

## KINEMATIC PARAMETERS DIFFERENCES BETWEEN THE COUNTERMOVEMENT JUMP (CMJ) AND SQUAT JUMP (SJ)

UDC: 796.431.012

*(Preliminary communication)*

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### Abstract

*Determination the amount of one or a series of vertical jumps is one of the oldest methods for establishing the physical abilities. Jump from a standing position with hands on hips (countermovement jump - CMJ) is derived from a standing position with legs stretched in the knee joint with hands on hips. Squat jump (SJ) involves the performance of maximum vertical jump from a half squat position (knee joint angle of 90 °), with hands placed on the hips. The main objective of this study was to compare the obtained qualitative and quantitative indicators of the counter movement jump (CMJ) and squat jump from (SU) in the field of kinematics. The sample was the athlete who performed CMJ and SJ, and the material was taken with a digital video camera. Video record is processed in the software for kinematical analysis of KA Video. In this study, we used the 2D kinematical analysis. Maximal velocity values of shoulder, hip, knee and ankle joint centers ranged from about 4m/s in the center of the shoulder joint to 3.1 m / s in the center of the ankle. There was a difference between the squat jump (SJ) and counter movement jump with (CMJ) at a height of about 0.5 cm.*

**Keywords:** *physical abilities, motor testing, muscle contractions, video camera recording, kinematical analysis, velocity values, joint centers*

### INTRODUCTION

Determination of one or a series of vertical jump height is one of the oldest methods for establishing the physical abilities. While traditional methods within the jump reach height makes possible only the measure and limited analysis of one jump type (with a free swing of the arm), advanced measurement methods allow testing of different kinds and types of vertical jumps performed singly or in variable number series. Execution of different test protocol allows detailed qualitative and quantitative analysis of individual phase muscle contraction of the upper and lower extremities involved in the execution of move. Jump from a standing position with hands on hips (countermovement jump - CMJ) is derived from a standing position with legs stretched in the knee joint and with

hands placed on the hips. Maximum vertical jump after rapid half squat allows indirect estimation of the lower extremities extensor, i.e. ability to make quick removal from eccentric to concentric contractions and the transfer of elastic energy, essential for sporting achievement (Bobert, Gerritsen, Litjensen, & Wan, 1996, taken from Ostojić, Stojanović and Ahmetović, 2008)..

Squat jump (SJ) involves the performance of maximum vertical jump from a half squat position (knee joint angle of 90 °), with hands placed on the hips. This type of measurement estimates the ability of isolated concentric muscle contractions of knee extensors. It can be performed with the additional load, like the other tests (Dugan, Doyle, Humphries, Hasson, & Newton, 2004).

The main objective of this study was to

compare the obtained qualitative and quantitative indicators of the counter movement jump (CMJ) and squat jump (SJ) in the field of kinematics.

## METHODS

The sample athlete executing counter-movement jump (CMJ) and squat jump (SJ). The subject performs jumps, and the material was taken with a digital video camera. Video record is processed in the software for kinematics' analysis of KA Video. In this study, we used the 2D kinematics' analysis.

## RESULTS AND DISCUSSION

The squat jump technique is divided into three phases: rebound phase (concentric), flight phase and landing phase (eccentric), while the countermovement jump technique (CMJ) divided into four phases: preparing phase, the rebound phase, flight phase and landing phase. CMJ jump duration is 90 frames, and SJ jump is 54 frames. The changes of speed and body balance during flexion and extension muscles of the lower extremities, trunk and arms, while the hands are fixed on the hips were analyzed for CMJ and SJ in the sagittal view. Velocity values were analyzed for the purpose of this study.

Kinematics is a branch of mechanics which describes the movement (by position, displacement, velocity and acceleration). Linear kinematics examines the linear and curvilinear moves (one point) with the position, displacement, velocity and acceleration (Stanković, et al., 2008).

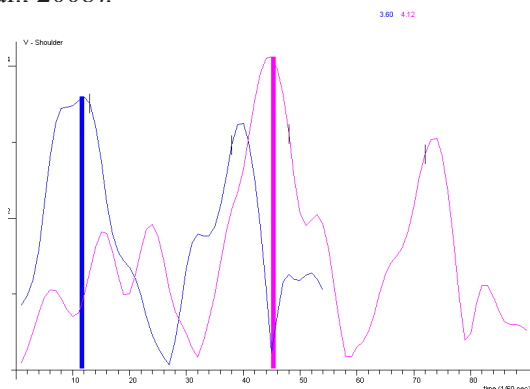


Figure 1. The shoulder joint centers velocity values

The shoulder joint center velocity values are given in the Figure 1. It can be seen that the maximum velocity value is reached one

frame before the rebound moment and was 3.60 m / s at SJ.

At CMJ maximum velocity value is two frames before the rebound moment and is 4.12 m / s. Analysis of other points were obtained to achieve maximum speed just before the rebound moment, except in the center of the ankle joint, which can be clearly seen from the chart.

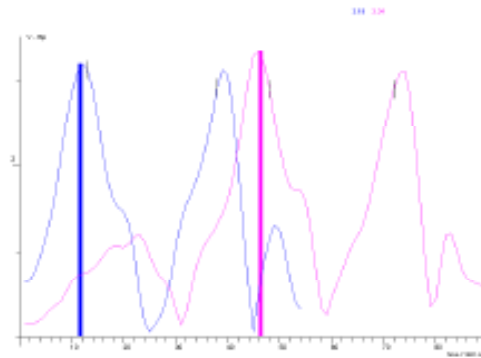


Figure 2. The hip joint centers velocity values

Figure 2 shows the velocity values of hip joint. The maximum values are reached, as in the shoulder joint, one or two frames before the rebound moment and amounted to 3.19 m / s for SJ and 3.34 m / s for CMJ.

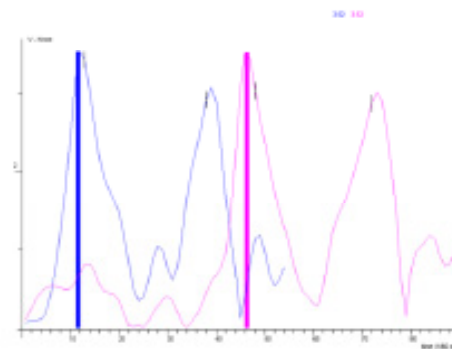


Figure 3. The knee joint centers velocity values

The figure 3. presented maximal velocity for knee joint centers, which were the same when performing a squat jump and counter-movement jump and reached one or two frames before the rebound moment. Their value were 3.52 m / s.

Figure 4 presents the maximal ankle joint velocity, which amounts 3.23 m / s for CMJ and 3.14 m / s for SJ, achieved two frames after the rebound moment in both cases. It may

be noted that this is the only center with a maximum velocity recorded after a rebound moment, comparing with the other centers is not taken into consideration because their movement was minimal and insignificant for the analysis.

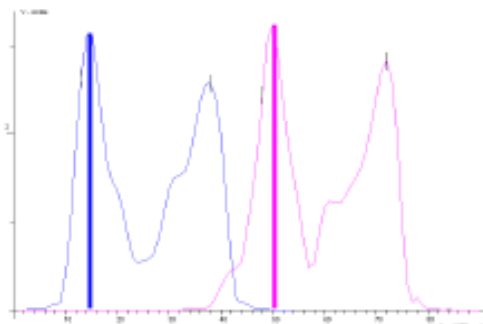


Figure 4. The ankle joint center velocity values

Table 1. CG displacement at X and Y coordinates

	X	Y		X	Y	
21	0.363	1.336		53	0.356	1.306
22	0.363	1.356		54	0.357	1.336
23	0.383	1.370		55	0.357	1.383
24	0.382	1.375		56	0.358	1.388
25	0.380	1.375		57	0.359	1.401
26	0.380	1.375		58	0.359	1.408
27	0.361	1.373		59	0.358	1.409
28	0.362	1.366		60	0.359	1.405
29	0.384	1.358		61	0.360	1.400
30	0.386	1.343		62	0.361	1.392
31	0.388	1.323		63	0.365	1.381

Table 1 presents the body center of gravity (CG) displacement in the X and Y coordinates for the SJ and CMJ. The table shows that the values of the Y coordinate, in the flight phase amounted to 1.373 m for SJ and 1.409 m for CMJ, and this happened at the time when speed was about zero, i.e. when the subject reached its highest point. The difference that occurs in a jump height between SJ and CMJ is the consequence of elastic energy released in the first phase of CMJ. At this phase, the body center of gravity moves down (eccentric contraction), then the movement stops and pushes vertically upward (concentric contraction), resulting in greater muscular strength produced during the second phase of the jump. The CG vertical velocity in two muscle contraction was

9.5% higher than in the single-phase concentric muscle contraction. The transition from eccentric to concentric contractions carried out at an angle of 89 ° in the knee joint (Čoh et al., 2009, taken from Kreft, 2010). In a study conducted by Bosko et al. (1982, there were differences between the squat jump (SJ) and counter movement jump (CMJ) in the height for 18% - 20%. CMJ height can be higher for 3-4cm compared to the SJ showed the study that was conducted by Bobert, et al. (1996). The strongest activation includes a counter movement during which the muscle stretches first and then shortens. This action is called a cycle of muscle stretching and shortening (stretch-shortening cycle SSC) and involves many complex interactions of neural and mechanical processes. A large part of the research has been directed towards the study about cycles of stretching and shortening, as it has been observed that a greater effect in SSC movements than if the activity is performed concentric action purely (Newton, R., 1998).

**CONCLUSION**

In the previous literature it was found that subjects can achieve greater heights in the counter movement jump (CMJ) than in the squat jump (SJ). The aim of this study was to compare the obtained qualitative and quantitative indicators of the counter movement jump (CMJ) and squat jump (SJ) in the field of kinematics.

Maximal velocity values of shoulder, hip, knee and ankle joint centers ranged from about 4m/s for center of the shoulder joint to 3.1 m / s in the center of the ankle. Speed reference points in the two muscle contraction increased by about 8% compared to single-phase concentric muscle contraction. There was a difference between the squat jump (SJ) and counter movement jump (CMJ) at a height of about 0.5 cm. Comparing this study with so far conducted, it is evident that similar results were obtained both in terms of velocity values for reference points and CG height between CMJ and SJ.

This approach to the analysis of vertical jump may be an encouragement for future research that would have the aim to determine the choice of appropriate means and training methods that are suitable for the development of explosive strength in young athletes.

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## РАЗЛИКИ НА КИНЕМАТИЧКИТЕ ПАРАМЕТРИ НА СКОКОТ СО КОНТРА ДВИЖЕЊЕ (СМЈ) И СКОКОТ ОД ЧУЧНУВАЊЕ (SJ)

УДК: 796.431.012

(Прейходно соопштение)

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## Апстракт

Оредувањето висината на еден или на серија вертикални скокови, е една од најстарите методи за утврдување на физичките способности. Скокот од став во стоење со рацете на колковите (countermovement jump – CMJ), се изведува со испружени нозе во зглобовите на колената. Скокот од чучнување (squat jump – SJ) подразбира изведување на максимално вертикално напрегнување од позиција на получучнување (зглобот на колената е под агол од 90°) со рацете на колковите. Основната цел на ова истражување беше да се споредат добиените квалитативни и квантитативни показатели на скокот со контра движење (CMJ) и скокот од чучнување (SJ) во просторот на кинематиката. Споредбата е направена од добиените показатели на спортист кој ги изведуваше овие два скокови. Материјалот е сниман со дигитална видео камера. Видео записот е обработен во софтвер за кинематичка анализа на КА Видео. Во истражувањето е користена 2D кинематичка анализа. Вредностите на максималната брзина на референтните точки на центрите на зглобовите на рамената, колковите, колената и зглобовите на стапалата се движеа од околу 4 м/с, во центрите на зглобовите на рамената, до 3 м/с во центарот на скочните зглобови. Утврдена е разлика во височина од околу 0,5 см. меѓу скокот од чучнување (SJ) и скокот со контра движење (CMJ).

**Клучни зборови:** физички способности, мојорно шесирање,

*мускулна контракција, видео камера снимање, кинематичка анализа,  
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