

A STUDY OF STORAGE AND UTILIZATION OF ELASTIC ENERGY IN HUMAN LOWER LIMB MUSCLES

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INTRODUCTION: In order to reveal how load, length of muscles, velocity of stretch and other factors affect the storage and the utilization of the elastic energy, lower limb muscular eccentric contraction in take-off phase of jumping were studied. In the past, Many studies about this topic was based on muscles in vitro, but this paper was based on muscles in vivo and from the perspective of movement structure.

METHODS: Six male athletes of Chengdu Institute of Physical Education were recruited as subjects in this study. Their age ranged from 18 to 23 years old and their best performance of long jump ranged from 6.60m to 7.00m. The subjects were requested to perform maximal vertical jumps on a KISTLER (Switzerland) force-platform. The jumps were performed (1) from a semi squatting position, (2) with counter-movement from a standing position, (3) depth jumping from heights of 32, 42, or 50cm. During the test, a high-speed camera was directed at the flank of athletes to shoot a film with frequency of 65 frames per second. The film was analyzed by NAC SPORTA-2000 (Japan) film analysis instrument.

Based on the kinematics parameter and dynamic curve of take-off phase, lower limb muscular force at the end of pre-stretch, maximum height of flight (H_{max}), and positive work done by lower limb muscles (mgH_{max}) was obtained. Elastic energy stored by muscles in jumps from a semi squatting position is supposed to be zero. Comparing the other four kinds of jumps, with the jumps from semi squatting position, the more positive work was done by lower limb muscles, which is thought to be the elastic energy stored by muscles in the centrifugal contraction (E). Similar to the positive work, when athlete performs depth jumping from heights of h , negative work (w) is equal to mgh . Then utilization of the negative work is E/w . As to jumps performed with counter-movement from standing position, kinetic energy of the athlete ($mv^2/2$) at the moment of force curve intersecting weigh line in squatting phase is regarded as negative work done by lower limb muscles. (m is the mass of the athlete, and v is the velocity of athlete's centre of gravity.)

RESULTS AND DISCUSSION: Storage of elastic energy was directly proportional to muscular force at the end of pre stretch. Activated by a correct power and velocity, muscles store the most elastic energy. The average and maximum energy was 73.38J and 125.9J, respectively. Besides, the utilization rate of negative work in eccentric phase decreased (average from 55.74% to 35.13% to 25.06% and to 8.62%) with the increasing load (from the jumps performed with counter-movement from a standing position to depth jumping from heights of 32, 42, and 50cm).

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