KINEMATIC ANALYSIS OF A SQUAT JUMP (SJ)

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(Preliminary communication)

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Abstract
In the contemporary sport science and practice often are examined the measurements and interpretations of individual or serial vertical jumps performed in order to assess muscular strength, anaerobic capacity and athletic performance. Squat jump (SJ) involves the performance of the maximum vertical jump from the half squat position (knee joint angle of 90°), with hands placed on the hips. This type of measurement determines the ability of isolated concentric muscle contractions of knee extensors. The main objective of this study was to obtain qualitative and quantitative indicators of the squat jump (SJ) in the space of goniometry and kinematics. There has been analyzed: individual phases length, the maximum velocity values, when they occur in the centers of the shoulder, hip, knee and ankle joint (3.60 m/s, 3.19 m/s, 3.52 m/s, 3.14 m/s respectively), and maximum angle values of the hip joints, knee and ankle. Except the center of the ankle velocity value, which reached maximum immediately after the rebound moment (in the 15th frame), all other joints is reached the maximum before the rebound moment (12th frame). Angle values decrease after rebound in all observed joint.

Keywords: velocity, muscular strength, goniometry, physical ability, motor testing, video camera recording, values of the joint angles

INTRODUCTION
A special group of muscle strength tests are consisted of tests of individual or series of vertical jumps. Their interpretation is very widespread within the modern sport science and practical work. Determination of a single or vertical jump series is one of the oldest methods for determining the physical ability. While traditional methods within reach height of the jump was good enough for a limited analysis of one jump type (with a free swing of the arm), advanced measurement methods allows different types of vertical jumps testing performed singly or in series. A different test protocol performance allows detailed qualitative and quantitative muscle contraction phase analysis of the upper and lower extremities involved in the execution of move. (Bobbert et al. 1996; taken from Ostojic, Stojanovic and Ahmetovic, 2008).

Picture 1. Showing the position of the body while performing the squat jump – SJ.
SJ is the maximum vertical jump performance from a half squat position (knee joint angle of 90°), with hands placed on the hip region (Picture 1). This type of measurement estimates the isolated concentric muscle contractions ability of knee extensors. It can be performed with the additional load, like other tests (Dugan, Doyle, Humphries, Hasson, Newton, 2004).

The main objective of this study was to obtain qualitative and quantitative indicators of the squat jump (SJ) in the space of goniometry and kinematics.

METHODS
The sample is athlete executing jump from the squat (squat jump-SJ). The candidate performs SJ, and material was taken with a digital video camera. Video record is processed in the software for kinematical analysis KA Video. In this study, we used the 2D kinematical analysis.

RESULTS AND DISCUSSION
The squat jump technique is divided into a three phases: rebound phase (concentric), flight phase and landing phase (eccentric). Jump duration consisted of 54 frames. The changes were analyzed of speed and body balance during flexion and muscles extension of the lower extremities, trunk and arms, while the hands are fixed on the hips of subject in the sagittal view. Jump starts from a squat position – rebound phase, ending the 14-th frame with the transition in flight phase, which lasts up to 38-th frame. The landing phase is from the 38-th to the 54-th frame. Based on the recording speed (1/60 of a second) it can be concluded that the phase of flight took (38-14) * 24 * 0016 = 0016 sec = 0.4 seconds. The changes in values of relative velocity and joint angles in the relevant time period were analyzed for the purpose of this study.

The kinematical results
Kinematics is the branch of mechanics which describes the movement (by position, displacement, velocity and acceleration). Linear kinematics studies linear and curvilinear trends (one point) with the position, displacement, velocity and acceleration. (Stankovic, Obredovic and Schlaiauf, 2008). The shoulder joint center velocity value was given at the Figure 1. It has been seen that the maximum velocity value was achieved in 12-th frame, and amounted to 3.60 m / s. The other points analysis were obtained that the maximum speed reached just before the moment of rebound, except in the ankle joint center, which can be clearly seen from the chart. Figure 2 shows the hip joint velocity value. The maximum value of speed was 3.14 m / s, and was achieved in 12-th frame (the rebound phase), one frame before the rebound moment.

The Figure 3. represents the maximum knee joint center velocity value, which was achieved in the 12-th frame, the same as the hip and shoulder, and was 3.52 m/s. Maximum speed in all three joints were achieved one frame before the rebound moment. Figure 4. represents the maximum ankle speed, which is 3.14 m/s, achieved by two time intervals after the rebound moment, in the 13-th frame. This is the only center with a maximum speed record after a moment of rebound, compared with the centers of the joints that this work didn’t took under its consideration.
Angular position is an important measure that allows defining the rotation of the body. For the two-dimensional movements, the angular position of a given segment is set as the angle between the segment “representative line” (usually set as a vector between the proximal point of the segment and its distal point) and the direction of forward movement (Stanković et al., 2008). Figure 5. shows the relative angles of the hip joint. The values ranged from 164 ° in rebound phase to 170 ° in the landing phase. The maximum value is achieved in the 22nd frame, and amounted to 187 °. The figure shows that the angle increases and moves from flexion in retro flexion, and in the second half of the flight phase reduced with the transition to flexion. Figure 6. presents values of the relative angles in the knee joint. The maximum value is achieved in the 22nd frame, and amounted to 187 °. It has been observed that the maximum values of the angles for all three joints were reached beyond the rebound point as well as after reflection is flexion in all three joints.

CONCLUSION
The purpose of this study was to obtain qualitative and quantitative results from the squat jump (SJ) in the space of goniometry and kinematics. Velocity values in centers of shoulder, hip, knee and ankle joint were ranged from 3.1 m / s to 3.6 m / s, except the ankle joint center velocity value, which reached the maximum immediately after the rebound moment in the 15th frame, while within the all other joints the maximum was reached before the rebound moment (12th frame).

The values of the relevant joint angles ranged around 180 ° for the hip joint, 170 ° in knee joint and about 30 ° in the ankle joint, which indicates that these angles were constantly falling after the rebound moment. Further, it indicates that the flexions were observed in all joints. Maximum value in the centers of the joints, that were considered achieved at the time of reaching maximum height and were 187 ° in the hip, 173 ° in the knee and 37 ° in the ankle. 

This approach to quantifying technique may be an encouragement for further research and finding the parameters which could determine the efficiency of the vertical jump, and possibilities to choose appropriate means and methods that will be attractive for developing explosive leg strength in athletes.
КИНЕМАТИЧКА АНАЛИЗА НА СКОКОТ ОД ЧУЧНУВАЊЕ (SQUAT JUMP-SJ)

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Апстракт

Во современата спортска наука често се вршат мерења и интерпретации на одделни или сериозни изведен врткалиски скокови со цел да се процени мускулната снага, аероб-ната способност и спортското движење. Скокот од чучнување (squat jump – SJ), подразбира максимално изведување на вертikalното напретнување од позиција на получучнување (со колениот зглоб под агол од 90°), со поставени раце на колковите. Овој вид на мерење овозможува проценување на способноста на изолираната концентрична мускулна контракција на испружувачите на долните екстремитети. Основната цел на истражувањето беше да се добијат квалитативни и квантитативни показатели на скокот од чучнување (SJ) во просторот на кинематиката и гониметријата. Анализирани се: должината на одделни фази, максималните вредности на брзината и времето во кој тие се јавуваат во центарот на зглобовите на рамената, колковите, колената и зглобот на стапалото (3,60 m/s, 3,19 m/s, 3,52 m/s, 3,14 m/s итн.), како и максималните вредности на аглите во зглобовите на колот, колената и зглобот на стапалото. Освен брзината на центарот на зглобот на стапалото, која максимумот го достигна непосредно по моментот на одскокот (во 15. фрејм), во сите други зглобови, максимумот е постигнат пред моментот на одскокот (во 12. фрејм). Во сите третирани зглобови, вредностите на аглите опаѓаат по одскокот.

Ключни зборови: брзина, мускулна снага, гониметрија, физички способности, моторно тестирање, видео камера снимање, вредности на аглите во зглобовите

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Кинематичка анализа на скокот од чучнување (SQUAT JUMP-SJ)