Title: The reliability of the squat jump force-velocity and load-velocity profiles

Running Head: Vertical jump force-velocity and load-velocity

ABSTRACT

The purpose of this study was to investigate the between-session reliability of the squat jump force-velocity (FV) and load-velocity (LV) profiles. Eighteen subjects (age = 28.1 ± 4.8 years; height = 1.7± 9.7; mass = 74.7 ± 12.8) who could back squat >1.5 times body mass participated in this study. Each subject completed a familiarization session followed by two experimental sessions each separated by 72 hours. Subjects performed a series of squat jumps on a force plate against external loads between 0 and 100% of their body mass in a quasi-randomized block order. Intraclass correlation coefficient (ICC) and coefficient of variation (CV) were used to examine the between-session reliability. Peak (PV) and mean velocity (MV) at each load were highly reliable (ICC >0.80, CV% <7.41, SEM <0.13 m/s, SDD <0.31 m/s, ES <0.21). FV profiles created with peak force and relative peak force resulted in poor to excellent reliability (ICC = 0.34-0.92, CV% = 11.9-26.3). When mean and relative mean force were used to create FV profiles there was poor to good reliability (ICC = 0.03-0.85, CV% = 18.1-39.4). When the LV profile was calculated with PV (ICC = 0.60-0.90, CV% = 7.9-16.9) or MV (ICC = 0.49-0.91, CV% = 11.1-23.4) there was poor to excellent reliability. There was no time effect found between sessions for both FV and LV profiles. The squat jumps FV and LV profiles established with a force plate are not reliable. Therefore, these profiles are not recommended to be used to inform programming decisions.

Key Words: Maximum strength, vertical jumping, performance assessment, force generation capacity.

INTRODUCTION

When attempting to improve force-generating capacity, athletes perform resistance training that is designed to target the development of muscular strength and an increase in movement velocity (17, 32). A critical factor to consider when constructing targeted training plans is that appropriate training loads are prescribed (32). Typically, training loads are manipulated by altering the training intensity, volume, exercise order, or exercise sequences in order to target specific training outcomes and maximize the athlete's performance (32).

One method of manipulating resistance training load that has recently gained in popularity is to create a force-velocity (FV) profile that is used to guide programming decisions (28). With this method the FV profile is used to direct the training focus for a given athlete by determining whether the athlete is force or velocity deficient during jumping tasks (17, 28). If the athlete's FV profile indicates a force deficit then their theoretical maximum force (F_0) would be lower, and they would not be able to generate adequate force at higher loads (17). Conversely, if the FV profile displays a velocity deficit, the athlete will have a lower theoretical maximum velocity (V_0) which would indicate that they are not able to generate high forces with lighter loads (17). It has been suggested that by targeting these deficits with specific resistance training interventions, an athlete can improve their force-generating capacity across the entire FV spectrum in a more precise manner, which has been hypothesized to result in greater improvements in sports performance (17). Previous studies have reported that an eight-to-nine-week individualized resistance training program based on the deficit determined with the FV profile resulted in a more 'balanced' FV profile and an enhanced vertical jump performance (17, 29). While previous studies suggest the efficacy of implementing training focus based upon the FV profile (17, 29) , it is important to consider the reliability of the FV profile between sessions. If the FV profile is not reliable, then the use of the profile to guide training may not result in the intended outcome(s) and may result in training interventions that are not accurately aligned with the athlete's actual deficit.

Another method of manipulating resistance training load is to create a load-velocity (LV) profile that can be used to determine the load and velocity relationships that can be used to modify resistance training on a repetition-by-repetition basis (35). As there is an inverse relationship between the load lifted and movement velocity during resistance exercise, a simple linear regression analysis can be used to calculate the theoretical maximum load at zero velocity (L_0) and the theoretical maximal velocity (V_0) (16). Once this has been accomplished, an individualized LV profile can be created (16). Although this method has been suggested to be an effective tool for prescribing resistance training load (11), to our knowledge, the reliability of the LV profile during a squat jump (SJ) has yet to be thoroughly established. As such, it is important to establish the reliability of this profile in order to ensure that training loads are prescribed accurately when employing velocity-based training methods.

Therefore, the purpose of this study was to investigate the between sessions reliability of the FV and LV profiles. We hypothesized that there would be no difference in the FV and LV profiles between sessions and that these profiles would be reliable.

METHODS

Experimental Approach to the Problem

All subjects participated in one familiarization and two experimental sessions, each separated by 72 hours. Anthropometric data (height, body mass), SJ starting position and self-selected feet width were determined and recorded in the familiarization session. Once these data were recorded, back squat one-repetition maximum (1RM) was assessed, followed by the familiarization of the SJ protocol with light to heavy loads. In the experimental sessions, a series of SJs were performed in order to determine the reliability and stability of peak velocity (PV), peak force (PF), mean velocity (MV), and mean force (MF) in developing the FV and LV profiles across 0% to 100% of body mass (BM) loads. To determine SJ performance, all subjects performed a series of SJs in a quasi-randomized block order. In each block, all subjects performed two repetitions of the SJ against the given external loads in a randomized order. Subjects returned to the laboratory 72 hours after first experimental session to repeat the experimental protocol, allowing for the determination of between-session reliability of PV and MV, as well as the stability of the FV and LV profiles.

Subjects

Eighteen subjects (n = 3 females, 15 males; age = 28.1 ± 4.8 years; height = 1.7± 9.7 m; mass = 74.7 ± 12.8; back squat 1RM = 1.8 ± 0.3 $kg \cdot kg^{-1}$, unloaded vertical jump height = 0.34 ± 0.09 m) participated in this study. All subjects read and signed an informed consent form prior to participating in this study in accordance with Edith Cowan University Human Research Ethics Committee guidelines (Project 20335). All subjects were healthy and had no current lower body injuries that would impact their ability to perform squatting and jumping movements. All subjects were required to be able to back squat a minimum of 1.5x body mass and were screened for strength training background with standard questionnaires. Additionally, all subjects were asked to refrain from any lower body strenuous exercises for 72 hours prior to all testing sessions. Finally, subjects were required to wear the same footwear in both familiarization and experimental sessions.

Procedures

Data Acquisition

In the familiarization session, subjects randomly performed a series of SJs with one randomly selected load from each of the four loading blocks used in this study: 1) 0%, 10%, 20%, 2) 30%, 40%, 50%, 3) 60%, 70%, 80%, and 4) 90%, 100% of BM. Before performing the SJ each subject's starting position and back squat depth knee-angle were measured using a hand-held goniometer (Exacta Goniometer, California, USA). Additionally, the self-selected SJ foot width was recorded with a 5 cm intersected grid on the force plate, so that it could be maintained during each testing session (33). All subjects were allowed to use a weightlifting-belt during the back squat 1RM and SJ and this was kept consistent for the following testing sessions. All subjects performed a 10-15 minute self-selected dynamic warm-up which was recorded and kept consistent through the remaining testing sessions, followed by the free weight (Eleiko, Halmstad, Sweden) back squat 1RM protocol based upon the procedures of Banyard et al. (1). All subjects were required to squat down to a 90° knee-angle and then stand up with the barbell without pausing. To ensure the required depth was attained during each 1RM attempt, subjects squatted to an elastic cord attached to the squat rack in the position established during the familiarization session (31).

During the experimental testing sessions, subjects performed a series of SJs from Block 1 to Block 4; 1) 0%, 10%, 20%, 2) 30%, 40%, 50%, 3) 60%, 70%, 80%, and 4) 90%, 100% of BM. In each block, subjects performed two SJs against the given external loads in a randomized order. One minute of rest was allocated between repetitions, while two minutes were allocated between loading conditions. All subjects were required to place the barbell across their shoulders and adopt the same foot placement as during the back squat 1RM. A carbon fiber pole (0.5kg) was used at 0% of BM in order to standardize the movement across loading conditions. A 5-kg and 20-kg free-weight barbell were used for loads >10% of BM to adjust loads for each individual. They were instructed to squat down to an elastic cord at the previously determined 90º knee angle. This position was held for at least two seconds to remove the influence of the stretch-shortening cycle. Subjects were then instructed to jump as high as possible after a countdown of "3, *2, 1, Jump*". Repetitions were repeated if the investigator observed the barbell or carbon fiber pole leaving the subject's shoulders or if a visually obvious countermovement prior to initiation of the propulsive phase was present during real-time observation of the force trace (24). On average, a total of three jumps were performed at each load tested. All trials were performed in a custom-designed power rack while standing on an in-ground force plate (AMTI BP6001200, MA, USA). As per standard operating procedures in our laboratory, the force plate was calibrated before all testing sessions. Vertical ground reaction forces were collected at 2000 Hz through a BNC-2090 interface box with an analog-to-digital card (NI-6014; National Instruments, Austin, TX, USA).

Data Analysis

All unfiltered force-time data were analyzed using a custom Excel spreadsheet (Microsoft, Redmond, WA, USA). The start of the jump was identified as the point at which force exceeded 5 SDs of body weight calculated during a one second period of 'standing quiet'. Take-off was identified using a three step process: 1) the first force value less than 10 N and the next force value greater than 10N were identified; 2) the center of the flight phase was determined as 30 ms after and before the points identified in step 1; and 3) take-off was then determined as the mean of the flight phase force + 5 standard deviations (21). System center of mass velocity was calculated by dividing net force by system mass (body mass + external barbell mass) on a sample-by-sample basis and then integrating the product with respect to time using the trapezoid rule and an initial velocity of 0 m/s (22). The concentric phase was defined as the portion of the force-time curve between the start of the jump and take-off. MV was defined as the average velocity and PV as the highest instantaneous velocity during the concentric phase, respectively (21). The trial at each load with the highest PV calculated from force plate data at each load were used for subsequent analyses (20).

To determine the FV profile, a linear regression was calculated using a custom Excel spreadsheet (Microsoft, Redmond, Washington) to assess the relationship between velocity of the system's center of mass and force generated with each % of BM load to determine FV profiles using both absolute force (N) and relative forces ($N \cdot kg^{-1}$: absolute force divided by body mass) (17, 26, 28). FV profiles were created with both PF and MF. LV profiles were also calculated from each % of BM and velocity (23). Additionally, both the PV and MV were used to create LV profiles.

Statistical analyses

The Shapiro-Wilk test was used to access the normality of the sampled data. To determine the between-session reliability of the velocity (PV, MV) at each % of BM load and for the FV and LV profiles, the intra-class correlation coefficient (ICC [3,1]) (19) and coefficient of variation (CV) with 95% confidence intervals (CI) were calculated in an Excel spreadsheet (15). ICC 95% CI values were interpreted as poor (< 0.5), moderate (0.5-0.75), good (0.75-0.9) and excellent (> 0.9) reliability (19), while CV values were interpreted as good (<5%), moderate (5-10%), poor (>10%) (5). The smallest detectable difference (SDD) was calculated in a custom spreadsheet to determine the smallest difference that represents a meaningful measurement change in PV and MV between sessions using the equation SDD = $1.96 \times \sqrt{2} \times$ SEM, where SEM is the standard error of the measurement (2). Differences between-sessions in PV and MV were also assessed using separate 2 (time) x 11 (load) repeated measures analysis of variance (ANOVA). Where significant effects were found, post hoc pairwise comparisons with Holm's Sequential Bonferroni corrections were performed (13).

Differences between sessions in parameters calculated from both FV profiles and the LV profiles were assessed using paired t-tests. The alpha level for each test was set at $\alpha = 0.05$. The magnitude of difference in profiles between sessions were estimated by calculating Hedge's *g* effect size statistics (12), which were interpreted as trivial (<0.2), small (0.2-0.6), moderate (>0.6-1.2), large (>1.2-1.99), very large (≥2.0) (14). Statistical analyses were performed in the R programming language (version 4.0.2) (27). Repeated measures ANOVAs were performed using the *afex* package (version 0.28-0) (30). Hedges *g* effect sizes were calculated in a custom script (12), with 95% CIs obtained using the *MBESS* package (version 4.8.0) (18).

RESULTS

When the LV profile was calculated from PV there was a moderate to excellent relative reliability (ICC = 0.83; 95% CI = 0.60-0.93) and a moderate to poor absolute reliability (CV = 10.7; 95% CI =7.9-16.9%). When MV was used to calculate the LV profile, there was a poor to excellent relative reliability (ICC = 0.77; 95% CI = 0.49 - 0.91) and a poor absolute reliability (CV = 15.1; 95% CI = 11.1- 23.4%). There was good to excellent relative reliability and good to moderate absolute reliability for PV at each load tested (Figure 1A-B).

Insert Figure 1 about here

Additionally, when using the PV to create the LV profile there were no significant differences between sessions for the slope (p = 0.642, g = -0.071, 95% CI = -0.583-0.724), the V_0 (p = 0.799, g = 0.019, 95% CI = -0.634-0.672), and the L_0 (p = 0.693, g = -0.058, 95% CI = -0.711-0.596) of the profile (Figure 2A-B).

Insert Figure 2 here

MV at each load resulted in moderate to excellent relative reliability and good to poor absolute reliability (Figure 1C-D). There were no significant time effects for PV and MV between sessions at all loads. Descriptive statistics for PV and MV are presented in Table 1.

Insert Table 1 about here

When using the MV to create the LV profile there were no significant differences between testing sessions for the slope (p = 0.670, g = 0.068, 95% CI = -0.587-0.721), the V_0 (p = 0.308, g = 0.098, 95% CI = -0.556-0.751), and the L_0 (p = 0.725, g = -0.055, 95% CI = -0.708-0.599) of the profile (Figure 2C-D).

When the FV profile was created based upon the PF and PV results, there was moderate to excellent relative reliability (ICC = 0.80; 95% CI = 0.55-0.92) and poor absolute reliability (CV = 16.2; 95% CI = 11.9-26.2%). Additionally, there were no significant differences in the slope (p = 0.282, g = -0.198, 95% CI = -0.852-0.458), V_0 (p = 0.595, g = -0.092, 95% CI = -0.745-0.563), and F_0 (p = 0.595, g = 0.100, 95% CI = -0.555-0.753) (Figure 3A-B) between testing sessions.

Insert Figure 3 here

Additionally, when relative PF and PV were used to create the FV profile there was poor to good relative reliability (ICC = 0.69; 95% CI = 0.34-0.87) and poor absolute reliability (CV = 16.2; 95% CI = 11.9-26.2) was exhibited. When this FV profile was compared between sessions there were no significant differences between the slope (p = 0.279, g = -0.238, 95% CI = -0.893-0.419), V_0 (p = 0.595, g = -0.092, 95% CI = -0.745-0.563) and F_0 (p = 0.380, g = 0.177, 95% CI = -0.479-0.830) (Figure 4A-B).

Insert Figure 4 here

When MF and MV were used to construct the FV profile there was poor to good relative reliability (ICC = 0.62; 95% CI = 0.25-0.85) and poor absolute reliability (CV = 24.8%; 95% CI = 18.1-39.4%). Additionally, there were no significant differences in the slope (p = 0.401, g = -0.166, 95% CI = -0.819-0.490), V_0 (p = 0.696, g = 0.068, 95% CI = -0.587-0.721), and F_0 (p = 0.696, g = 0.110, 95% CI = -0.544-0.763) between testing sessions (Figure 3C-D).

Similarly, when the FV profile was created from relative MF and MV there was poor to moderate relative reliability (ICC = 0.48; 95% CI = 0.03 – 0.77) and poor absolute reliability (CV = 24.8%; 95% CI = 18.1-39.4%) When this FV profile was compared between sessions there were no significant differences between the slope (p = 0.456, g = -0.179, 95% CI = -0.833-0.477), V_0 (p = 0.696, g = 0.068, 95%CI = -0.587-0.721) and F_0 (p = 0.466, g = 0.180, 95% CI = -0.476-0.833) (Figure 4C-D).

DISCUSSION

The purpose of current study was to investigate the between-session reliability of the FV and LV profiles determined with the free-weight SJ. The LV profile was more reliable than the FV profile, while the FV profile calculated with relative force was determined to be the least reliable. Importantly, however, all profiles were unreliable despite there being no significant differences between sessions. This was particularly the case when each profile was calculated using MF and MV, which resulted in the poorest ICC (0.48-0.77) and CV (15.1-24.8) values. Poor absolute reliability (CV = 10.7-16.2) was also noted when PF and PV were used to create both profiles, while using these variables resulted in better relative reliability (ICC = 0.69-0.83). Based upon these findings, FV and LV profiles that are created with the SJ should not be used to guide the focus of a resistance training program. Nor should these profiles be used to define training loads for this exercise.

Currently, there are a limited number of peer reviewed studies that have examined the between-session reliability of a FV profile determined during a SJ (4, 6, 9). In one study, Garcia-Ramos et al. (6) reported that the FV profile determined with a free-weight SJ performed with loads between 17 kg to 75 kg resulted in moderate to good reliability for the F_0, V_0, and slope when calculated with PV (ICC = 0.80-0.88, CV% = 4.2-7.2). When calculated with MV the F_0, V_0, and slope were determined to have good to poor absolute reliability (CV% = 3.8-12.6) (6). Similarly, Cuk et al. (4) reported that when the FV profile was calculated with either PV or MV there was a moderate to excellent reliability for the F_0, V_0, and slope (peak: ICC = 0.86-0.96, CV% = 3.6-9.8). Furthermore, Garcia-Ramos et al. (9) reported that when creating the FV profile with the PF and PV during a free-weight SJ with loads between 0 to 75 kgs there is moderate to good reliability for F_0, V_0, and slope (ICC = 0.74-0.84, CV% = 3.6-8.6). The findings observed in the current study did not agree with those found in these studies as the FV profile determined within the current study displayed poor to moderate reliability when PV and MV were used.

One possible explanation for the differences in the present study and those of Garcia-Ramos et al. (6, 9) and Cuk et al. (4) may be related to the strength level of the populations used in each study. In the current study all subjects were able to squat at least 1.5 x BM. Previously, Cormie et al. (3) has presented data that clearly shows that there are differences in the FV profiles and velocities of movement when comparing stronger (1RM squat >1.55 x BM) and weaker (1RM squat <1.55 x BM) individuals. It is possible that the subjects used by Garcia-Ramos et al. (6, 9) and Cuk et al. (4) were weaker than the subjects in the present study, but this is impossible to confirm as none of these studies have reported maximal lower body strength levels for their subjects. Conceptually, strength would indeed exert a significant impact on the FV profile if absolute loads or percentages of body mass are used to determine the loads used during SJ testing. For example, if an absolute load of 75 kg were used as one of the test loads, someone with a body mass of 80 kg and is able to squat 1.7 times BM would be tested with a SJ performed with 55% of their maximum squat. Conversely, if the same 80kg athlete had a maximum back squat of 80 kg (i.e., 1.0 x BM) they would be required to be tested with a SJ load which would be ~94% of their maximum squat. As it is well documented that the velocity of movement is less reliable the closer one gets to the 1RM (1, 35), it is very likely that different reliabilities may be achieved when comparing studies that use absolute loads, percentages of BM, or percentages of 1RM. As such it is critical that when creating the FV profile, maximal strength levels are determined for each individual tested.

While both the present study and the previous works by Garcia-Ramos et al. (6, 9) examined the use of SJs performed with free-weights, it is possible that the loads used in these studies do not necessarily match each subjects' strength level. For instance, Garcia-Ramos et al. (6, 9) used standardized absolute loads of 0, 17, 30, 45, 60, and 75 kg. Using the previous example, if the two individuals are the same body mass of 80 kg and their maximum strength are different (1.7 x BM, 1.0 x BM respectively), the weaker individual is required to perform SJs with a higher relative intensity at each load compared to the stronger individual. This might hinder assessing the FV profile for both individuals and may not lead an intended training direction.

As such, it is recommended to use relative to BM loads or %1RM loads in order to assess actual individual FV profile.

A second possible explanation for the differences between the present study and the current literature may be related to the different exercise modes used to create each FV profile. The present study utilized a free-weight barbell SJ while the study by Cuk et al. (4) used a rubber band-based pulley machine that employed two long rubber bands to modulate the body mass during the SJ. Specifically, this system allowed the body mass to be reduced to as low as 0.7 x body mass or as high as 1.3 x body mass during the SJ (4). As such the maximum load applied during these jumps was 30% of body mass, which was substantially lower than the majority of loads used in the present study. Due to the fact that the FV profile reported by Cuk et al. (4) was created based upon unloaded and low load conditions it is difficult to compare with the present study where body mass was kept constant and load was added for each jumping condition. Additionally, it might not be unexpected to see higher reliabilities for the FV profiles created with unloaded and low load conditions as the subjects would be performing SJs at substantially lighter loads relative to their maximal strength.

A third possible explanation for the results of the present study and those seen in the studies by Garcia-Ramos et al. (6, 9) may be related to the number of trials used to create the FV profile (7). Based upon the current body of literature it appears that the standard SJ test used to create a FV profile requires between 5 and 8 data points in order to ensure an accurate profile is calculated (6, 9, 17). Conversely, Garcia-Ramos and Jaric (8) suggest that the use of the multiple-point method may be too time consuming and result in excessive fatigue which could impact the results of the FV profile test. Based upon the fact that the FV displays a fairly linear relationship, several authors have recommended the use of significantly less data points (i.e., 2 data points) when creating a FV profile (7, 9). For example, Garcia-Ramos et al. (9) have demonstrated that the FV profile can be accurately and reliably determined with the use of as few as two data points when performed with the SJ. In this study, one low load and one high load (i.e., 0 kg and 75 kg) were used to create the FV profile that produced moderate relative and absolute reliability with the ICC >0.72 and CV% <8.06 for F_0, V_0, and slope of the FV profile. In the present study, the FV profiles were created based upon 11 data points, which is substantially more data points than those presented in previous studies (4, 6) and particularly the two-point method (9). Therefore, it is possible that the reduced reliability of the FV profile in the present study may be a function of accumulated fatigue stimulated by the greater number of jump trials performed negatively impacting the subject's ability to perform the prescribed jumping tasks. While this line of reasoning is plausible, it is important to note that to date there are no known studies which have attempted to examine the two-point methods ability to accurately and reliably estimate the FV profile with the SJ methods utilized in the present study.

While there is some research looking at the FV profile, to our knowledge, there is only one known study that has reported the reliability of the LV relationship during loaded SJs (10). Garcia-Ramos et al. (10) reported the reliability of the LV relationship when calculated from all loads with a Smith Machine SJ across range of loads of 25%, 50%, 75%, and 100% of BM. In this study there was a higher reliability based upon the high ICC (PV: 0.97-0.99, MV: 0.90-0.95) and low CV% (PV: 2.0-2.8, MV:3.9-4.5). While PV and MV were highly reliable there was no data presented examining the reliability of these measures at each load tested, nor where the L_0, V_0, and slope of the LV profile determined. Importantly, due to the fact that Garcia-Ramos et al. (10) utilized a Smith Machine to assess the LV relationship, it is difficult to compare to the results of present study where free-weight SJs were performed. It is possible that the use of free weights enables barbell movement in both horizontally and vertically which may introduce additional error into the measures and while this could be considered a strength of the Smith Machine based research (because horizontal displacements are controlled), its findings can only be applied to those who have access to a Smith Machine (10) .

To our knowledge, the present study is the first study to examine the between-session reliability of the LV profile during a free-weight SJ. While there were no statistically significant differences in the LV profiles in the present study, poor to excellent relative reliability and moderate to poor absolute reliability was determined when using PV and MV to create each profile. Based upon the results of the present study it appears that the LV profile is variable between days. While the LV profiles in the present study were determined in the absence of fatigue, it is possible that the LV profile will shift to a greater extent when fatigue is present. Recent research by Vernon et al. (34) has examined how the LV profile determined during a progressively loaded squat protocol changes at 24, 48, 72, and 96 hours after the completion of a strength (5 sets of 5 repetitions at 80% of 1RM) session. Moderate reductions were observed in the LV profiles created with PV and MV at 24 and 48 hours following the strength-oriented training session, while trivial to small reductions were observed after 72 hours. While the study by Vernon et al. (34) and the present study used different exercise to generate the LV profile, it is clear that these profiles change from day to day and are highly sensitive to fatigue.

When interpreting the reported results, practitioners should consider a number of limitations to this study. The LV and FV profiles were constructed based on an 11-load jumping protocol and therefore the results may have been impacted by fatigue accumulated throughout the testing process, particularly at the heavier loads. Furthermore, although all subjects had previously performed loaded squats jumps as part of their resistance training programs, one familiarization session may not have been sufficient to stabilize the profiles and therefore may have impacted their reliability. Previously, Meylan et al. (25) performed three familiarization sessions prior to testing, however the number of sessions required to stabilize the FV and LV profiles is currently unknown and remains an avenue for future investigation.

PRACTICAL APPLICATIONS

The results of the present study confirm that the FV and LV profiles calculated with PV and MV determined from a force plate during a series of loaded SJs are not reliable between sessions and therefore provide the strength and conditioning professional with only a snapshot of the athlete's performance capacity at a single time-point. Based upon these results, the SJ FV and LV profiles should not be used when attempting to prescribe the training direction and/or load, especially if the athlete is not familiar with performing loaded SJs. If the practitioner does choose to use these profiles to guide training decisions or prescribe training loads significant familiarization with loaded SJs is warranted and a protocol that uses fewer trials to establish these profiles is warranted. While the present study has examined the use of the force plate for the determination of these profiles, further research is required to determine the between-session reliability and validity of these measures when using velocity metrics obtained via other commercially available measurement devices such as linear position transducers and accelerometers. This is important because as these devices are more commonly used by strength and conditioning professionals to create these profiles.

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LIST OF FIGURES

Figure 1. Comparison of the between-session reliability of peak and mean velocity during a squat jump. (A) ICC for peak velocity (B) CV% for peak velocity, (C) ICC for mean velocity, (D) CV% for mean velocity. The shaded areas represent the levels of relative and absolute reliability. (ICC <0.5 = poor, shaded in white; ICC 0.5-0.75 = moderate, shaded in light gray; ICC >0.75-0.9 = good, shaded in medium gray; ICC >0.9 = excellent, shaded in dark gray; CV <5% = good, shaded in medium gray; CV 5-10% = moderate, shaded in medium gray; CV >10% = poor, shaded in white); error bars represent 95% confidence intervals, ICC = intraclass correlation, CV% = coefficient variation, %BM = percent body mass.

Figure 2. Between sessions comparison of the load-velocity profile during squat jumps against loads from 0% to 100% of body mass. %BM = percent body mass.

Figure 3. Between sessions comparison of the force-velocity profile during squat jumps against loads from 0% to 100% of body mass. %BM = percent body mass.

Figure 4. Between sessions comparison of the force-velocity profile calculated with relative force during squat jumps against loads from 0% to 100% of body mass. %BM = percent body mass.