SQUAT AND POWER CLEAN STRENGTH ARE NOT RELATED TO APPROPRIATE DROP JUMP HEIGHT IN FEMALE COLLEGIATE ATHLETES

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The purpose of this study was to determine if an appropriate drop jump height for female athletes could be determined from squat and/or power clean maximums. Thirteen female collegiate basketball or volleyball players had their appropriate drop jump height determined by both maximal jump height (MJH) and reactive strength index (RSI) methods. The two methods often determined different appropriate jump heights for the athletes. Pearson's correlations showed moderate to trivial relationships between drop jump height and: squat maximum (r =-0.41 MJH, -0.09 RSI), power clean maximum (r =.-0.34 MJH, -0.19 RSI). It appears it is necessary to perform either MJH or RSI testing to determine appropriate drop jump height for female collegiate athletes.

KEY WORDS: Maximum Jump Height, Reactive Strength Index (RSI), Plyometrics

INTRODUCTION: Drop jumps are a commonly used plyometric exercise. An appropriate drop jump height must be chosen to provide adequate stimulus and limit the chance of injury. There are two prominent methods of determining appropriate drop jump height. The first method, maximal jump height (MJH), has athletes perform vertical jumps from the floor to determine maximal jump height (Chu & Myer, 2013). The athletes then performs drop jumps off boxes of increasing height until they can no longer match the maximal height reached from the floor. The second method, the reactive strength index (RSI), requires the use of a force platform or jump mat as it measures the time from landing to takeoff (contact time) as well as the height of the jump (McClymont & Hore, 2004). The height of the jump is divided by the contact time to calculate the RSI. To determine the optimal height using the RSI method, athletes start at a low box height and continue to higher boxes until the RSI starts to decrease.

Both of these methods require increased testing time, which may not be available at the collegiate level due to practice time constraints. The RSI method also requires the use of a force platform/jump mat that may not be readily available to all teams. Most conditioning programs typically test for measures of performance such as maximal strength or vertical jump ability. Appropriate drop jump height should be dependent upon athletes' performance variables. Thus, the purpose of this study was to assess the magnitude of the relationship between measures of muscular strength and power and appropriate drop jump height as determined by MJH and RSI methods. Because gender differences would most likely affect this relationship, it was determined to focus on female athletes.

METHODS: Thirteen Division 1 female collegiate basketball or volleyball players volunteered for participation (mean ± SD: age = 19 ± 1 y; height = 173 ± 8 cm; weight = 68 ± 9 kg). This study was approved by the University's Institutional Review Board prior to any data collection.

Athletes' squat and power clean one repetition maximums (1-RM) were determined on separate days during their normal strength training workouts. A minimum of 48 hours occurred between sessions. The athletes first warmed up using a standardized protocol provided by the strength coach. Likewise, a 1RM protocol used by the strength coach (Table 1) was performed for both the squat and power clean. The squat was performed to 90º of knee flexion.

A third testing session occurred outside of the athletes' scheduled workouts. Athletes had 48 hours of recovery prior to this testing session. Athletes warmed up on a cycle ergometer for five minutes at speed and resistance of their own choosing. Maximal countermovement jump height was determined using a commercial Vertec device.

Table 1. Squat and Power Clean 1 Repetition Maximum Protocol.

Set	Intensity (% of Previous 1RM)	Repetitions	Recovery (min)
1	60	5	2
2	70	3	2
3	80	3	2
4	90	1	3
5	100	1	3-5
If needed (up to 4 attempts)	±2.5-10 kg of previous attempt	1	3-5

Three vertical jumps were performed and the average of the three was used as the baseline jump height. One minute recovery was allowed between jumps. The athletes then performed three drop jumps from a 30 cm adjustable platform onto on 3’ X 3’ force platform (Roughdeck-16960, Rice Lake Weighing Systems, Rice Lake, WI). The Vertec device was situated by the force platform and was used to verify that athletes maintained their vertical jump height during each drop jump. If two of the three attempts met the baseline height, the platform height was increased by 15 cm (up to a maximum of 60 cm). If less than two attempts met the baseline level, the platform height was decreased by 5 cm and three more attempts were allowed that new height. Force data were recorded using Labview software (National Instruments, Austin, TX) and evaluated using MatLab software (Mathworks, Natick, MA). Data were collected at 2000 Hz and filtered with a fourth order Butterworth low pass filter (20 Hz cutoff frequency). Reactive strength index was calculated from the force platform data and appropriate box height was also determined using this method of assessment (Byrne et al., 2010). Squat and power clean maximums were normalized to body mass. Pearson correlations were performed between appropriate box jump height and squat and power clean maximums respectively. Correlation values were assessed using the scale of magnitude provided by Hopkins (2013a). A paired t-test was performed between the MJH and RSI box heights to determine if there was a statistical difference between the two methods. Alpha level was set at $p < 0.05$. Statistical analysis was performed using PASW statistical software (Version 17, IBM, Armonk, NY). Confidence intervals were calculated using an Excel Spreadsheet (Hopkins, 2013b).

RESULTS: Individual results are provided in Table 2. One subject did not perform the power clean maximum due to a previous upper extremity injury. Pearson’s correlations showed moderate to trivial relationships between box height (as determined by MJH and RSI) and: squat maximum (MJH: r=-0.41, 95% CI: -.78 to .18, RSI: r=-0.09, 95% CI: -0.61 to 0.55) power clean maximum (MJH: r= -0.34, 95% CI: -0.76 to 0.29, RSI: r= -0.19, 95% CI: -0.69 to 0.43). The differences in appropriate jump height were not statistically significant (p = 0.12).

DISCUSSION: The goal of this study was to assess the magnitude of the relationship between measures of muscular strength and power and appropriate drop jump height. The results of this current study would suggest that appropriate box height has little relationship to these measures of strength for collegiate female athletes. The drop jump is thought to develop the reactive strength of the stretch shortening cycle (Barr and Nolte, 2011; Byrne et al., 2010), while the squat is typically believed to be a measure of maximal muscular strength (Swinton et al., 2012) and the power clean a measure of explosive strength (Comfort, Allen & Graham-Smith, 2011). While quantifying strength in these terms may be fairly crude, the data from this study does suggest that these may be separate distinct indices of muscular strength.

Table 2. Individual Results of Squat and Power Clean Maximums and Appropriate Box Height.

Participant	Mass (kg)	Squat Maximum (kg)	Squat Maximum (%BM)	Clean Maximum (kg)	Clean Maximum (%BM)	Appropriate Box Height-MJH (cm)	Appropriate Box Height-RSI (cm)
1	73.6	93.2	127	61.4	83	55	55
2	87.7	79.5	91	65.9	75	60	30
3	52.7	75	142	47.7	91	25	30
4	68.9	75	109	47.7	69	60	45
5	59.8	75	125	43.2	72	60	30
6	66.6	70.5	106	43.2	65	50	55
7	77.7	75	96	47.7	61	60	45
8	59.1	79.5	135	43.2	73	25	25
9	71.8	90.9	127	52.3	73	60	45
10	57.7	65.9	114	N/A	N/A	25	30
11	74.3	102.3	138	56.8	76	60	45
12	66.8	102.3	153	61.4	92	35	45
13	66.1	72.7	110	38.6	58	35	45

N/A-did not perform due to a previous upper extremity injury.

The strength levels of the athletes in this study were fairly homogenous and most likely greatly influenced the results of this study. A larger sample, representing more diverse strength levels, may have provided the results that were expected. However, the strongest athlete tested in this study was found to require a relatively low drop jump height (35 cm MJH, 45 cm RSI). Likewise, while there was most likely a ceiling effect due to limiting the maximal drop jump height to 60 cm, many of the weaker athletes were able to achieve this height. This methodology was based on Peng's (2011) recommendation to limit drop jumps to this height. While it has been suggested that drop jump training should not occur until athletes can squat 1.5 times their body weight (Chu & Myer, 2013), six of the participants (Squat max range: 91-138% of body weight) in this study could maintain their maximal vertical jump height from a drop of 60 cm.
Appropriate drop jump height differed, although not significantly, between MJH and RSI methods. The lack of statistical significance is most likely due to the small sample size. This discrepancy has been noted in other studies (Barr and Nolte, 2011; Byrne et al., 2010). Coaches need to assess which method of drop jump determination is more appropriate for their desired training. As the RSI focuses on minimizing ground contact time, sports, such as sprinting, may benefit more from using this method. Sports that sole focus is maximal height may benefit more from the MJH method.

CONCLUSIONS: There are differences in the appropriate height for drop jumps depending upon the method used (MJH vs. RSI). Regardless of method used, appropriate drop height was not related to measures of maximal muscular strength or power. Therefore, the strength and conditioning coaches cannot use these measures to determine the appropriate drop jump heights of their athletes.

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