ISOKINETIC KNEEL MUSCLE STRENGTH CHARACTERISTICS IN HIGH JUMP ATHLETES

CARACTERÍSTICAS DA FORÇA MUSCULAR ISOCINÉTICA NA ARTICULAÇÃO DO JOELHO EM ATLETAS DE SALTO EM ALTURA

CARACTERÍSTICAS DE LA FUERZA MUSCULAR ISOCINÉTICA EN LA ARTICULACIÓN DE LA RODILLA EN ATLETAS DE SALTO DE ALTURA

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ABSTRACT

Introduction: Vertical jump is inherent to the practice of high jump and demands great capacity of force generation and work of the knee muscles, especially the quadriceps muscle. Due to this demand, imbalances between the extensor and flexor knee muscles may be present, leading to an overload of the musculotendinous structures of the knee joint. Therefore, it is necessary to establish the characteristics of isokinetic muscle strength in the knee joint of these athletes. Objective: This study aimed to analyze the biomechanical properties of the knee flexor and extensor muscles in high jump athletes. Methods: Ten high jumpers volunteered for the experiment. They were divided into experimental and control groups. Both groups performed basic strength training. The experimental group added isokinetic knee muscle training based on this training. Statistical analyses were performed on the training data of the two groups of athletes using relevant mathematical statistics. Results: The high jump consists of four phases being respectively the approach run, the jump itself (impulsion, elevation, transposition), and the fall. The strength of the ankle joint dorsiflexion and plantar flexors was significantly increased in the experimental group of athletes. In contrast, the strength of the plantar flexors in the control group was significantly increased. Statistical differences were found between the two groups (P<0.05). Conclusion: The isokinetic knee joint strength training mode can improve the leg support strength of jumpers. This paper suggests that high jump athletes can further adopt this lower limb strength training method. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Resistance Training; Knee Joint; Athletes.

RESUMO

Introdução: O salto vertical é inerente à prática do salto em altura e demanda grande capacidade de geração de força e trabalho da muscular do joelho, principalmente do músculo quadríceps. Devido a esta demanda, desequilíbrios entre os músculos extensores e flexores podem estar presentes, levando à sobrecarga das estruturas musculotendíneas da articulação do joelho. Sendo assim, torna-se necessário o estabelecimento das características da força muscular isocinética na articulação do joelho desses atletas. Objetivo: Este estudo teve como objetivo analisar as propriedades biomecânicas dos músculos flexores e extensores do joelho nos atletas de salto em altura. Métodos: Dez saltadores voluntariaram-se para o experimento. Eles foram divididos em grupos experimentais e grupos de controle. Ambos os grupos realizaram o treinamento básico de força. O grupo experimental adicionou treinamento muscular isocinético do joelho baseado neste treinamento. Foram realizadas análises estatísticas sobre os dados de treinamento dos dois grupos de atletas, utilizando estatísticas matemáticas pertinentes. Resultados: O salto em altura consiste de quatro fases, sendo respectivamente a corrida de aproximação, o salto em si (impulsão, elevação, transposição) e a queda. A força da dorsiflexão da articulação do tornozelo e dos flexores plantares foi significativamente aumentada no grupo experimental de atletas. Em contraste, somente a força dos flexores plantares no grupo de controle foi significativamente aumentada. Foram encontradas diferenças estatísticas entre os dois grupos (P<0,05). Conclusão: O modo de treinamento de força isocinética da articulação do joelho pode melhorar a força de apoio nas pernas dos saltadores. Este artigo sugere que os atletas de salto em altura podem adotar mais este método para o treinamento de força para membros inferiores. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Treinamento de força; Articulação do joelho; Atletas.*

RESUMEN

Introducción: El salto vertical es inherente a la práctica del salto de altura y exige una gran capacidad de generación de fuerza y trabajo de los músculos de la rodilla, principalmente del cuádriceps. Debido a esta demanda, puede haber desequilibrios entre los músculos extensores y flexores, lo que lleva a la sobrecarga de las estructuras musculotendinosas de la articulación de la rodilla. Por lo tanto, es necesario establecer las características de la fuerza muscular isocinética en la articulación de la rodilla de estos atletas. Objetivo: El propósito de este estudio fue analizar las propiedades biomecánicas de los músculos flexores y extensores de la rodilla en atletas de salto de altura. Métodos: Diez saltadores de altura se ofrecieron como voluntarios para el experimento. Se dividieron en grupos experimentales

y de control. Ambos grupos realizaron un entrenamiento de fuerza básico. El grupo experimental añadió un entrenamiento muscular isocinético de la rodilla basado en este entrenamiento. Se realizaron análisis estadísticos de los datos de entrenamiento de los dos grupos de atletas utilizando las estadísticas matemáticas pertinentes. Resultados: El salto de altura consta de cuatro fases, que son respectivamente la carrera de aproximación, el salto propiamente dicho (impulsión, elevación, transposición) y la caída. La fuerza de la dorsiflexión de la articulación del tobillo y de los flexores plantares aumentó significativamente en el grupo experimental de atletas. Por el contrario, sólo aumentó significativamente la fuerza de los flexores plantares en el grupo de control. Se encontraron diferencias estadísticas entre los dos grupos (P<0,05). Conclusión: El modo de entrenamiento isocinético de la fuerza de la articulación de la rodilla puede mejorar la fuerza de apoyo de la pierna en los saltadores. Este artículo sugiere que los atletas de salto de altura pueden adoptar este método para el entrenamiento de la fuerza de las extremidades inferiores.
Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.

Descriptores: *Entrenamiento de Fuerza; Articulación de la Rodilla; Atletas.*

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INTRODUCTION

The knee and ankle joints of high jumpers are fundamental joints. The relevant joints of the take-off leg are subjected to enormous forces during the landing cushioning and thrusting phases. This places very high demands on the muscles around the knee and ankle joints. The knee and ankle joints of high jumpers are vulnerable joints. It all has to do with the strength characteristics of the muscles around the joints.[1] This study used the Isomed2000 isokinetic test system combined with daily strength training to train the knee and ankle joints of 10 second-level elite high jumpers. We have achieved specific practical results through research. The research results of this paper hope to provide a specific reference for high jumpers to perform joint muscle strength training.

METHOD

Research objects

This paper takes ten second-level elite high jumpers as the research object. (Table 1) The players who participated in the test took off with the left leg, and the right leg was the swing leg.

Isokinetic test of dominant leg ankle strength

Knee and ankle muscle strength tests were performed in strict accordance with the instructions of the test equipment.[2] We secure the subject to the instrument in a reasonably safe manner. The rotation axis of the power arm of the instrument is parallel to the active axis of the joint. The test speed is 60°/s and 120°/s.

Knee and ankle joint isokinetic muscle training

In each training, in addition to basic strength training, the experimental group was required to perform five sets of isokinetic muscle training for the knee and ankle joints of the left jumping leg. Perform ten repetitions of flexion and extension in each group (10 repetitions for 60°/s and 120°/s for each group). The athlete continuously repeats the maximal contraction.[3] Each set is separated by 3 minutes. The control group did only basic strength training.

Simulation of the effect of volleyball squats on the decline of isokinetic muscle strength in knee flexion and extension

COE, COP represents the displacement and velocity of the center of mass at a particular moment.[4] We use the formula (1) to obtain the measurement threshold of the athlete's knee flexion and extension isokinetic muscle force dynamic stability.

Table 1. Basic information of players.

Number of people	Age	Height (cm)	Weight (kg)	Training years
5	19.2±3.1	187.2±5.2	76.4±7.8	6.4±2.1
5	19.4±2.9	188.6±5.8	77.4±6.9	6.8±1.9

$$\hbar(C,M) = \frac{B\max(T)}{\omega_{(\chi)} \times N_q} \times COE \times COP \tag{1}$$

B stands for quantifying the immediacy difference between the athlete's center of mass position and the velocity factor. (T) represents the dynamic stability at a particular moment.[5] The dynamic stability when the right foot and left foot land on the ground is represented by ℓ, Υ,. τ represents the daily habitual speed of its athlete's squat. We use equation (2) to change the stability of the athlete's knee joint during squatting.

$$\Psi(C) = \frac{[\ell \times \Upsilon]^{\tau}}{d(m)} \times S(P,O) \tag{2}$$

$d\,(m)$ represents the ratio of speed to $\omega_{(\chi)}$. $S(P, O)$ stands for squatting speed, step length, step width, and other gait parameters. j, k, c, b, l represents the presence of primary osteoporosis factors in athletes such as decreased estrogen and an unbalanced diet. X represents the set of valid measurements of the athlete's knee flexion and extension isokinetic dynamic stability confirmed at time $t+1$. We use the formula (3) to calculate the absolute difference of the indicators of different characteristic parameters of the athlete's knee flexion and extension isokinetic muscle strength decline.

$$\xi(S,P) = S[\zeta] \times \frac{[j,k,c,b,l]}{X(t+1)} \delta(Y) \tag{3}$$

$S\,[\zeta]$ represents the state measurement value corresponding to each valid observation. $\delta\,(Y)$ represents the association probability among the factors associated with X and the athlete's knee flexion and extension isokinetic muscle strength decline probability data. $\vartheta\,(j)$ represents the dynamic stability consistency of the athlete and the ordinary person in the front-back direction of squatting.[6] We use Equation (4) to find the difference in dynamic stability between athletes and everyday people in the medial and lateral directions of squatting.

$$u_{(j)} = \frac{\vartheta(j) \times \xi(k)}{\xi(S,P)} + \frac{\eta(\lambda,H)}{\partial(A,O)} \times \nu(\hbar) \tag{4}$$

$\eta(\lambda, H)$ represents the membership interconnection matrix of the athlete's knee flexion and extension isokinetic muscle strength decline factors. $\partial(A, O)$ represents the maximum associated probability value associated with athlete's knee flexion and extension isokinetic muscle decline. $v(\hbar)$ represents the difference instability in the medial-lateral direction between the athlete and the ordinary person.

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

RESULTS

The data in Tables 2 and 3 reflect that the relative peak moments of flexion and extension of the knee and ankle joints decreased sequentially. This is in line with the principle that the strength of the human body, from large joints to small joints, decreases in turn. The conclusions of this paper are similar to those of related studies. The strength of the athletes' ankle dorsiflexors and plantar flexors in the experimental group increased significantly after isokinetic training.[7] In the control group, only the strength of the plantar flexors was significantly increased. The ankle joint of the supporting leg of the high jump is subjected to enormous forces. It plays a huge role. After a short buffering, the supporting leg immediately enters the process of kicking and stretching. Pushing and stretching require the plantar flexor muscles of the ankle joint to generate a solid concentric contraction force. Standard lower limb strength training such as vertical jump, squat, and other training methods affect the ankle joint. But this is only a local-scale force stimulus. Isokinetic training allows maximum strength training of joint muscle groups throughout the joint's full range of motion. Second, it provides a compliant drag torque, the size of which is the same as the power of the muscle. This will not cause damage to the ankle joint, and the training will be more comprehensive. The training effect at this time is also better. Therefore, it can be seen from the results that the results of isokinetic training are good. In contrast, isokinetic muscle strength testing provides information on a range of muscle properties.[8] The model can evaluate the properties of muscles under concentric and eccentric contractions.

DISCUSSION

An increase in the strength of the ankle dorsiflexors is essential. The main focus is no matter what form of strength training, high jumpers do ankle plantar flexion. There are few specific methods or means of training the strength of the dorsiflexors. Over time, the strength of the extensor groups in the ankle increased, while the strength of the flexor groups did not increase significantly.[9] This can lead to more remarkable and more significant differences in the strength of the ankle flexor and extensor groups. Numerous studies have shown that an imbalance in the flexor and extensor groups ratio increases the risk of joint injury. Experiments have shown that in many sports states, the antagonist muscle also contracts when the agonist's muscle contracts. The purpose of antagonist muscle contraction is to determine the position of the stable joint. This makes it follow a specific trajectory change. This prevents the range of motion from being too large. Some high jumpers have strained or even ruptured the Achilles tendon. We speculate that the reason is that when the extensor muscles suddenly exert force, the dorsiflexor muscles are too weak, and the strength of the extensor muscles is too different.

Table 2. Relative peak torque for concentric contraction of ankle flexor and extensor groups.

		Before experiment		After the experiment	
		60°/s	120°/s	60°/s	120°/s
Test group	Dorsiflexion	0.26±0.14	0.19±0.09	0.31±0.15	0.26±0.10
	Plantar flexion	1.16±0.31	0.97±0.26	1.25±0.32	1.10±0.28
Control group	Dorsiflexion	0.25±0.08	0.19±0.07	0.27±0.12	0.19±0.06
	Plantar flexion	1.17±0.32	0.95±0.29	1.17±0.29	0.97±0.30

Table 3. Relative peak torque for concentric contraction of knee flexor and extensor groups.

		Before experiment		After the experiment	
		60°/s	120°/s	60°/s	120°/s
Test group	Bend	2.26±0.43	1.71±0.29	2.55±0.56	1.95±0.28
	Stretch	3.26±0.35	2.68±0.44	3.78±0.49	2.97±0.45
Control group	Bend	2.16±0.41	1.72±0.53	2.24±0.39	1.96±0.23
	Stretch	3.19±0.45	2.71±0.38	3.29±0.42	2.97±0.39

The dorsiflexors cannot be effectively antagonized. This causes the Achilles tendon to be overstretched, instantly exceeding the range of motion, resulting in strain or rupture of the Achilles tendon. A high jumper's ankle is a highly vulnerable joint. This is an important reason for the differences in the flexor and extensor groups. Ordinary high jumpers rarely train the strength of the ankle dorsiflexors. One of the reasons is the lack of awareness, and the second is that you want to train the strength of the ankle dorsiflexors well, but there are few excellent equipment or methods. In this study, ISOMED2000 was used to find that the strength of the ankle dorsiflexors in the experimental group was significantly increased through specific exercises.[10] This shows that the isokinetic training system has a unique application effect on high jumpers' ankle joint strength training.

The individual differences in absolute peak torque are primarily due to differences in subject body weight. Relative peak torque (PT/W) refers to peak torque per unit of body weight. Therefore, this study uses relative values to represent strength. Compared with the control group, the strength of the experimental group members' knee flexor and extensor muscles increased during the 60°/s test. The athlete produces tremendous thrusting force through the concentric contraction of the extensor group. This contributes to the evacuation of the human body. From the test results of 60°/s, it can be seen that although the strength of the extensor group of the experimental group and the control group has increased, there is no significant difference. This shows that regular strength training is practical for the lower body. However, isokinetic strength training at 60°/s increased the strength of the knee extensor group in the experimental group. However, it was not significantly different from the control group. During the 120°/s test, the strength of the flexor and extensor muscles of the experimental group was significantly greater than that of the control group. The speed can reach the set faster speed. This allows the knee joint to be trained in rapid flexion and extension. Fast power is significant for high jumpers. Daily strength training is also based on knee extensor training. When squatting, the concentric contraction of the knee extensors is the agonist. If the flexor muscles of the knee joint cannot be effectively stimulated for a long time, the strength ratio of the flexor and extensor muscles will be uncoordinated. This is one of the important causes of joint damage. Knee flexors are effectively trained by isokinetic strength training. This promotes coordination of the strength of the flexor and extensor groups. This is very beneficial for high jumpers.

CONCLUSION

Isokinetic strength training effectively increases the strength of the ankle dorsiflexors in high jumpers. This plays an essential role in improving the ratio of ankle flexor and extensor muscle groups in high jumpers. After isokinetic strength training, the rapid strengthening of the knee flexor and extensor groups is effectively increased. This strength training method can better train the explosive power of the knee flexor and extensor groups. In addition, isokinetic strength training is also a good increase in the strength of the knee flexors. This has a significant effect on improving the strength ratio of the knee flexor and extensor groups.

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