PLATFORM HEIGHT FOR DROP JUMP DETERMINED BY COUNTER MOVEMENT JUMP

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The purpose of the study was to apply personal counter movement jump (CMJ) ability as a standard of choosing the height of the platform and to analyze the kinematics and kinetics during DJ in order to find the appropriate height of the platform for an individual. Twenty male Division I college volleyball players were the participants. Data were collected using 11 infrared Eagle cameras and two AMTI force platforms. The major finding was that the personalized platform height designed according to personal jumping ability showed significant increase in the impulse of eccentric phase during the drop height being above 100%CMJ. The platform height chosen according to 100%CMJ would be an appropriate height for an individual.

KEY WORDS: plyometric, drop jump, counter movement jump, stretch-shortening cycle

INTRODUCTION: Drop jump is commonly applied in the plyometric training exercises. The research has shown that drop jump (DJ) training can enhance the jumping performance of athletes (Gehri, Ricard, Kleiner, & Kirkendall, 1998). Plyometric exercise training is regarded as a highly repetitive, high impact and high intensity training, which involves the stretch-shortening cycle (SSC) where an eccentric contraction is followed by a concentric contraction that will improve the ability to produce explosive force and power (Aura & Komi, 1986). The height of the platform is optional and usually adjusted by the coach and athlete according to the purpose of the training, it has been defined as the amount of stress placed on involved muscles connective tissues and joints and is dictated by the type of plyometric exercise that is performed (Potach & Chu, 2008). Ebben, Blackard,& Jensen (1999) indicated that the intensity of plyometric exercise has to be set based on the weight and the acceleration of gravity of the subject. Different athletes can take on different levels of training intensity; therefore, the intensity of the training is varied. Previous studies showed that jumping from a higher platform would lead to insufficient push-off during the concentric phase and impose extreme loads on the musculoskeletal system and a higher risk of injury during eccentric phase (Peng, 2011; Peng, Kernozek, & Song,2011). Previous researchers have applied biomechanical methods on quantifying DJ such as electromyography (EMG) (Ebben, Simenz, & Jensen, 2008), ground reaction force (GRF) (Jensen & Ebben, 2007; Wallace et al., 2010) and joint reaction force (Jensen & Ebben, 2007; Peng et al., 2011). The researches maintioned above applied with a fixed height of platformfrom 30-cm to 61-cm. No study has standardized the height of platform to examine the drop jump according to individual's jumping ability. The purpose of the study was to apply personal counter movement jump (CMJ) ability as a standard of choosing the height of the platform and to analyze the kinematics and kinetics during DJ in order to find the appropriate height of the platform for an individual.

METHODS: The participants were twenty players from male Division I college volleyball team (Age: 22±2year-old/ Height: 182.3±7.8cm/ Weight: 78.4±14.4 kg/ Experience: 8±4 years). The study used 50%, 75%, 100%, 125% and150% of the averaged CMJ height (50%CMJ, 75%CMJ, 100%CMJ, 125%CMJ and150%CMJ) as individual platform height for DJ. Participants randomly chose the height and practiced three times of DJ at each height with one-minute rest in-between. Averaged data of the three DJs were used for analysis. Motion data were collected using 11 infrared Eagle cameras (Motion Analysis Corporation, Santa

Rosa, CA, USA) at a 200-Hz sampling rate. Twenty-one reflective markers were used to identify body segments of the lower extremity. Cameras were synchronized with two force platforms (AMTI Inc., Watertown, MA, USA) to collect GRF data at a sampling rate of 2000 Hz. Kinematic and kinetic data were recorded using EVaRT software (Version 4.6, Motion Analysis Corporation, Santa Rosa, CA, USA).Three-dimensional kinematic and kinetic variables were analyzed using the MotionMonitor software (Version 8; Innovative Sports Training Inc., Chicago, IL, USA). All the parameters were selected from the data of the dominant foot defined as the foot usually used to kick a ball. The total support phase during DJ landing was devided into two phases: 1) eccentric phase defined as the the time from foot contactto the maximum knee flexion; 2) concentric phase defined as the the time from the maximum knee flexion to foot takeoff the ground. The foot contact and takeoff the ground were determined by the GRF being greater and less than 30 N, respectively. Statistical analyses were performed using SPSS 18.0 for Windows (SPSS, Inc., Chicago, IL, USA). Descriptive statistics (mean ± standard deviation, SD) were used to determine characteristics of the participants. Repeated-measures one-way ANOVAs were performed with heights of platforms as factors for kinematics and kinetics variables. The alpha level was set at p<0.05. The Fisher's LSD method was used in *post-hoc* tests.

RESULTS: The height of the platform depended on individual jumping ability which determined the personalized platform height. The average CMJ ability was 46.2 ± 6.7cm. When the heights of platform was adjusted to 50%, 75%, 100%, 125% and 150% of the CMJ height, they were 23.1 ± 3.3cm, 34.7 ± 5.0cm, 46.2 ± 6.7cm, 57.8 ± 8.4cm and 69.4 ± 10.1cm, respectively. GRF showed significant differences from different heights. The GRF increased significantly with the increasing height of the platform. As shown in Table 1, the impulse of eccentric phase in 100%CMJ, 125%CMJ and 150%CMJ were significantly greater than 50%CMJ and 75%CMJ. However, there was no significant difference in the impulse of concentric phase.

Table 1
Normalized kinetic parameters: ground reaction force (GRF), impulse of eccentric phase (IE) and impulse of concentric phase (IC)

	50%CMJ	75%CMJ	100%CMJ	125%CMJ	150%CMJ
GRF (BW)	2.70 ±0.09	2.91±0.12 ^{a}	3.28±0.18 ^{ab}	3.86±0.13 ^{abc}	4.19±0.13 ^{abcd}
IE(BW•s)	0.49 ±0.10	0.51 ±0.10	0.55±0.07^{ab}	0.58 ±0.09^{ab}	0.61 ±0.08^{abcd}
IC (BW•s)	0.55 ±0.10	0.57 ±0.11	0.57 ±0.12	0.57 ±0.10	0.59 ±0.10

^{a} represented that there was significant difference with 50%CMJ. ^{b} represented that there was significant difference with 75%CMJ. ^{c} represented that there was significant difference with 100%CMJ. ^{d} represented there was significant difference with 125%CMJ (p<.05).

As shown in Figure 1, the negative work of knee joint of 100%CMJ, 125%CMJ and 150%CMJ were all significantly greater than that of 50%CMJ. The negative work of knee joint of 150%CMJ was significantly greater than that of 100%CMJ and 125%CMJ. The negative work of ankle joint of 75%CMJ, 100%CMJ, 125%CMJ and 150%CMJ were all significantly greater than that of 50%CMJ. The negative work of ankle joint of 125%CMJ and 150%CMJ were all significantly greater than that of 75%CMJ and 100%CMJ. As shown in Figure 2, the hip joint power absorption of 75%CMJ, 100%CMJ, 125%CMJ and 150%CMJ were significantly greater than that in 50%CMJ. 125%CMJ and 150%CMJ were significantly greater than 100%CMJ. 150%CMJ was significantly greater than 125%CMJ. The knee joint power absorption of 75%CMJ, 100%CMJ, 125%CMJ and 150%CMJ were significantly greater than that in 50%CMJ. The ankle joint power absorption of 75%CMJ, 100%CMJ, 125%CMJ and 150%CMJ were significantly greater than that in 50%CMJ.

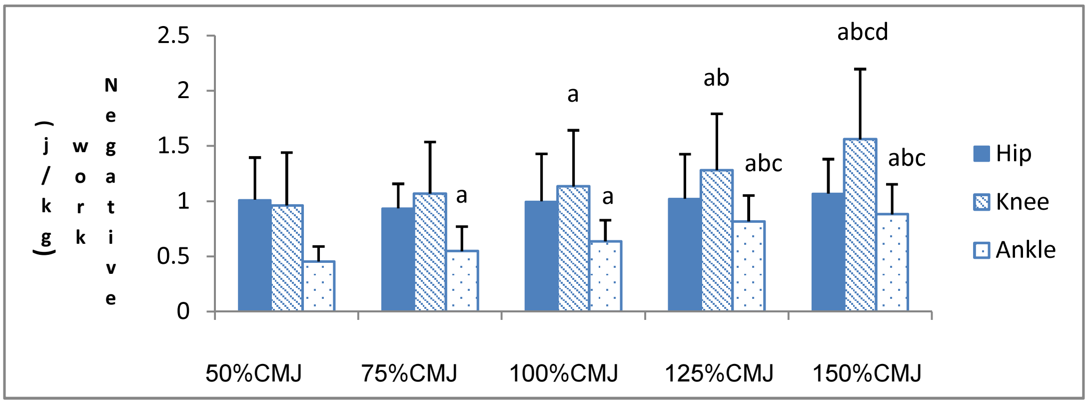

Figure 1: The negative work chart of hip, knee and ankle joint. [a] represented there was a significant difference with 50%CMJ. [b] represented there was a significant difference with 75%CMJ. [c] represented there was a significant difference with 100%CMJ. [d] represented there was a significant difference with 125%CMJ (*p*<.05).

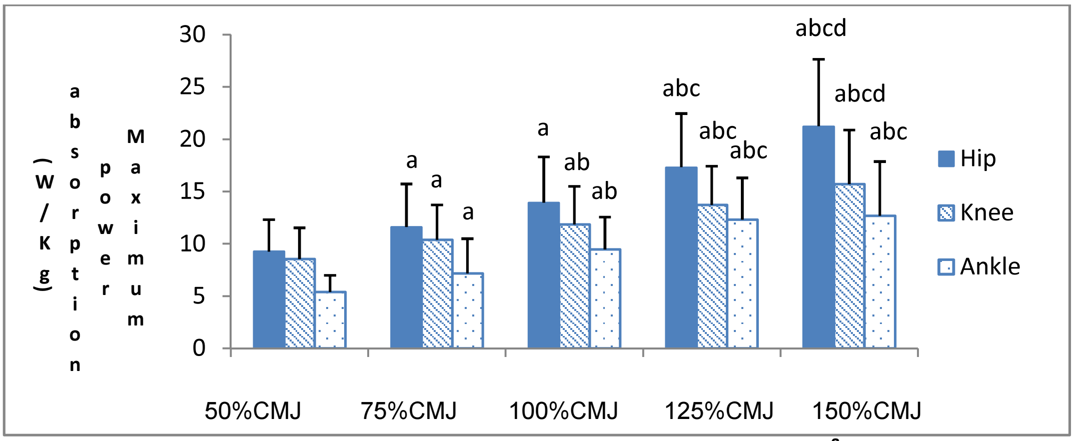

Figure 2: The maximum power absorption of hip, knee and ankle. [a] represented that there was a significant difference with 50%CMJ. [b] represented that there was significant difference with 75%CMJ. [c] represented that there was significant difference with 100%CMJ. [d] represented that there was significant difference with 125%CMJ (*p*<.05).

DISCUSSION: The major finding of this study was that the personalized platform height designed according to personal jumping ability showed significant increase in the impulse of eccentric phase during the drop height being above 100%CMJ. When the height reached 125%CMJ and above, the negative work of knee and ankle joint and the power absorption of hip joint showed significant increase. The ground reaction force, eccentric impulse and power absorption of knee and ankle joint all increase significantly with the increase of drop height.
The result of eccentric impulse being increased significantly with the 100%CMJ in this study was in accordance with previous research indicating that the impulse of eccentric phase increased significantly with the height being above 50 cm (Peng, 2011). The impulse of eccentric phase contributed to breaking movement while the impulse of concentric phase contributed to propulsive movement. It seemed participants mainly exerted effort for breaking when dropped from 100%CMJ height.
The landing movement of this study showed that the negative work and power absorption were significantly produced during eccentric contraction of hip, knee and ankle joints especially when the platform was above 125%CMJ height. The results of negative work and power absorption were also in accordance with previous research indicating that the negative work and power absorption increased along with the increase of platform height but the positive work and power generation did not increase according to the increase of height

(Bobbert et al., 1987; Peng, 2011). Decker et al. (2003) indicated that power was calculated by joint torque and angular velocity of joint. Greater joint torque and angular velocity of joint resulted in greater power which could cause the risk of ACL injury. The current study showed that dropping from above 125%CMJ height increased the maximum absorption power during eccentric phase which could also increase the risk of ACL injury.

CONCLUSION: Platform height of drop jump being greater than 125%CMJ caused greater loads at the hip, knee and ankle joints during eccentric movement. The platform height chosen according to 100% of the personal CMJ ability would be an appropriate height for an individual. Further study using EMG would be guaranteed to observe the muscle activities.

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