ISOKINETIC MUSCLE STRENGTH TESTING AND TECHNOLOGY OF TRAINING IN SPORTS MEDICINE

TESTE ISOCINÉTICO DE FORÇA MUSCULAR E TECNOLOGIA DE TREINAMENTO NA MEDICINA ESPORTIVA

PRUEBAS ISOCINÉTICAS DE FUERZA MUSCULAR Y TECNOLOGÍA DE ENTRENAMIENTO EN MEDICINA DEPORTIVA

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ABSTRACT

Introduction: Current research in sports medicine on muscles adjacent to joints in patients with joint instability focuses on functional instability. However, few studies on muscle strength in the muscles adjacent to the joints in typical patients. Objective: This study tests the changes in isokinetic muscle strength in flexion-extension muscle groups in common subjects' knees and elbows. Methods: Randomly selected ordinary citizens to perform isokinetic muscle strength testing with grip strength, explosive pedaling force, and elbow and knee joint movement speeds of 60°/s. Results: The single work of the normal knee flexors and extensors decreases with test speed at different movement speeds. Conclusion: The grip strength test and isokinetic pedaling test can be used as simple muscle strength tests for fitness monitoring. ***Evidence Level II; Therapeutic Studies - Investigating the result.***

Keywords: Technique, Training; Sports; Sports Medicine.

RESUMO

Introdução: Pesquisas atuais na medicina esportiva sobre os músculos adjacentes às articulações em pacientes com instabilidade articular concentram-se na instabilidade funcional. Entretanto há poucos estudos sobre a força muscular nos músculos ao redor das articulações em pacientes comuns. Objetivo: Este estudo testa as alterações na força muscular isocinética nos grupos musculares de flexo-extensão em joelhos e cotovelos de indivíduos comuns. Métodos: Selecionamos aleatoriamente cidadãos comuns para realizar testes isocinéticos de força muscular com força de aderência, força explosiva de pedalar e velocidades de movimento da articulação do cotovelo e joelho de 60°/s. Resultados: O trabalho único dos flexores e extensores normais do joelho diminui com a velocidade de teste em diferentes velocidades de movimento. Conclusão: O teste de força de aderência e teste isocinético de pedalar podem ser usados como testes de força muscular simples para o monitoramento do condicionamento físico. ***Nível de evidência II; Estudos Terapêuticos - Investigação de Resultados.***

***Descritores**: Técnica de Treinamento; Esportes; Medicina Esportiva.*

RESUMEN

Introducción: La investigación actual en medicina deportiva sobre los músculos adyacentes a las articulaciones en pacientes con inestabilidad articular se centra en la inestabilidad funcional. Sin embargo, hay pocos estudios sobre la fuerza muscular en los músculos que rodean las articulaciones en pacientes comunes. Objetivo: Este estudio comprueba los cambios en la fuerza muscular isocinética en grupos musculares de flexión-extensión en rodillas y codos de sujetos comunes. Métodos: Seleccionamos al azar a ciudadanos normales para realizar pruebas isocinéticas de fuerza muscular con fuerza de agarre, fuerza explosiva de pedaleo y velocidades de movimiento de la articulación del codo y la rodilla de 60°/s. Resultados: El trabajo individual de los flexores y extensores normales de la rodilla disminuye con la velocidad de la prueba a diferentes velocidades de movimiento. Conclusión: La prueba de fuerza de agarre y la prueba de pedaleo isocinético pueden utilizarse como pruebas sencillas de fuerza muscular para el control de la condición física. ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

***Descriptores:** Técnica de Entrenamiento; Deportes; Medicina Deportiva.*

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INTRODUCTION

Joint instability is the most common sports injury, accounting for about 10% to 15% of all sports injuries. The main manifestation is "beating soft legs" or about to "beating soft legs" when carrying weight. Clinically, there are two types of joint instability: (1) Functional instability refers to "soft legs" caused by the patient's subjective fear of exerting force. (2) Joint mechanical instability refers to the weakness of the patient's joint stabilization structure. Such as the "soft leg" caused by the anterior talofibular ligament tear.[1] The abnormal function of the muscles around the joints has always been considered one of the important factors affecting joint instability. Joint muscle strength training is also a regular part of the joint instability rehabilitation program. However, the current research on the muscles around the joints of patients with joint instability mostly focuses on functional instability. There are few studies on the muscle strength of the muscles around the joints in patients with joint mechanical instability.[2] This study tested the changes in isokinetic muscle strength of the flexor and extensor muscles of the affected. To explore its significance in the pathogenesis and clinical rehabilitation of joint mechanical instability.

METHOD

Research object

Twenty patients were clinically diagnosed with joint mechanical instability. Seven cases were on the left side, and 13 were on the right--side.[3] There were 11 males and 9 females. The average age was 25.3 years, the height was 166.4±5.0cm, the weight was 64.7±4.8kg, and the disease course was 28.6±18.3 months.

Diagnostic criteria for joint mechanical instability: (1) There is a history of the joint sprain. (2) There are symptoms of joint instability. (3) The physical examination showed that the front drawer test was positive. (4) MRI and B-ultrasound examination showed that the anterior talofibular ligament was injured.

Research methods

Test the bilateral joints of subjects with mechanical instability of the joints and compare the isokinetic muscle strength of the affected and unaffected joints.

Before the test, a random decision was made to test one joint first. All tests are performed on the Biodex3 isokinetic tester.[4] After 5 minutes of warm-up exercise, the subject sits on the isokinetic tester and fixes the waist and chest with straps. Fix the lower limbs and place the tested foot on the pedal to fix it. Take the subject's active mobility as the starting and ending angle. We use the Advantage software that comes with the Biodex system to set the exercise program. The subjects first performed 5 centripetal and eccentric exercises as preparation activities. They then performed 2 sets of tests in the following order: The first group performed 60°/s centripetal joint flexion and extension exercises × 3 times. The second group performed 120°/s centripetal joint flexion and extension exercises × 3 times. Rest for 1 min between the two groups. Rest for 15 seconds between each test in the group.

During the test, the peak torque, average power, and total work were recorded. Take the average and calculate the following related indicators. (1) Relative peak torque: the peak torque per unit weight can better compare the difference in strength between different individuals. (2) Flexion-extension torque ratio: the ratio of the relative peak torque of the flexor and extensor muscles, which represents the balance function of the joint. (3) Average power: the work done by the muscles in a unit of time, which can reflect the ability of the muscles to exert force to a certain extent quickly; (4) Total work: reflect the total functional power of the muscles.

Simulation model of human lower limb muscle force distribution

It is necessary to solve further the distribution of individual muscle force based on the muscle-skeletal model.[5] Through analysis, a solution model for muscle force distribution can be established. According to the principle of multi-rigid body dynamics, the Newton-Euler dynamic equation is established:

$$\ddot{q} = M^{1}(q) \times \{B(q) \times \dot{q}^{2} + G(q) + T_{m} + T_{ext}(q, \dot{q})\} \tag{1}$$

$q, \dot{q}, \dot{q}^2$ is the angular displacement, angular velocity, and angular acceleration vector of the generalized coordinate. $M(p)$ is the generalized mass matrix of the system. $G(p)$ is the generalized force vector produced by gravity. $B(p)$ is the vector of Coriolis force and centrifugal force. T_{ext} is the generalized external moment vector experienced by the system. T_m is the flexion of the joint moment generated by the muscle force vector F_m. It is assumed that the coordination of related muscles at any moment of human movement follows a certain basic principle.[6] Several commonly used optimization objective functions are as follows:

1. Sum of minimum muscle stress

$$J = \min \sum_{i}^{m} (F_i / PCSA_i)^n = \min \sum_{i}^{m} \sigma^n \tag{2}$$

2. The sum of the relative force of the smallest muscle

$$J = \min \sum_{i}^{m} (F_i / F_{i\max})^n = \min \sum_{i}^{m} \overline{F}^n \tag{3}$$

3. Sum of minimum muscle strength

$$J = \min \sum_{i}^{m} (F_i)^n \quad n = 1, 2 \tag{4}$$

In the formula, $PCSA_i$ is the physiological cross-sectional area of the muscle. F_i is the strength of the i muscle. F_{imax} is the maximum muscle strength of the i muscle. To obtain physiologically acceptable results, join the constraint set.

1. Satisfy dynamic constraints

$$T_m = R(q) \times F_m \tag{5}$$

In the formula, $R(q)$ is the moment arm matrix-vector of each muscle.
2. Physiological range restriction of muscle strength. $0 \le F_i \le F_{imax}$ $i = 1, 2, \cdots, m$.m is the number of muscles.

Statistical analysis

All data are input into the computer and analyzed by SPSS13.0 software. A paired-sample t-test was used to compare the test results of the affected side and the healthy side. The alpha level is set to P<0.05.

RESULTS

Table 1 shows no statistical significance in the relative peak torque, average power, and total work of the extensor muscle groups between the two groups at 60°/s. There was no significant difference in the relative peak torque and average power of the flexor group. There was no significant difference in the flexion-extension torque ratio.[7] There is a significant difference in the total work of the flexor group. There were no significant differences in the relative peak torque, average power, and total work of the extensor muscle groups between the two groups at 120°/s. However, the flexor muscle group's relative peak torque, average power, and total work have significant differences. There is a significant difference in the ratio of flexion and extension moments.

DISCUSSION

Previous studies mostly believed that the decreased muscle strength of joint valgus was an important factor affecting joint instability. But these studies mainly rely on manual muscle strength testing and personal subjective evaluation. Studies have found that patients with joint instability have no decline in valgus muscle strength.[8] Eversion muscle strength is not an important factor in the pathological mechanism of joint instability. The changes in muscle strength of other muscle groups around the joint, including varus, dorsiflexion, and plantar flexion, may play a role in the pathological mechanism of joint instability.

The joint Dorsi muscle strength is mainly produced by the anterior tibialis muscle, extensor pollicis longus, extensor digitorum longus, and

Table 1. Comparison of isokinetic muscle strength of the joints on both sides of the patient (n=20).

Angular velocity	Test index	Affected side	Healthy side	*P*
60°/s	**Extensors**			
	Relative peak torque (N·m/kg)	0.27±0.10	0.31±0.69	0.303
	Average power (W)	10.12±5.90	11.25±5.41	0.548
	Total work (J)	119.79±64.43	129.53±61.07	0.452
	Flexors			
	Relative peak torque (N·m/kg)	0.42±0.27	0.50±0.20	0.417
	Average power (W)	8.33±5.61	11.60±5.01	0.275
	Total work (J)	117.25±54.02	156.93±25.31	0.043*
	Flexion-extension moment ratio	1.53±0.90	1.59±0.50	0.87
120°/s	**Extensors**			
	Relative peak torque (N·m/kg)	0.19±0.33	0.21±0.33	0.096
	Average power (W)	11.12±3.45	11.65±6.13	0.069
	Total work (J)	80.61±30.89	86.10±19.09	0.233
	Flexors			
	Relative peak torque (N·m/kg)	0.23±0.15	0.33±0.19	0.030*
	Average power (W)	7.60±5.03	14.21±10.82	0.043*
	Total work (J)	51.71±37.13	104.24±38.95	0.017*
	Flexion-extension moment ratio	1.23±0.55	1.58±0.50	0.036*

the third peroneal muscle. Plantar flexor strength is mainly produced by calf triceps, flexor digitorum longus, flexor pollicis longus, and posterior tibialis.[9] The peak torque of normal adult joint back extension is only 31.43% of the peak torque of plantar flexion. The peak torque of the extensor Dorsi muscle group in normal youth is only about 1/3 of the peak torque of the plantar flexor muscle group. This may be one of the reasons why joints are easily sprained. Patients with functional joint instability have decreased eccentric plantarflexion torque, but their varus, valgus and back extension torques are not significantly different from normal people. There was no significant difference between the flexor and extensor group torques of patients with functional instability and normal people. But these studies mainly evaluate functional joint instability. At present, there are few studies on the mechanical instability of joints.

This study found that the relative peak torque, average power, and total work of the affected side joint extensor muscle group were not significantly different from those of the healthy side in patients with joint mechanical instability at 60°/s or 120°/s. This shows no obvious muscle strength abnormality in the affected side extensor muscle group.[10] Extensor muscle strength may not be the main reason for the symptoms of mechanical instability of joints. There was no significant difference in the relative peak torque and average power of the flexor group of the affected side at 60°/s compared with the healthy side. There was a significant difference in total work. Compared with the healthy side, the relative peak torque, average power, and total power at 120°/s are significantly different. 120°/s is fast movement, and 60°/s is the slow movement. As the contraction speed increases, the percentage and number of fast-twitch fibers mobilized also increase. Although the total work decreased during slow motion, other indicators did not change significantly. However, the flexor torque and muscle work of the affected side decreased during rapid exercise, and the balance of the flexors and extensors decreased. This shows that the muscle strength of the joint flexor group is abnormal during rapid movement. Sprains of joints in daily life often occur when the joints need to be balanced immediately. It is to counteract the force that causes sprained joints. Muscles need to quickly recruit motor units in a short period to maintain joint stability. This is a typical fast movement. At this time, the decline of the muscle strength of the plantar flexor muscle group may cause the muscle strength of the muscle group around the joint to be imbalanced and affect the joint's stability.

Previous studies have found that the joint flexor torque of patients with functional joint instability also decreases. The following factors may cause this: (1) When the joint is sprained, the surrounding muscles and ligaments are damaged simultaneously, which reduces the strength of the extensor and flexor muscles. (2) Joint sprain can lead to joint-derived muscle inhibition. (3) The afferent feedback mechanism is impaired after the joint sprain, and the stress of the muscle motor unit decreases. (4) Muscle-fascia interface damage can affect muscle activity. Due to mechanical instability of joints, injuries are often more serious than functional instability. If there is additional ligament damage, etc. Therefore, the muscle strength of the plantar flexor group in patients with mechanical instability of the joint may be more severe than that in patients with functional instability. We will further clarify this possibility in future research.

However, based on the existing literature and the results of this study, the relationship between the decline of plantar flexor muscle strength and joint stability is still unclear. Changes in the muscle strength of the plantar flexors may contribute to joint instability or may result from joint instability.

CONCLUSION

This study showed that compared with the healthy side, the plantar flexor muscles of the affected side decreased their muscle strength during rapid movement. This may be related to its joint stability.

The author declare no potential conflict of interest related to this article

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