Effect of Instructions on Selected Jump Squat Variables

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Abstract

Talpey, SW, Young, WB, and Beseler, B. Effect of instructions on selected jump squat variables. *J Strength Cond Res* 30(9): 2508–2513, 2016—The purpose of this study was to compare 2 instructions on the performance of selected variables in a jump squat (JS) exercise. The second purpose was to determine the relationships between JS variables and sprint performance. Eighteen male subjects with resistance training experience performed 2 sets of 4 JS with no extra load with the instructions to concentrate on (a) jumping for maximum height and (b) extending the legs as fast as possible to maximize explosive force. Sprint performance was assessed at 0- to 10-m and 10- to 20-m distances. From the JS jump height, peak power, relative peak power, peak force, peak velocity, and countermovement distance were measured from a force platform and position transducer system. The JS variables under the 2 instructions were compared with paired *t*-tests, and the relationships between these variables and sprint performance were determined with Pearson's correlations. The jump height instruction produced greater mean jump height and peak velocity ($p < 0.05$), but the fast leg extension instruction produced greater ($p < 0.05$) peak force (3.7%). There was a trivial difference between the instructions for peak power output ($p > 0.05$). Jump height was the variable that correlated most strongly with 10-m time and 10- to 20-m time under both instructions. The height instruction produced a stronger correlation with 10-m time ($r = -0.455$), but the fast leg extension JS produced a greater correlation with 10–20 time ($r = -0.545$). The results indicate that instructions have a meaningful influence on JS variables and therefore need to be taken into consideration when assessing or training athletes.

Key Words testing, countermovement jump, power output

Introduction

A jump squat (JS) is a vertical jump without an arm swing and is often performed with added resistance such as a barbell on the shoulders. If performed with no added resistance, the arms are often held on the hips (11) or a light stick is held on the shoulders (16). This jump with no added resistance is often described as a countermovement jump (13,17). For the purpose of this study, a vertical jump with either added resistance or no added resistance (bodyweight only) will be referred to as a JS.

The JS is widely used as a training exercise for the development of leg muscle explosive capabilities (4,12) and a test of leg power (16). When used as a test, a variety of loads may be used to obtain an incremental-load profile with the objective of identifying the load that maximizes power output, described as the "optimum load" (5,6,16). The power output expressed in watts is a popular variable for assessment (1,8), although other variables can be obtained, which measure somewhat different expressions of muscle explosive function (18). To accurately measure power output, a system comprising a force platform to measure force directly and a position transducer to record distance directly are recommended (6). With such a system, a range of JS variables can be recorded, such as power, jump height, force, velocity, and rate of force development. Values can be expressed in absolute terms or relative to body mass, as mean or peak scores, and they can be described separately for the concentric and eccentric phases of the jump.

Variables of JS have been shown to be sensitive to power training (17). Another variable that could potentially influence acute JS performance is the instructions given to participants. In the drop jump exercise, instructions have been shown to have a marked effect on jumping performance (19). For example, when participants were instructed to jump for height from a 30-cm drop, the mean jump height was 40.2 cm and the height divided by the ground contact time (interpreted as reactive strength) was 101 $cm \cdot s^{-1}$. When the same participants were instructed to jump for both maximum height *and* minimum ground contact time, the jump height reduced by 17.7% to 33.1 cm and the height divided by time increased by 89% to 191 $cm \cdot s^{-1}$. Unfortunately, the instructions used when administering a JS test have not been standardized and can vary considerably. For example, one

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instruction was to "reach a maximum jump height" to maximize power output (2), whereas another was to move the resistance "as fast as possible" to achieve maximum power output (3). These examples indicate that some researchers emphasize jump height, whereas others emphasize the speed of movement. According to Dugan et al. (6), the instructions given can have a tremendous effect on the determination of the optimum load and suggested that the instructions used should be addressed by researchers. A recent study (15) compared various instructions on performance of a standing long jump. It was found that an instruction to focus on jumping for horizontal distance produced a superior performance ($p < 0.05$) than an instruction to extend the "knees as rapidly as possible." Unfortunately, no other jump variables, such as force, velocity, or power production, were assessed.

Sprinting is a common and important movement for most sports. Previous research has highlighted the significant relationship between JS variables and sprint performance (9,11,18). Therefore, the strength of the relationship between JS variables and sprint performance may have implications on the programming of strength and power training to improve sprint performance. It is important to determine how instructions influence the correlation between variables obtained from the JS and measures of sprint performance.

The main purpose of this study was to determine the influence of 2 different instructions on selected variables of JS performance. Another purpose was to determine the relationships between the JS variables and sprint performance and whether these relationships would differ for the 2 instructions. The findings of this study are expected to inform practitioners and researchers about the instructions that should be used to maximize power output in a JS and the preferred instructions that relate to sprint performance.

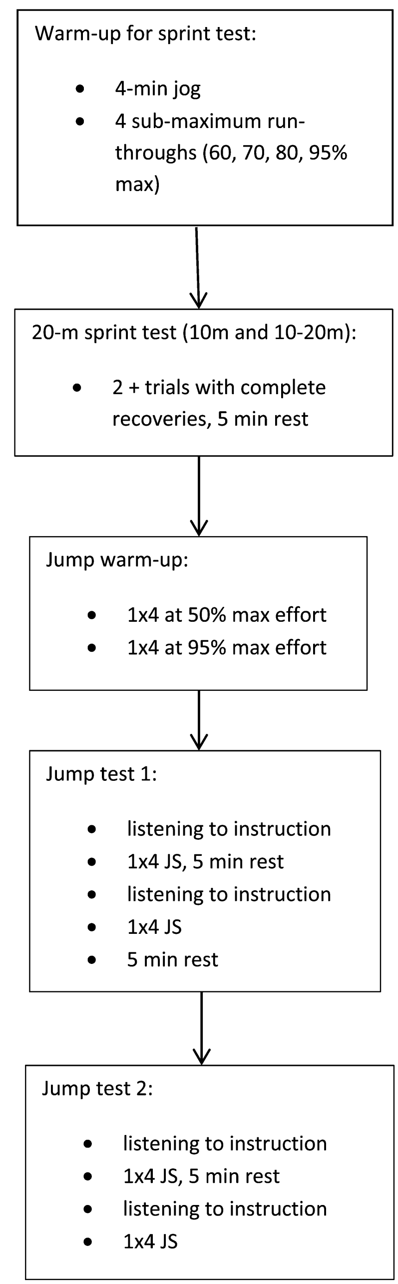

Figure 1. Flow chart showing the sequence of testing.

Methods

Experimental Approach to the Problem

A within-subjects repeated measures design was chosen to investigate the potential differences between 2 instructions for performing JS. One instruction emphasized jump height, and the other emphasized the speed of leg extension. Participants were familiarized with the procedures by performing the warm-up and 3 sets of 4 JS with both instructions 2–3 days before testing. Both JS tests were conducted in 1 session in a counterbalanced order so that half of the participants performed one JS condition first and the other half performed the other JS condition first. Participants were also assessed on sprint performance with a 20-m sprint (Figure 1).

Subjects

Eighteen physically active men (mean ± SD, age = 20.6 ± 1.1 years; height = 181.2 ± 4.0 cm; body mass = 79.8 ± 5.3 kg) who currently or previously participated in sports such as track and field and various team sports involving jumping and sprinting at a recreational level were recruited. All participants had at least 6 months experience performing resistance training. Participants signed an informed consent form, and the study was approved by the University Human Research Ethics Committee.

Procedures

Sprint Test. On arrival at the laboratory, a standardized warm-up was administered, which started with a 4-minute jog. Participants were instructed to jog at a pace that would

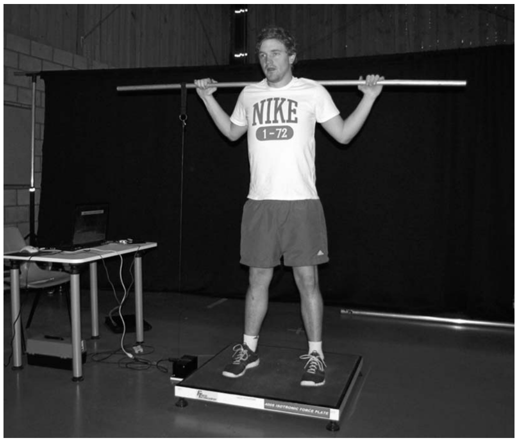

Figure 2. Equipment for assessing the jump squat variables.

elicit a light sweat after 4 minutes. This was followed immediately with four 20-m submaximum run-throughs at 60, 70, 80, and 95% of maximum effort with a slow walk-back recovery. After about a 1-minute rest, the 20-m sprint test was conducted. The participant used a standing start with the toe of the front foot just behind the start line and was allowed to start when ready. He or she was required to commence the sprint from a stationary position so that the first forward movement would trigger the timing. Dual-beam infrared light gates (Swift Performance Equipment, Brisbane, Australia) were placed at the start and at 10 and 20 m. The testing was conducted indoors on an all-purpose floor in a temperature-controlled building (approximately 20° C). Two 20-m sprints were performed with complete recoveries of 2–3 minutes. If the second trial was better than the first, a third trial was performed, and the best trial was retained for analysis. The time to 10 m was considered as a measure of acceleration performance, and the time between 10 and 20 m (flying 10 m) was considered as a measure of high-speed sprinting. The peak maximum speed for each participant was not assessed because of the lack of the necessary space to conduct a longer sprint.

Jump Squat Testing. The JS testing was conducted after a 5-minute rest from the sprint test. It started with a specific warm-up consisting of 2 submaximum sets of 4 repetitions of JS at 50 and 95% effort, respectively. After this warm-up, an audiorecording was played stating, "when you jump we will be measuring the height of the jump as well as how much explosive force you produce when you push off the ground." Immediately after this, a recorded instruction was played before commencement of the first JS test. These were as follows:

1. *Jump height instruction.* "In this condition, just concentrate on jumping for maximum height."
2. *Fast leg extension instruction.* "In this condition, just concentrate on extending the legs as fast as possible to maximize explosive force."

The recordings of the instructions guaranteed that the delivery of the instructions was identical for all participants. This was considered important because a change in emphasis during a verbal instruction could be interpreted differently, which could influence the results. No other instructions were provided about the technique to use when performing the jumps. After the first JS test, a 5-minute rest was provided, and then, the recorded instruction was played again immediately before a second set of 4 JS was performed. Another 5-minute rest was provided, and then, the second JS instruction was played and that JS condition was assessed. Both JS tests consisted of 2 sets of 4 jumps, with 1–2 seconds between each jump. The mean of the 2 sets (8 jumps) for all JS variables was retained for analysis. This relatively high number of jumps was considered advantageous to determine a representative score for each instruction.

Table 1. Descriptive results (mean ± *SD*) and statistical comparisons for the 2 instructions.

Countermovement jump variable	Jump height instruction	Fast leg extension instruction	% difference from jump height instruction	*p*	Effect size (qualitative descriptor)
Height (cm)	45.9 ± 5.8	44.0 ± 5.2	−4.1	0.003	0.34 (small)
Peak velocity ($m\cdot s^{-1}$)	2.58 ± 0.24	2.43 ± 0.23	−5.8	0.002	0.64 (moderate)
Peak force (N)	1,752.4 ± 192.9	1,817.6 ± 242.7	3.7	0.029	0.30 (small)
Peak power (W)	4,089.7 ± 622.5	4,036.4 ± 608.9	−1.3	0.181	0.09 (trivial)
Relative peak power ($W\cdot kg^{-1}$)	51.2 ± 6.4	50.4 ± 5.8	−1.6	0.165	0.13 (trivial)
Downward dip distance (cm)	54.9 ± 10.0	47.5 ± 11.6	−13.5	0.001	0.68 (moderate)

Table 2. Correlations between jump squat variable and sprint test variables for both conditions.*

	Jump height instruction		Fast leg extension instruction	
	10-m time	10- to 20-m time	10-m time	10- to 20-m time
Jump height	−0.455 (M)	−0.517 (L)†	−0.330 (M)	−0.545 (L)†
Peak velocity	−0.335 (M)	−0.356 (M)	−0.140 (S)	−0.248 (S)
Peak force	−0.108 (S)	−0.185 (S)	−0.099 (T)	−0.052 (T)
Peak power	−0.336 (M)	−0.169 (S)	−0.251 (S)	−0.165 (S)
Relative peak power	−0.373 (M)	−0.195 (S)	−0.288 (S)	−0.199 (S)

*T = trivial; S = small; M = moderate; L = large.
†$p < 0.05$.

Measurement of Jump Squat Variables

Jump squat variables were assessed with the Ballistic Measurement System (Fitness Technology, Adelaide, Australia), which consisted of a position transducer (PT5A) and a force platform (400 Series) (17). The position transducer was attached to one end of a light pole (0.46 kg), which was held firmly on the shoulders (Figure 2). The force platform sampled force during the jump at 500 Hz. Jump height was recorded from the peak height of the jump relative to the standing position. The downward distance of the countermovement (dip) was recorded from the bar displacement because this aspect of technique was not standardized or controlled. The peak power, peak velocity, and peak force were all determined from the concentric phase of the jump, and these variables have been shown to have good test and retest reliability with previously reported intraclass correlation coefficients between 0.77 and 0.89 (16). Peak power was also expressed relative to body mass because this measure has been shown to be more strongly correlated to sprint performance than absolute peak power (18).

Statistical Analyses

To compare JS under the 2 instruction conditions, paired *t*-tests were performed. The differences between the means in the instructions were also described with percentages and effect size statistics using descriptors of 0–0.19 = "trivial," 0.2–0.59 = "small," 0.6–1.19 = "moderate," 1.2–1.99 = "large," and 2.0–4.0 = "very large" (7). Pearson's correlations were performed to determine the relationships between JS variables and sprint performance, and the strength of the correlation was described as r = 0–0.09 = "trivial," 0.10–0.29 = "small," 0.30–0.49 = "moderate," 0.50–0.69 = "large," and 0.70–0.90 = "very large" (7). The Statistical Package for the Social Sciences (version 19; SPSS, Inc., Chicago, IL, USA) was used to perform the statistical tests, and the significance was set at $p \leq 0.05$.

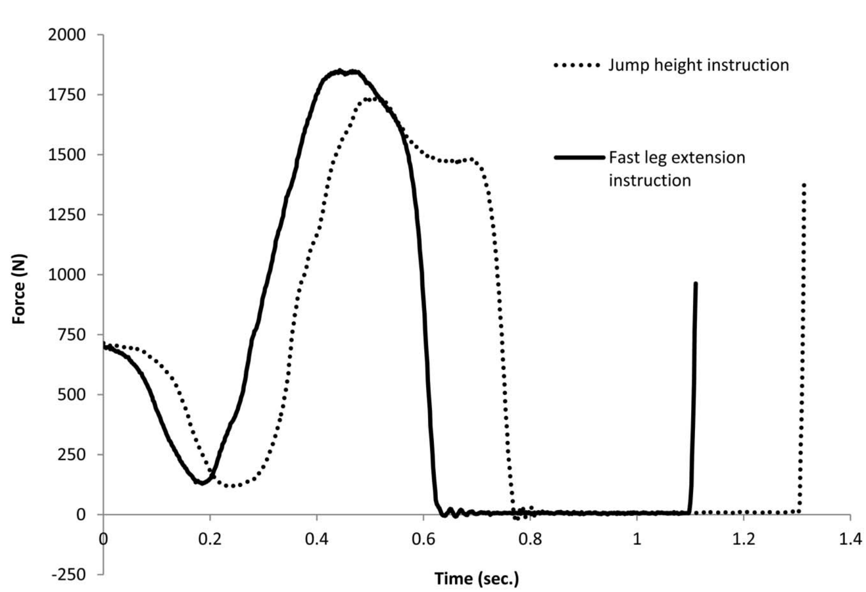

Figure 3. Example of force-times curves for a representative subject.

Results

The mean ± *SD* sprint times were 1.92 ± 0.07 seconds, 3.22 ± 0.13 seconds, and 1.30 ± 0.07 seconds for time 10 m, 20 m, and the 10–20 m, respectively. The descriptive results and statistical comparisons for the 2 instruction conditions are shown in Table 1. The height instruction produced a greater ($p < 0.05$) mean jump height, peak velocity, and downward countermovement distance than the JS performed with the fast leg extension instruction. Conversely, the fast leg extension instruction yielded a greater ($p < 0.05$) peak force (3.7%) compared with the height instruction. There was a trivial difference between the instructions for peak power and relative peak power ($p > 0.05$). The correlations between the JS variables and the sprint test variables are shown in Table 2. The only large and statistically significant relationship was for jump height and 10–20 m time ($r = -0.517$ and -0.545 for height and fast leg extension instructions, respectively). The correlation between 10-m time and 10- to 20-m time was $r = 0.585$, which represents 34% common variance.

The difference in force-time curves during JS between the 2 instruction conditions for a representative subject is shown in Figure 3. With the fast leg extension instruction, the peak force was greater, but as a result of a smaller downward dip (not indicated on the curves), the total takeoff time (eccentric plus concentric phases) was less, resulting in a lower jump height.

Discussion

This was the first study to evaluate the effect of instructions on the performance of JS variables. The main finding was that there was no statistically significant difference between the JS with different instructions for peak power output ($p > 0.05$), but there were small-to-moderate differences for the other variables ($p < 0.05$). The mean difference in peak power with the 2 instructions was 1–2%. This occurred because although the fast leg extension instruction caused an increase in peak force, it was accompanied by a decrease in velocity. Furthermore, the difference between the instruction conditions was similarly trivial when peak power was expressed relative to body weight. Although this trivial change in peak power suggests that JS performance was insensitive to different instructions, peak power is not the only useful JS variable. Indeed, Hori et al. (9) reported that jump height had a slightly stronger correlation with 20-m sprint performance than relative peak power. This is consistent with the findings in the present study where stronger correlations were found for jump height than peak power or peak power/weight with sprint performance, regardless of the JS instruction. Because jump height was significantly greater with the jump height instruction ($p = 0.003$), it can be concluded that instructions have a meaningful influence on JS performance, at least as the JS relates to sprinting.

The fast leg extension instruction produced a 3.7% greater peak force production compared with the jump height instruction, and this was accompanied by 7.4 cm (13.5%) smaller mean downward countermovement. This suggests that the concentric phase of the jump would have commenced from slightly greater hip and knee angles. It is likely that these larger joint angles explain the greater peak force produced because of a more favorable length-tension relationship for the hip and knee extensor muscles. The fast leg extension instruction produced a decreased jump height, and this is consistent with the reduced horizontal distance produced during a standing long jump under a similar instruction (15). If the fast leg extension causes a reduced countermovement distance and takeoff time, a smaller impulse and velocity at the instant of takeoff can be expected, resulting in a smaller jump distance (vertically or horizontally).

In the present study, the relationships between peak force in the JS and sprint performance were trivial to small (Table 2). However, previous research has shown peak force to correlate strongly ($r = -0.70$; $p < 0.05$) with 10-m time (10) and 2.5-m time from a block start ($r = -0.86$; $p < 0.05$) (20). Therefore, it remains unclear which JS variables are most related to sprint performance. This ambiguity is likely to be related to various factors, including the instructions for the JS, different JS protocols and equipment used, the athletic sample tested, and the speed qualities assessed in sprint testing. Additionally, executing multiple sets of JS and only between 2 and 3 sprint attempts, where a third sprint attempt was made only if the second was faster than the first, may have impacted these results.

The findings of this study should provide impetus for future research to evaluate the aspects not examined in this study. Because an in-depth biomechanical analysis of the JS associated with the 2 instructions was not conducted, it is not possible to explain how participants interpreted the instructions and modified their technique. A comprehensive analysis of JS technique, including a more in-depth analysis of the force-time curve using different instructions would be valuable for future research. Inclusion of muscle activation patterns via electromyography may also be useful. Additionally, recent research by Nibali et al. (14) has highlighted that the assessment of the eccentric phase of a JS may provide valuable insight into explosive leg muscle function. The current investigation did not analyze these variables; however, future research could focus on how the eccentric phase of JS is influenced by specific instructions. Furthermore, because only 2 instructions were compared in the present study, it would be worthwhile assessing other instructions that could potentially affect power output. For example, an instruction to jump for maximum height *and* a fast leg extension could yield greater power output because these instructions would seem to maximize peak velocity and peak force, respectively. Our study used a limited number of JS variables and was only performed with body weight as the resistance to the jumps. Therefore, future research could use other JS variables and aim to determine if the differences between the instructions remain when JS are performed with additional loads or unloaded conditions (less than body weight).

Practical Applications

The present study demonstrated that jump height, peak velocity, peak force, and the downward dip distance in the JS were all influenced by the instructions provided. The first implication is that instructions should be standardized so that comparisons can be made over time when monitoring athletes. If this is not done, it is possible that an athlete may vary the emphasis applied during different jumps, which would be expected to influence JS performance. This, in turn, would potentially influence the strength qualities being assessed.

Based on the correlations with sprint performance, it is not clear which of the 2 instructions is preferred for testing or training athletes who require explosive leg muscles for sprinting. However if it is known that peak velocity with maximum jump height is the main goal, the height instruction would be preferred. Likewise, if peak force in the JS is desired, the fast leg extension instruction would be a better choice. It is not necessary to specify the depth of the dip because this seems to be adjusted naturally according to the instruction provided.

References

1. Cormie, P, McBride, JM, and McCaulley, GO. Validation of power measurement techniques in dynamic lower body resistance exercises. *J Appl Biomech* 23: 103–118, 2007.
2. Cormie, P, McBride, JM, and McCaulley, GO. Power-time, force-time, and velocity-time curve analysis of the countermovement jump: Impact of training. *J Strength Cond Res* 23: 177–186, 2009.
3. Cormie, P, McGuigan, MR, and Newton, RU. Adaptations in athletic performance after ballistic power versus strength training. *Med Sci Sports Exerc* 42: 1582–1598, 2010.
4. Cronin, J and Sleivert, G. Challenges in understanding the influence of maximal power training on improving athletic performance. *Sports Med* 35: 213–234, 2005.
5. Dayne, AM, McBride, JM, Nuzzo, JL, Triplett, T, Skinner, J, and Blurr, A. Power output in the jump squat in adolescent male athletes. *J Strength Cond Res* 25: 585–589, 2011.
6. Dugan, EL, Doyle, TLA, Humphries, B, Hasson, CJ, and Newton, RU. Determining the optimum load for jump squats: A Review of methods and calculations. *J Strength Cond Res* 18: 668–674, 2004.
7. Hopkins, WG. A new view of statistics. 2012. Available at: http://www.sportsci.org/resource/stats/index.html. Accessed February 7, 2013.
8. Hori, N, Newton, RU, Andrews, WA, Kawamori, N, McGuigan, MR, and Nosaka, K. Comparison of four different methods to measure power output during the hang power clean and the weighted jump squat. *J Strength Cond Res* 21: 314–320, 2007.
9. Hori, N, Newton, RU, Andrews, WA, Kawamori, N, McGuigan, MR, and Nosaka, K. Does performance of hang power clean differentiate performance of jumping, sprinting, and changing of direction? *J Strength Cond Res* 22: 412–418, 2008.
10. Mauler, PS, Bradshaw, EJ, and Keogh, J. Jump kinetic determinants of sprint acceleration performance from starting blocks in male sprinters. *J Sports Sci Med* 5: 359–366, 2006.
11. Markovic, G, Dizdar, D, Jurik, I, and Cardinale, M. Reliability and factorial validity of squat and countermovement jump tests. *J Strength Cond Res* 18: 551–555, 2004.
12. McBride, JM, Triplett-McBride, T, Davie, A, and Newton, RU. The effect of heavy- Vs light-load jump squats on the development of strength, power, and speed. *J Strength Cond Res* 16: 75–82, 2002.
13. McGuigan, MR, Cormack, S, and Newton, RU. Long-term power performance of elite Australian Rules football players. *J Strength Cond Res* 23: 26–32, 2009.
14. Nibali, ML, Chapman, DW, RObergs, RA, and Drinkwater, EJ. Validation of jump squats as a practical measure of post-activation potentiation. *Appl Physiol Nutr Metab* 38: 306–313, 2013.
15. Porter, JM, Anton, PM, Wikoff, NM, and Ostrowski, JB. Instructing skilled athletes to focus their attention externally at greater distances enhances jumping performance. *J Strength Cond Res* 27: 2073–2078, 2013.
16. Sheppard, JM, Cormack, S, Taylor, K, McGuigan, MR, and Newton, RU. Assessing the force-velocity characteristics of the leg extensors in well-trained athletes: The incremental load power profile. *J Strength Cond Res* 22: 1320–1326, 2008.
17. Sheppard, J, Hobson, S, Barker, M, Taylor, K, Chapman, D, McGuigan, M, and Newton, R. The effect of training with accentuated eccentric load counter-movement jumps on strength and power characteristics of high-performance volleyball players. *Int J Sports Sci Coach* 3: 355–363, 2008.
18. Young, W, Cormack, S, and Crichton, M. Which jump variables should be used to assess explosive leg muscle function? *Int J Sports Physiol Perform* 6: 51–57, 2011.
19. Young, WB, Pryor, JF, and Wilson, GJ. Effect of instructions on characteristics of countermovement and drop jump performance. *J Strength Cond Res* 9: 232–236, 1995.
20. Young, W, McLean, B, and Ardagna, J. Relationship between strength qualities and sprinting performance. *J Sports Med Phys Fitness* 35: 13–19, 1995.