (mmol/L)	1.37±0.32	5.05±1.68	1.47±0.21	2.74±1.37
Src (mmol/L)	93.68±20.53	138.95±26.95	94.74±18.53	110.53±22.42
400 interest (s)	171.58±32.53	243.16±55.58	109.47±24.53	106.32±24
Group	**Good fitness group**		**Professional group**	
	Before	**After**	**Before**	**After**
BR (beats/min)	24.21±5.26	29.47±4.95	24.21±4.53	25.26±4
HR (beats/min)	80±22.74	104.21±16.42	76.84±19.37	78.95±20.21
LA (mmol/L)	1.47±0.32	2.53±0.84	1.37±0.53	1.47±0.11
Src (mmol/L)	98.95±18.21	108.42±19.37	94.74±20.95	95.79±21.37
400-meter test (s)	73.68±13.47	76.84±10.32	56.84±4.53	57.89±3.79

environment and suffered some damage. Neither group changed after 60 minutes of jogging. This shows that people with low physical fitness are only suitable for jogging for less than 60 minutes.[11] All non-athletic college students experienced some degree of tiredness after 120 minutes. This shows that 120 minutes is the upper limit of jogging for non-sports college students in our city. Long-term jogging for more than 120 minutes is physically exhausting for non-sports college students.

CONCLUSION

Jogging can reduce excess calories in college students' bodies, preventing them from turning into excess fat. Jogging can improve their muscles and muscle strength. Jogging at the same time can also improve the function of their heart and lungs. In one exercise cycle, the overall motion angle of the lower limbs is the largest, and the overall activity of the muscle cells is the highest. The sagittal joint angles of the hip, knee, and ankle joints changed during one motion cycle. An extended period of jogging can cause blood lactate and serum creatinine to rise. At the same time, jogging for a long time can also cause physical fatigue and discomfort. This article suggests that college students should jog for no less than 60 minutes at a time, and those with poor physical fitness can appropriately shorten the jogging time.

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