MUSCULOSKELETAL TRAINING AND MECHANICAL CHARACTERISTICS OF ATHLETES

TREINO MUSCULOESQUELÉTICO E CARACTERÍSTICAS MECÂNICAS DE ATLETAS

ENTRENAMIENTO MUSCULOESQUELÉTICO Y CARACTERÍSTICAS MECÁNICAS DE ATLETAS

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ABSTRACT

Introduction: Studying the biomechanical characteristics of lower limb muscles during depth jumps is of great significance, but it is also important in meeting the practical needs of strength training. Objective: To explore the musculoskeletal exercise training and mechanical characteristics of athletes' lower limbs. Methods: Analysis and discussion of the test results of kinematics, dynamics and the EMG of 8 muscles of the lower extremity when athletes jump at different falling heights and different motion states. Results: only by using different falling heights in a certain proportion can training efficiency be improved and the training effect of depth jumps reach the practical purpose of sports training. Conclusions: from the point of view of exercise physiology, the generation, storage and reuse of muscle elastic deformation energy and the reflex regulation of the central nervous system are the main reasons for the economic and efficient contractive ability of the extensor muscle group of lower limbs during depth jumps. From the point of view of muscle mechanical properties, the centrifugal contractility of lower limb muscles is the primary factor that determines the athletes' lower limb muscle explosive push ability. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Athletes; Lower Extremity; Sports.

RESUMO

Introdução: O estudo das características dos músculos dos membros inferiores durante o salto de profundidade é de extrema importância, mas é também importante para se conhecer as necessidades práticas do treino de força. Objetivo: Explorar o treino de exercícios musculoesqueléticos e as características dos membros inferiores de atletas. Métodos: Análise e discussão dos resultados de testes cinemáticos e dinâmicos, além do EMG de 8 músculos de membros inferiores quando atletas saltam de diferentes alturas de queda e em diferentes estados de movimento. Resultados: É apenas quando se usam diferentes alturas de queda em certa proporção que a eficiência do treino pode ser melhorada e o efeito do treino de saltos de profundidade pode alcançar o objetivo prático do treinamento esportivo. Conclusões: do ponto de vista da fisiologia do exercício, a geração, o armazenamento e a reutilização da energia da fadiga elástica do musculo e a regulação reflexa do sistema nervoso central são os motivos principais para a habilidade contrativa econômica e eficiente do grupo de músculos extensores dos membros inferiores durante saltos de profundidade. Do ponto de vista das propriedades mecânicas, a contratilidade centrifuga dos músculos dos membros inferiores é o fator principal determinando a habilidade do impulso explosivo dos músculos de membros inferiores de um atleta. ***Nível de evidência II; Estudos terapêuticos – investigação de resultados de tratamento.***

Descritores: *Atletas; Extremidade Inferior; Esportes.*

RESUMEN

Introducción: El estudio de las características de los músculos de los miembros inferiores durante el salto en profundidad es de extrema importancia, pero es también importante para conocerse las necesidades prácticas del entrenamiento de fuerza. Objetivo: Explorar el entrenamiento de ejercicios musculoesqueléticos y las características de los miembros inferiores de atletas. Métodos: Análisis y discusión de los resultados de testes de cinemática, dinámica y EMG de 8 músculos de miembros inferiores cuando los atletas saltan de diferentes alturas en caída y en diferentes estados de movimiento. Resultados: Es solo cuando se usan diferentes alturas de caída en cierta proporción que la eficiencia del entrenamiento puede mejorarse y el efecto del entrenamiento de saltos en profundidad puede alcanzar el objetivo práctico del entrenamiento deportivo. Conclusiones: Del punto de vista de la fisiología del ejercicio, la generación, el almacenamiento y la reutilización de la energía de deformación elástica del músculo y la regulación refleja del sistema nervioso central son los motivos principales para la habilidad contractiva económica y eficiente del grupo de músculos extensores de los miembros inferiores durante saltos en profundidad. Del punto de vista de las propiedades mecánicas, la contractilidad centrífuga de los músculos de los miembros inferiores es el factor principal a determinar la habilidad del impulso explosivo de los músculos de miembros inferiores de un atleta. ***Nivel de evidencia II; Estudios terapéuticos – investigación de resultados de tratamiento.***

Descriptores: *Atletas; Extremidad Inferior; Desportes.*

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INTRODUCTION

It is very important for the human body to cope with the external environment in daily life. For example, for grasping fragile objects, the force control of the limbs in the process of movement becomes extremely necessary.[1] In the process of movement, the nervous system must coordinate and generate precise control signals for a large group of muscles to ensure the accuracy of human movement. Accurate muscle contraction quantitative model is essential for understanding motor nerve control. Describing exactly how a muscle is capable of producing force allows us to better understand how the muscle activates and implements the desired body movement. Mathematical models provide a good way to test the relationship between muscle physiology and anatomy. The force control of some humanoid robots usually adopts low contact impedance control under critical damping and admittance control to adjust force output. Human limbs are often modeled as second-order mechanical systems under the assumption that tendon stiffness is much greater than muscle fiber stiffness.[2]

METHOD

Experimental subjects

6 third-level jumping athletes were selected from the track and field special class of the sports department of a physical education institute, and 6 first-level jumping athletes were selected from the track and field team of a physical education institute as the research and test objects. Class 3 athletes belong to the ordinary group, and class 1 athletes belong to the excellent group. All the subjects were male, aged between 20 and 24, in good health, with no major history, no lower limb muscle injury and good exercise ability at present. No strenuous exercise and no muscle fatigue within 24 hours before the test. The room temperature for testing was 22-24 ºC. The subjects' physical fitness and body fat percentage were measured before the test. The measuring instrument of body fat percentage is the pleated caliper, which adopts the international unified technical standard, and the measuring site is the iliac part. The basic information of the subjects is shown in Table 1.[3]

Test instruments and related equipment

One set of Kistler 3D force measuring platform system (90×60×100cm), one TM-6710CL high-speed camera, one set of 16-channel portable wireless telemetry surface EMG test system (MEGA-ME6000T16, Finland), one Monark829 power bicycle, one height and weight measuring instrument.[4]

Test scheme

The test subjects were dropped from the platform 20cm, 40cm, 60cm, 80cm and 100cm away from the force measuring platform on the center or near the center of the Kistler 3D force measuring platform without vertical initial velocity, and then they tried their best to jump up vertically as soon as possible and fell back to the platform. The platform is 10cm away from the edge of the force measuring table. TM-6710CL high-speed camera, Kistler three-dimensional force measuring platform and ME6000T-16-channel portable wireless telemetry surface EMG test system were adopted to conduct synchronous test on the complete deep jump exercise of the test object.[5]

Data reading and calculation

Ariel-APAS image analysis system was used to process and calculate moving images, and dot analysis was performed one by one. The human body parameter model adopted the default model of Ariel-APAS image analysis system, and the five-point cubic smoothing method was adopted for data smoothing processing.[6] The parameters obtained by the analysis are the height of re-jump, the time of each stage, velocity, angular velocity, peak angular velocity, Angle and velocity at the time of landing and departure, etc.[7]

RESULTS

Variation characteristics of landing stage time

The temporal characteristics reveal the relation between the motion of an object and time. When the movement starts and ends, how long the movement lasts and the time structure of the movement can reflect the nature of human movement to a certain extent. The time of the landing stage and the ratio of the time between the stretching period and the buffering period can reflect the sports nature and working ability of the athletes to a great extent when they jump from different heights.[8]

As can be seen from the test results in Table 2: In terms of the time value at each falling height, the buffer period (centrifugal period) and push extension period (centripetal period) time of elite group athletes in the landing stage or landing stage were shorter than those of ordinary group ($P<0.01$). In the relative fatigue state, both the ordinary group and the excellent group took longer landing time to complete the deep jump at the falling height of 40cm than the landing time from the falling height of 20-100cm in the normal state, but the ratio of stretching time to cushion time was smaller ($P<0.05$).[9]

On the contrary, the athletes in the normal group need to spend more time on the buffering movement, which is a manifestation of the lower limb extensor muscle's low "surrender ability" due to the weaker strength of the lower limb muscle group, and also a manifestation of the athletes' relatively low impact load resistance ability. then, with the increase of the falling height, the ratio shows a downward trend (as shown in Figure 1).

Table 1. Basic information of normal group and excellent group.

Name	Age	Height	Weight (kg)	Percentage of body fat	Project	The current results	Best
Zhao	20	170	67.0	15.8	The high jump	1.68	1.70
Qian	20	180	74.5	14.2	The long jump	5.88	5.90
Sun	22	182	76.3	13.4	The long jump	5.93	6.00
Li	22	177	81.0	11.7	The long jump	6.00	6.00
Zhou	21	191	71.3	12.1	The triple jump	12.20	12.29
Wu	21	184	72.8	15.58	The triple jump	12.90	12.29
Zheng	20	181	75.0	61.3	The long jump	7.21	7.30
Wang	24	190	82.0	15.8	The long jump	7.28	7.35
Feng	24	185	65.1	12.1	The triple jump	15.35	15.40
Chen	19	190	67.0	11.7	The triple jump	15.19	15.32
Zhu	20	1.88	75.0	12.1	The triple jump	15.27	15.35
Wei	21	183	71.0	12.5	The long jump	7.29	7.29

Table 2. The landing stage and the time of each stage of the normal group and the excellent group.

Drop height	The time of the landing stage	Buffer period	Stretching period time	Stretching time/ buffering time
20	0.263±0.048	0.118±0.027	0.145±0.022	1.228±0.150
40	0.269±0.058	0.120±0.027	0.149±0.032	1.241±0.105
60	0.287±0.071	0.131±0.039	0.170±0.041	1.326±0.090
80	0.309±0.079	0.143±0.038	0.172±0.045	1.216±0.139
100	0.334±0.050	0.161±0.028	0.180±0.037	1.116±0.065
Fatigue (40)	0.354±0.094	0.187±0.069	0.197±0.072	1.057±0.082
20	0.175±0.018	0.072±0.007	0.102±0.011	1.414±0.066
40	0.179±0.021	0.073±0.010	0.106±0.012	1.450±0.101
60	0.184±0.013	0.075±0.006	0.109±0.008	1.453±0.057
80	0.188±0.028	0.078±0.001	0.110±0.015	1.410±0.089
100	0.200±0.030	0.090±0.017	0.110±0.014	1.234±0.110
Fatigue (40)	0.229±0.038	0.105±0.017	0.123±0.022	1.175±0.093

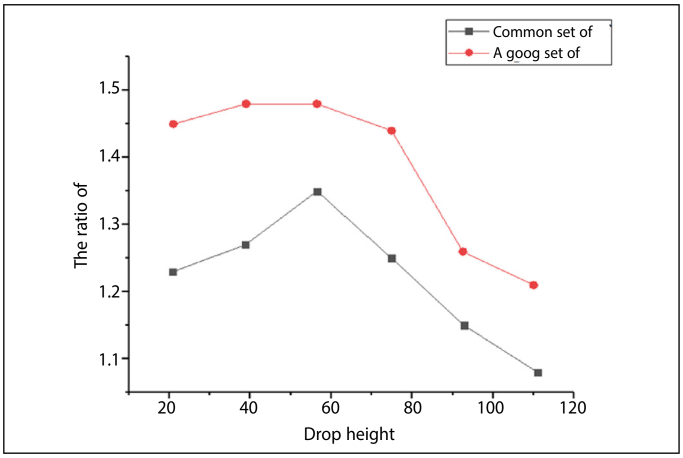

Figure 1. Corresponding relation between the ratio of push stretching time to buffer time and falling height.

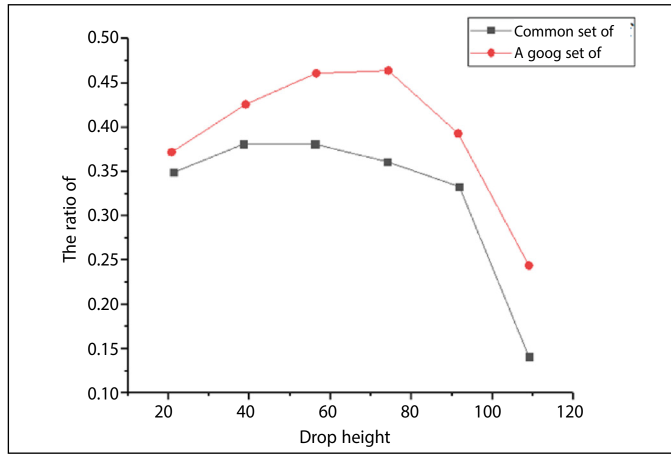

Figure 2. The corresponding relationship between the height of the center of gravity of the body and different falling heights.

Change characteristics of re-jump height of body center of gravity

One of the purposes of deep jump is to improve the rapid exertion ability of the nerve - muscle system of lower limbs and improve the jumping ability of athletes, so as to improve the athletic performance of athletes. The different height of the deep jump reflects the different sports load exerted on the athletes.[10]

As can be seen from the curve change trend of the height of the body center of gravity in the re-jump in Figure 2, in the deep jump, the athletes have different heights of the body center of gravity when they fall from different heights and re-jump. When the athletes of both the excellent group and the ordinary group fall from different falling heights, the height of the center of gravity that they jump up again as soon as possible has the same trend with the change of falling height, that is to say, with the increase of the fall height, the height of the center of gravity will rise again as soon as possible. When the height of the center of gravity of the re-jump reaches a certain height, with the increase of the fall height, the height of the center of gravity of the re-jump will decrease instead of increasing.[11]

DISCUSSION

Kinematic characteristics of hip, knee and ankle joints

From the movement technical characteristics of the subjects in the deep jump in this study, the relative fixation of the upper limb reduces the influence of the upper limb movement on the overall movement effect, and the movement effect is mainly determined by the movement of the lower limb joints. Falling height is the scale of impact force, with the increase of falling height, the intensity of impact force will also increase, because the ultimate goal of athletes is not buffer but to jump again as soon as possible, and the higher the jump, the better, which puts forward high requirements on the ability of athletes to resist impact and the ability to push quickly. Therefore, the range of flexion and extension of lower limbs hip, knee and ankle joints, the timing of flexion and extension, the sequence of movements between the joints and the cooperative working relationship play an extremely important role in the process of movement. In deep jump, the activities of hip, knee and ankle joint are mainly flexion and extension movement around the frontal axis of each joint, and the variation of Angle and angular velocity of flexion and extension movement reflect the range and speed of movement of each joint.

CONCLUSION

This paper presents a method to test the kinematics, dynamics and EMG of 8 muscles of lower limbs of deep jumpers at different falling heights and different motion states. The concrete content of this method is through the reading and calculation of test data of testing instruments and related equipment. Through experiments, it is observed that the lower limb is both a support organ and a power organ, and the lower limb muscles must be buffered after the impact of the force in completing various movements (such as running or jumping) before they can complete the push and stretch movement. In these cases, the extensor muscles of the lower extremities begin with centrifugal motion, followed by centripetal motion. To prove that the development of bone muscle elongation and contraction of the lower extremity joints occupies an important position in the strength training of various sports.

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

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