Could the Deep Squat Jump Predict Weightlifting Performance?

Francisco J. Vizcaya, Oscar Viana, Miguel Fernandez del Olmo, and Rafael Martin Acero

Department of Physical Education and Sports, Faculty of Sport Sciences and Physical Education, University of A Coruña, A Coruña, Spain

Abstract

Vizcaya, FJ, Viana, O, Fernandez del Olmo, M, and Martin Acero, R. Could the deep squat jump predict weightlifting performance? *J Strength Cond Res* 23(3): 729–734, 2009—This research was carried out with the aim of describing the deep squat jump (DSJ) and comparing it with the squat (SJ) and countermovement (CMJ) jumps, to introduce it as a strength testing tool in the monitoring and control of training in strength and power sports. Forty-eight male subjects (21 weightlifters, 12 triathletes, and 15 physical education students) performed 3 trials of DSJ, SJ, and CMJ with a 1-minute rest among them. For the weightlifters, snatch and clean and jerk results during the Spanish Championship 2004 and the 35th EU Championships 2007 were collected to study the relationship among vertical jumps and weightlifters' performance. A 1-way analysis of variance (ANOVA) showed significant differences between groups in the vertical jumps, with the highest jumps for the weightlifters and the lowest for the triathletes. An ANOVA for repeated measures (type of jump) showed better results for DSJ and CMJ than SJ in all groups. A linear regression analysis was performed to determine the association between weightlifting and vertical jump performances. Correlations among the weightlifting performance and the vertical jumps were also calculated and determined using Pearson *r*. Results have shown that both CMJ and DSJ are strongly correlated with weightlifting ability. Therefore, both measures can be useful for coaches as a strength testing tool in the monitoring and control of training in weightlifting.

Key Words vertical jumps, strength, power

Introduction

Vertical jumps have been widely studied in biomechanics or physiology to know the variables responsible for their performance. It is considered that the maximum vertical jump depends on mechanical, coordination, and neural factors (1), and the height reached is determined by the vertical speed during the impulse (4), which is influenced by the maximal muscle force and the acceleration distance of the kinematic chain (31).

Muscle fiber-type characteristics are among the factors that influence the ability to perform short-term or endurance exercise (2,3,8,18,30). Athletes with a high percentage of fast fibers and a greater fiber size are more successful in strength sports than those with more slow and smaller fibers (8,9,30,32) because they can generate a higher power and, therefore, can jump higher. On the contrary, endurance athletes can even show worse performance than untrained subjects in vertical jumping (23,32).

In many sport conditions, concentric and isometric or eccentric contractions are combined. Therefore, many vertical jump tests under different conditions were developed, such as the squat jump (SJ), the countermovement jump (CMJ), or jumps in which the intensity is increased with additional loads (14,34), jumping down from a height and after landing performing a maximal jump, also known as drop jump (DJ), or artificially reducing the body weight (13).

Apart from this, when testing or coaching highly trained athletes, it is essential that the mode of testing and coaching are carefully matched to the sport or type of activity that the athlete usually performs (2,12,21,27,33). However, the vertical jump tests described in most studies were executed with a half or even a very small knee flexion, which implies a demand of the hip and knee muscles that are not specific in sports such as weightlifting.

Although the deep squat jump (DSJ) without countermovement is a common exercise in sport training because of its importance in power development (28), it is rarely used as a performance test. There is, however, some research using squat jumps with a greater knee flexion than the traditional 90° (7,16,25,35), but without reaching the full-squatting position. Thus, this research was carried out with a double purpose: to describe and compare the DSJ with the SJ and CMJ jumps, and to evaluate the DSJ as a useful testing tool to predict performance in strength and power sport athletes such as weightlifters.

Methods

Experimental Approach to the Problem

To determine whether the DSJ could be used as a strength training tool in the monitoring and control of training in

Address correspondence to Rafael Martin Acero, maracero@udc.es.

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TABLE 1. Mean ages and body mass measures.

	N	Age	Body mass
Weightlifting	21	22.27 ± 4.22	71.29 ± 16.21
Triathlon	12	26.83 ± 5.97	70.41 ± 5.58
Control	15	21.20 ± 1.52	72.60 ± 6.41

strength and power sports, 3 groups from very different sporting activities (strength, endurance, and a control group) were compared to find whether there are differences among groups and vertical jumps. The relationship between the DSJ and the sport performance in the strength group would then be evaluated.

Subjects

Forty-eight male subjects participated in the study and were divided into 3 groups, depending on their sporting activity: weightlifters ($n = 21$), triathletes ($n = 12$), and a control group of physical education students ($n = 15$). The weightlifters and triathletes were elite athletes who took part in international meetings. The students had a mixed training background. All subjects were familiarized with the research procedures and gave their informed consent. The experimental procedure was approved by the local ethics committee of the University of A Coruña.

The mean ages and body mass measures for the participants are shown in Table 1.

Procedures

In the first session, the subjects were familiarized with the different vertical jumps (DSJ, SJ, and CMJ). In this session, the subjects received instructions to correctly perform the jumps, and then they performed several trials of each jump.

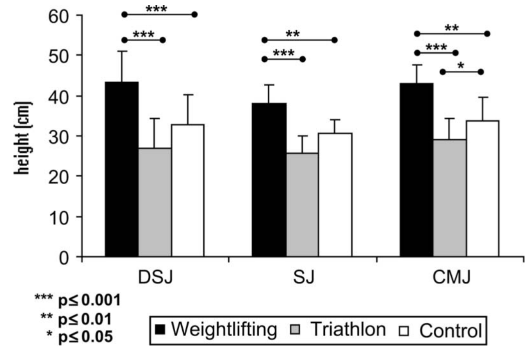

Figure 1. Vertical jump differences between groups.

In the test session, after a standard warm-up, the subjects performed 3 trials of DSJ, SJ, and CMJ, with 1 minute of recovery between jumps. A total of 9 jumps were recorded for each subject using a resistive (capacitative) platform (4) connected to a digital timer (accuracy = +0.001 seconds; ErgoJump, Psion XP, MA.GI.CA, Rome, Italy). For the performance of the DSJ test, subjects were asked to stand on the center of the platform in a full-squatting position, with their feet shoulder-width apart and their toes pointed forward or slightly outward. Participants performed the DSJ without any countermovement after keeping the full-squatting position for 3–4 seconds, to avoid taking advantage of elastic energy storage (24). For the SJ, the procedure was similar to the DSJ but with an initial position of semisquat (both knees at 90°). In the performance of CMJ, subjects were instructed to start in an upright position, rapidly squat down, and then jump into the air with maximal effort. During the CMJ, the angular displacement of the knee was standardized so that the subjects were required to bend their knees to approximately 90°. All jumps were performed with hands on the

TABLE 2. Vertical jump descriptive data.

		N	Mean	*SD*
DSJ	Weightlifters	21	43.38	7.70
	Triathletes	12	26.93	4.62
	Control	15	32.63	4.77
SJ	Weightlifters	21	38.07	7.51
	Triathletes	12	25.74	4.36
	Control	15	30.50	5.23
CMJ	Weightlifters	21	43.00	7.65
	Triathletes	12	29.19	3.44
	Control	15	33.76	5.73

DSJ = deep squat jump; SJ = squat jump; CMJ = countermovement jump.

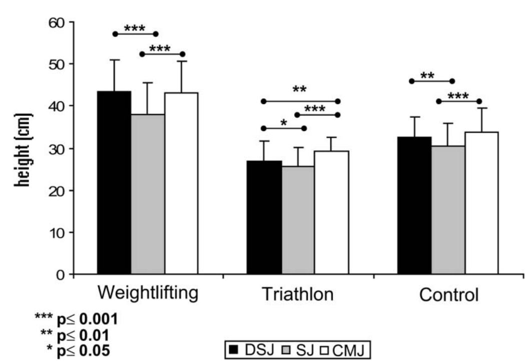

Figure 2. Vertical jump differences within groups.

Table 3. Weightlifters' descriptive data.

	N	Mean	*SD*
Snatch	21	97.19	27.44
Clean and jerk	20	119.42	30.96
Actual total	20	216.22	57.48
Sinclair total	20	287.74	58.88
DSJ	21	43.38	7.70
SJ	21	38.07	7.51
CMJ	21	43.00	7.65

DSJ = deep squat jump; SJ = squat jump; CMJ = countermovement jump.

hips to eliminate the effect of arm swing during the performance of each jump.

It should be highlighted that data from weightlifters were collected after participating in the Spanish Championship 2004 and in the 35th EU Championships 2007, where snatch and clean and jerk results were also registered, to study the relationship between the jumps and the weightlifters' performance. Moreover, although it has been criticized (20), the weightlifters' performance was adjusted for their body weight using the Sinclair equation. This equation was officially approved by the International Weightlifting Federation to answer the question, "What would be the total of an athlete weighing x kilograms if he or she were an athlete in the heaviest class of the same level of ability?" In the 35th EU Championships, 1 weightlifter could not lift the clean and jerk in any of his attempts. Triathletes and the control group were tested only in vertical jumps, and their data were collected in separate sessions.

Statistical Analyses

The recorded jump heights (cm) were analyzed by a 1-way analysis of variance (ANOVA), with 1 intergroup factor of 3 levels (weightlifting, triathlon, and control). In case of a significant *F* ratio, multiple comparisons were made with the Tukey post hoc test or with the Games-Howell test when the assumption of the homogeneity of the variance with the Levene statistic was violated. A general linear model for repeated measures was used to evaluate the differences in mean values among the vertical jump types. Linear regression analysis was performed to know the association of the weightlifting and vertical jump performances and to evaluate the R^2 to determine the portion of explained variation. Tests for multicollinearity, homocedasticity, normality, independence, and influential data points showed that the assumptions of regression had been met. Correlations among the weightlifting performance and the vertical jumps were also calculated and determined using Pearson *r*.

Statistical significance was set at $p \leq 0.05$ for all analyses.

Results

Subjects' vertical jump descriptive data are shown in Table 2, and statistical differences between groups are shown in Figure 1.

The ANOVA *F* ratio was significant ($p < 0.05$), and the assumption of the homogeneity of the variance with the Levene statistic was met in DSJ (Levene statistic = 2548, $p > 0.05$) and SJ (Levene statistic = 1806, $p > 0.05$) but not in CMJ (Levene statistic = 5474, $p < 0.05$). A Tukey post hoc test showed statistically significant differences between weightlifters and triathletes and between weightlifters and control subjects, both in DSJ (weightlifting-triathlon, mean difference = 16.447, $p < 0.001$; weightlifting-control, mean difference = 10.741, $p < 0.001$) and in SJ (weightlifting-triathlon, mean difference = 12.335, $p < 0.001$; weightlifting-control, mean difference = 7.571, $p < 0.01$). However, there were no statistically significant differences between triathletes and control subjects in DSJ and SJ. A Games-Howell test showed statistically significant differences among all groups in CMJ (weightlifting-triathlon, mean difference = 13.807, $p < 0.001$; weightlifting-control,

Table 4. Pearson correlations among performance variables of weightlifters.

	Snatch	Clean and jerk	Actual total	Sinclair total	DSJ	SJ	CMJ
Snatch	1	0.988*	0.997*	0.854*	0.751*	0.693*	0.753*
Clean and jerk	0.988*	1	0.997*	0.871*	0.782*	0.727*	0.789*
Actual total	0.997*	0.997*	1	0.865*	0.769*	0.714*	0.780*
Sinclair total	0.854*	0.871*	0.865*	1	0.825*	0.663*	0.750*
DSJ	0.751*	0.782*	0.769*	0.825*	1	0.897*	0.908*
SJ	0.693*	0.727*	0.714*	0.663*	0.897*	1	0.931*
CMJ	0.753*	0.789*	0.780*	0.750*	0.908*	0.931*	1

DSJ = deep squat jump; SJ = squat jump; CMJ = countermovement jump.
*$p < 0.01$.

TABLE 5. Weightlifting predicting models.

Lift	Predicting variables	Coefficients	R^2	p
Snatch	CMJ	−18.946 + CMJ × 2.701	0.567	0.000
Clean and jerk	CMJ	−18.072 + CMJ × 3.231	0.622	0.000
Actual total	CMJ	−42.373 + CMJ × 6.077	0.609	0.000
Sinclair total	DSJ	27.420 + DSJ × 6.013	0.681	0.000

DSJ = deep squat jump; CMJ = countermovement jump.

mean difference = 9.243, $p < 0.01$; control-triathlon, mean difference = 4.563, $p < 0.05$).

The analysis of the vertical jumps in each group showed the following results (Figure 2): in the weightlifter group, there were significant differences between DSJ and SJ (mean difference = 6.413, $p < 0.001$) and between SJ and CMJ (mean difference = 5.856, $p < 0.001$). Similar results were found in the control group, showing significant differences between DSJ and SJ (mean difference = 2.027, $p < 0.01$) and between SJ and CMJ (mean difference = 3.307, $p < 0.001$). In the triathlon group there were significant differences among all the vertical jumps, DSJ-SJ (mean difference = 1.017, $p < 0.05$), DSJ-CMJ (mean difference = 2.067, $p < 0.01$), and SJ-CMJ (mean difference = 3.083, $p < 0.001$).

Weightlifters' descriptive data for the snatch, clean and jerk, actual total, Sinclair total, and vertical jump performances are listed in Table 3.

Correlations among variables are shown in Table 4. Both CMJ and DSJ have a very strong and significant correlation with weightlifting performance, but, again, when subjects' body weight is taken into account, the correlation is stronger with DSJ than with CMJ.

Different models could explain weightlifting performance with just 1 vertical jump type (see Table 5), but when subjects' body weight is taken into account (Sinclair total), predicting variables change and the performance-predicting models include a different vertical jump type (either CMJ or DSJ).

DISCUSSION

In this study, we have shown that both DSJ and SJ could be used as strength training tools in weightlifting, because both were strongly correlated with Olympic lifts and could predict weightlifting performance.

As stated before, jump height is conditioned by the subject's vertical speed during the impulse, which is influenced by the muscle maximal force and the acceleration distance of the kinematic chain. This optimal acceleration distance will be determined by the subject's neuromuscular characteristics (21). Therefore, athletes from very different sporting activities (29), with different muscle fiber-type characteristics (2,3,8,18,30) and different training programs, could affect the vertical jump performance (15). In this regard, Kraemer et al. (22) have shown changes in muscle fiber areas as a result of different training programs. In this study, high-intensity endurance training led to a decrease of muscle type I fibers, but not in a high-intensity strength training group. This could explain why the triathletes had a lower vertical jump performance in comparison with the weightlifters. However, the triathletes also had a lower performance than the control subjects with a mixed training background. As 1 possible explanation for this finding, it has been reported that a combination of strength and endurance training results in an attenuation of the performance improvements and physiological adaptations typical of single-mode training (22).

In our study, the weightlifters were the best vertical jump performers. Their highest jump was DSJ, whereas the best vertical jump of triathletes and control subjects was CMJ. The increase in jump height in CMJ compared with SJ has been attributed to the longer duration of the CMJ (1), and it has been suggested that increasing the depth of squats should have a similar effect as a CMJ and, thus, should result in higher jumps (7).

Our results show that elite weightlifters take advantage of the longer acceleration distance of the kinematic chain in DSJ to jump even higher than a CMJ. On the contrary, triathletes and control subjects could only use this longer acceleration distance during DSJ to jump higher than the SJ but not more than the CMJ. Triathletes seem to take more advantage of the factors involved in producing strength in CMJ.

In contrast with other studies (7), our results show a higher height for the DSJ than for the SJ for all groups evaluated. This discrepancy could be explained by the fact that, in the study of Domire and Challis (7), the DSJ was performed with a knee flexion over 93.8°, compared with the 120–130° used in our study.

As we reported previously, there were statistically significant differences between weightlifters and triathletes and between weightlifters and control subjects in DSJ, but there were no differences between triathletes and control subjects. Furthermore, there were statistically significant differences among the vertical jump types in weightlifters. Thus, DSJ can be used as a strength training tool in the monitoring and control of training in weightlifting, because the mode of testing is carefully matched to the sport that the athlete usually performs. Moreover, empirical observations and research suggest that there is a strong relationship between weightlifting lifts and vertical jumps (5,6,11,12,19).

The analysis of the association of weightlifting and vertical jump performance shows that, depending on the type of lift, weightlifting performance could be explained with 1 type of vertical jump. This association already has been reported in the literature using regression analysis (10), showing that a vertical jump could explain 22.78% of the variance of weightlifting performance. In our study, the CMJ was the vertical jump that best predicted weightlifting performance. It could predict 56.7% of the variance of the snatch performance, 62.2% of the clean and jerk performance, and 60.9% of the actual total performance. However, if body weight were taken into account, as in the Sinclair total, weightlifting performance could be estimated with DSJ, which could explain 68.1% of the variance of the Sinclair total performance. This may be because of the similar correlations that exist between CMJ and DSJ, particularly in the snatch and the clean and jerk, and it could explain why the prediction model, to avoid multicollinearity, chose either CMJ or DSJ, because both vertical jumps have a similar correlation with the weightlifting lifts. Thus, in Sinclair total, the correlation is stronger with DSJ, and obviously it is the predicting variable.

It may be argued that, because the snatch and the clean and jerk start from a static position, a static vertical jump (DSJ or SJ) might correlate better with weightlifting performance (6), but the rebounding of the knees may be analogous to the countermovement (6), and thus CMJ correlated with Olympic lifts (14). However, both CMJ and DSJ are strongly correlated with weightlifting ability and could predict its performance. Therefore, both can be introduced as a strength testing tool in the monitoring and control of training in weightlifting, because 1 method does not have a major advantage over the other.

Practical Applications

Both CMJ and DSJ can be introduced as a strength test in the monitoring and control of training in weightlifting, because they are carefully matched to the sport and are strongly correlated with Olympic lifts. These vertical jumps are quick, easy, and low-cost tests, which are not very demanding physiologically and psychologically, and, therefore, without lifting a 1-repetition maximum and with the formulas given, coaches could determine the performance of their athletes. This predicting application could help coaches in competitions, because they could have an approximate idea of how much an athlete could lift and, thus, follow a very specific strategy with his or her attempts. As a monitoring and controlling training method, vertical jumps could give hints to coaches about the training effects, and, hence, they could make load adjustments to improve an athlete's training. Finally, another very practical application would be the talent identification approach of CMJ and DSJ. They could be used, alone or in addition to other tests, as part of a discriminant analysis, to search for young athletes who have a gift for weightlifting.

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