ISOKINETIC MUSCLE STRENGTH CHARACTERISTICS OF LOWER LIMB JOINTS IN LONG JUMPERS

CARACTERÍSTICAS DA FORÇA MUSCULAR ISOCINÉTICA DAS ARTICULAÇÕES DOS MEMBROS INFERIORES DOS SALTADORES DE SALTO EM DISTÂNCIA

CARACTERÍSTICAS DE LA FUERZA MUSCULAR ISOCINÉTICA DE LAS ARTICULACIONES DE LOS MIEMBROS INFERIORES EN SALTADORES DE LONGITUD

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ABSTRACT

Introduction: Joint strength of the lower limbs plays a decisive role in the competitive ability of long jumpers. Special strength training based on science and targeted at the strength of the lower limb joints is an essential topic for long jumpers. Objective: To analyze isokinetic muscle strength characteristics of lower limb joints in long jumpers. Methods: Voluntary jumpers were submitted to isokinetic concentric contraction tests of the lower limbs and hip joints. We also analyzed the effect of strength training on lower limb joint injury. Results: The knee muscles of the athletes have reduced eccentric contractility. The ankle of the athlete has the most vulnerable joint to injuries in the sport. Conclusion: The explosive force and eccentric contractility of long jumpers' lower limb extensor muscles have the most significant impact on joint thrust and extension speed. Athletes need muscle strength training to develop isokinetic muscle strength. This can effectively prevent injury to lower extremity joint movements. The research findings of this paper can provide a specific theoretical basis for formulating scientific training for long jumpers. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Athletes; Ankle Joint; Muscle Strength; Sports.

RESUMO

Introdução: A força conjunta dos membros inferiores desempenha um papel decisivo na capacidade competitiva nos saltadores de salto em distância. O treinamento de força especial baseado na ciência e direcionado para a força das articulações dos membros inferiores é um tópico essencial para os saltadores. Objetivo: Analisar as características de força muscular isocinética das articulações dos membros inferiores em saltadores de salto em distância. Métodos: Saltadores voluntários foram submetidos à testes de contração concêntrica isocinética dos membros inferiores e articulação do quadril. Efetuou-se também a análise do efeito do treinamento de força na lesão das articulações dos membros inferiores. Resultados: Os músculos dos joelhos dos atletas têm uma contratilidade excêntrica reduzida. O tornozelo dos atletas possui a articulação mais vulnerável a lesões no esporte. Conclusão: A força de explosão e a capacidade de contração excêntrica dos músculos extensores dos membros inferiores dos saltadores de salto longo têm o impacto mais significativo no empuxo das articulações e na velocidade de extensão. Os atletas precisam de treinamento de força muscular para desenvolver a força muscular isocinética. Isto pode efetivamente evitar lesões nos movimentos das extremidades inferiores das articulações. Os resultados da pesquisa deste trabalho podem fornecer uma base teórica específica para a formulação do treinamento científico para os saltadores de salto longo. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Atleta; Articulação do Tornozelo; Força Muscular; Esportes.*

RESUMEN

Introducción: La fuerza articular de los miembros inferiores desempeña un papel decisivo en la capacidad competitiva de los saltadores de longitud. El entrenamiento de fuerza especial basado en la ciencia y dirigido a la fuerza de las articulaciones de los miembros inferiores es un tema esencial para los saltadores. Objetivo: Analizar las características de la fuerza muscular isocinética de las articulaciones de los miembros inferiores en saltadores de longitud. Métodos: Los saltadores voluntarios fueron sometidos a pruebas de contracción concéntrica isocinética de los miembros inferiores y de las articulaciones de la cadera. También se realizó un análisis del efecto del entrenamiento de fuerza en las lesiones de las articulaciones de los miembros inferiores. Resultados: Los músculos de la rodilla de los atletas tienen una contractilidad excéntrica reducida. El tobillo de los atletas tiene la articulación más vulnerable a las lesiones en el deporte. Conclusión: La fuerza de explosión y la contractilidad excéntrica de los músculos extensores de las extremidades inferiores de los saltadores de longitud tienen el impacto más significativo en el empuje articular y la velocidad de extensión. Los atletas necesitan entrenar la fuerza muscular para desarrollar la fuerza muscular isocinética. Esto puede prevenir eficazmente las lesiones en los movimientos de las articulaciones de las extremidades inferiores. Los resultados

de la investigación de este trabajo pueden proporcionar una base teórica específica para la formulación del entrenamiento científico de los saltadores de longitud. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Atletas; Articulación del Tobillo; Fuerza Muscular; Deportes.*

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INTRODUCTION

The long-jump is a competitive sport. A study by some scholars found that 98 out of 156 long jumpers had sports injuries during the long jump. The damage rate was 62.8%. Some scholars have pointed out that injuries in long jump sports affect the normal training or competition of athletes and significantly reduce the "sports lifespan" of athletes.[1] This causes significant damage to the athlete's psychology. Some scholars have found that ankle injuries in long jump sports are spread across various positions on the long jump field. Its incidence ranks first in long jump sports injuries. We found that the current preventive measures for ankle injuries of long jumpers mainly strengthen the strength training of the ankle joints.

The preventive effect of these measures on ankle injury of long jumpers only stays in enhancing the ability of static balance. The completion of the movement technique of the long jumper is often carried out in a state of alternation and imbalance of static and dynamic balance.[2] At the same time, some studies have pointed out that the source of strength of the participants in the long jump is the result of the coordinated action of all the human body muscles. This maintains body posture and ensures the completion of various technical movements. Muscle strength training refers to the training of the muscles of the trunk axis and its deep small muscles. It enhances the athlete's small muscle groups' strength, stability, and balance. Some scholars have pointed out that the completion of any competitive sports technology is not only achieved by a single muscle work. It must be the collaborative work of most body muscle groups to maintain balance in motion. Some scholars have used muscle strength training to study the balance ability of taekwondo athletes, showing that muscle strength training can significantly improve the static and dynamic balance ability of taekwondo athletes. Therefore, athletes have good body balance in the fierce long jump confrontation.[3] Dynamic balance is the basis for participants to complete various techniques in a fierce physical confrontation effectively. It is more likely to be one of the critical factors in reducing long jump injuries.

The ability of the remote athlete's lower body muscles to bear the load is the main factor that affects the formation of skills, the level of performance, and the creation of performance.[4] Therefore, in this study, the isokinetic force measurement system was used to analyze the muscle strength characteristics of long jumpers. In this paper, a comprehensive analysis is carried out in combination with the kinematic characteristics of the particular technology. The research theory of this paper provides a scientific reference for long jump training.

METHOD

Research objects

This paper selects 20 long jumpers as the research object. In this study, the test subjects were divided into experimental and control groups according to the actual long jump achievement.[5] The average age of the athletes was (16±3.18) years old.

Experimental method

After the start of the experiment, the control group was given 6w of traditional strength training. The experimental group underwent 6w muscle strength training. This paper tested all subjects for balance ability and lower extremity joint isokinetic muscle strength before and after the experiment.[6] The static balance ability is standing on one foot with eyes closed, and the dynamic balance ability is the star offset test. This paper used the American-made BIODEX II multi-joint isokinetic force measurement and rehabilitation system for the muscle strength tests. The test adopts CON/CON and ECC/ECC methods. Concentric contractions were measured at 60°/s×5 times, 240°/s×15 times, and eccentric contractions were measured at 120°/s×10 times. We investigated ankle sports injuries in all study subjects after the experiment.

Kinematics model of leg muscles of long jumpers

In this paper, the control parameters are self-tuned according to the long jumper's leg muscle force.[7] In this way, we obtain the nonlinear system of equations controlled by the force parameters of the long jumper's leg muscles:

$$\overline{A} = -\frac{dV}{dL} - f[a(1-\varepsilon)^2 - b] \quad (1)$$

In this paper, the mechanical parameter variable $x = [\varphi, \dot{\varphi}, \theta]^T$ of the hip joint is obtained by the method of force balance parameter fusion. This paper constructs a proper relation. This paper obtains the inertia moment of the long jumper's leg muscles according to the motion sequence distribution of the long jumper's muscles. It is denoted as $\dot{x} = f(x,u)$. The state quantity $x_0 (x_0 = [\varphi_0, \dot{\varphi}_0, \theta_0]^T)$ of the output stability characteristic functional is obtained under the condition that the initial length of the long jumper's leg is determined.[8] This paper uses the shock spring damping parameter analysis to obtain the stability modeling equilibrium condition of the long jumper's leg muscle force: $f(x_0, u_0) = 0$. The dynamic characteristic equation of the leg muscles of the long jumper is:

$$\begin{aligned} x &= [{}_0^{\varphi} + \Delta\varphi, \dot{\varphi}_0 + \Delta\dot{\varphi}, \theta_0 + \Delta\theta]T \\ u &= \Delta u_0 \end{aligned} \quad (2)$$

In Eq. (2), x,u represents the solution of the equilibrium condition of the stability modeling of muscle force. From this, we get the kinematic equation of the long jumper's leg muscles:

$$F_{et} = \overline{A} + \frac{\pi D^2}{4}(x-u) \quad (3)$$

In this paper, a 4×4 homogeneous coordinate matrix ${}^{I}T_0\ (a_0, \beta_0, \gamma_0)$ is used to represent the motion inertia feature of the long jumper's leg muscles. It is denoted as ${}^{I}T_0\ (\theta_1, \theta_2, \theta_3)$. The feedback compensation parameter for energy deviation is $p_t = [x_t, y_t, z_t]^T$.

Statistics method

This paper uses SPSS statistical software to analyze the data. Measurement data are expressed as mean ± standard deviation.[9] Paired

t-test was used for intra-group comparisons. P<0.05 means there is a significant difference.

There is no need for a code of ethics for this type of study.

RESULTS

Comparative analysis of isokinetic muscle strength characteristics of knee joint

Table 1 shows that the relative peak torque and average output power of the knee joint of the athletes in the experimental group were higher than those in the control group.[10] The extensor muscle's peak systolic torque and eccentric systolic peak torque were significantly higher than those of the control group (P<0.01). It shows that the athletes in the control group are worse than the experimental group in terms of maximum knee strength and yielding contraction ability. The study also found that knee extensor retraction capacity was closely related to maximal and rapid forces. The correlation coefficients were 0.758 (P<0.01) and 0.561 (P<0.05), respectively. Knee extensor retraction ability was moderately correlated with stride and jump performance and vertical velocity of the center of gravity at the moment of ascension. The correlation coefficients were 0.629 (P<0.01) and 0.574 (P<0.05), respectively.[11] Therefore, it can be seen that the maximum explosive power generated in the kick-stretching stage is closely related to the ability of the athlete's take-off leg knee extensor muscles to yield and contract. Burst power is one of the main factors affecting jumping performance.[12]

Table 1. Comparison of relative peak torque of knee flexor and extensor muscle groups in long jumpers with different training levels (Nm/kg).

		60°/s(CON)		240°/s(CON)		120°/s(ECC)	
Group		**Flexor**	**Extensor**	**Flexor**	**Extensor**	**Flexor**	**Extensor**
Test group	Average	2.018	3.841	1.838	2.113	1.888	5.382
	Standard deviation	0.121	0.415	0.085	0.188	0.33	0.251
Control group	Average	1.888	3.11	1.515	1.84	1.858	4.438
	Standard deviation	0.338	0.468	0.211	0.251	0.382	0.555
P		>0.05	<0.01	<0.05	>0.05	>0.05	<0.01

Table 2. Effects of muscle strength training on the balance ability of amateur long jumpers.

Test indicators	The difference between the control group before and after the experiment	The difference between the experimental group before and after the intervention	t value	P value
Stand on one foot with eyes closed (s)	3.01±0.09	6.26±0.09	2.30	0.024
ALAT (cm)	1.91±0.04	6.34±0.11	2.00	0.049
LAT (cm)	2.39±0.05	9.29±0.21	2.05	0.043
PLAT (cm)	3.05±0.07	7.99±0.19	2.09	0.040

The effect of muscle strength training on the balance ability of amateur long jumpers

Balance ability in a long-jump is an essential physiological index to measure long jumpers. It is subdivided into static balance ability and dynamic balance ability. Eye-closed standing on one foot and star-shaped offset test is simple and effective indicators to test the body's static and dynamic balance ability. Muscle strength training can improve the balance ability of long jumpers by enhancing the coordination between muscles of various parts of the body. Muscle strength training has a significant effect on improving the balance ability of athletes. After 6w experimental intervention, the static balance ability of the control group and the experimental group was significantly enhanced (P<0.05). But only the experimental group's performance of the star-shaped shift test of dynamic balance ability increased significantly (P<0.05). This shows that traditional strength training and muscle strength training with 6w can enhance the static balance ability of amateur long jumpers.[13] But only 6w of muscle strength training can significantly enhance the dynamic balance ability of amateur long jumpers. (Table 2)

DISCUSSION

The isokinetic muscle strength characteristics of the lower limb muscles of long jumpers with different training levels were significantly different. This may be one of the factors affecting grades. The maximum strength of the hip and ankle joints determines the stability of the ground support technique.[14] The ability of the knee and ankle extensors to yield and contract and the rapid strength of the ankle flexors are the main tasks that affect the buffering effect of stepping. Muscle groups, ankle extensor rapid strength and eccentric contraction ability, and flexor rapid action ability have the most significant impact on ankle thrusting speed. It is the main factor that affects the effect of kicking and stretching. The peak torque ratios of long jumpers' hip, knee, and ankle joints were: 39%, 53%, 24% (60°/s CON); 36%, 92%, and 39% (240°/s CON). The incidence of ankle injuries remains high in long jumpers. The static balance ability (standing on one foot with eyes closed) and dynamic balance ability (ALAT, LAT, PLAT) of the long jumpers after 6w of muscle strength training were significantly enhanced (P<0.05). The incidence of ankle injury was only 8.79%. This shows that muscle strength training is more effective in enhancing the dynamic balance ability of amateur long jumpers. At the same time, it has essential preventive significance for reducing the ankle injury of amateur long jumpers.

CONCLUSION

This study aimed to investigate the characteristics of lower extremity joint muscle strength and its relationship with specific abilities in long jumpers. 6w muscle strength training can enhance the body balance of amateur long jumpers. This will ensure that it can effectively implement technical movements in a fierce physical confrontation and maintain the balance and stability of the body in fierce collisions. This can prevent ankle injuries. Participants should increase their awareness of muscle strength training. This provides scientific theoretical support for the self-protection of long jumpers.

All authors declare no potential conflict of interest related to this article

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