THE INFLUENCE OF TRAINING BACKGROUND ON DIFFERENT RATE OF FORCE CALCULATIONS DURING COUNTERMOVEMENT JUMP

**Daniel Boullosa[1,2], Lauri Abreu[3], Filipe Conceição[4],
Yaiza Cordero[5], and Pedro Jimenez-Reyes[5]**

[1]Physical Education, Catholic University of Brasilia, Brasilia, Brazil
[2]College of Healthcare Sciences, James Cook University, Townsville, Australia
[3]Independent researcher, Vigo, Spain
[4]Laboratory of Biomechanics, Faculty of Sport, Porto, Portugal
[5]Faculty of Sports, Catholic University of San Antonio of Murcia, Murcia, Spain

Original scientific paper
UDC: 796.015.1:519.2

Abstract:

The aim of this study was to look at differences in countermovement jump (CMJ) performance and selected kinetic parameters in athletes of different training backgrounds and to examine the relationships between these parameters. The subjects were 14 endurance athletes, 12 sprinters, and 13 fire-fighter aspirants (controls); each performed two CMJ on a force plate. The best jump of two attempts was selected and the following parameters were calculated: CMJ height (h), peak power (PP), normalized vertical stiffness (K*vert*), rate of force development (RFD), peak RFD (pRFD) during concentric phase, and the ratio between pRFD and the time of its occurrence (iRFD). Sprinters exhibited greater h, PP, K*vert* and RFD values than the other groups. A strong correlation was revealed between PP and h, and between pRFD and K*vert* in all groups. The magnitude of correlations improved with iRFD when compared to pRFD (.5-.6 vs. .7-.9). There were strong correlations (r>.7) between PP, K*vert*, and both pRFD and iRFD only for the endurance athletes group. From these results, it would be recommended to record different RFD calculations during CMJ evaluations, including the new RFD index (iRFD), in athletes of different training backgrounds.

***Key words**: explosiveness, stretch-shortening cycle, impulse*

Introduction

Countermovement jump (CMJ) is the most common test for the evaluation of lower limb explosiveness and neuromuscular fatigue (Boullosa, Tuimil, Alegre, Iglesias, & Lusquiños, 2011; Gathercole, Sporer, Stellingwerff, & Sleivert, 2015; Young, Cormack, & Crichton, 2011)which yielded several kinematic and kinetic variables describing leg muscle function. A 40 m sprint was also conducted to assess acceleration (10 m time. Its high validity for the evaluation of athletes from different sports is linked to its simplicity and reproducibility (Markovic, Dizdar, Jukic, & Cardinale, 2004) while expressing, in a simple movement, an individual's capacity for fast force production during a single stretch-shortening cycle (Bosco & Komi, 1979; Bosco, Komi, & Ito, 1981; Bosco, Viitasalo, Komi, & Luhtanen, 1982). Jump height is obviously the most important performance parameter as it represents the final outcome. However, other important kinetic and kinematic parameters can be evaluated when a force plate is available (Boullosa, et al., 2011; Cormie, McBride, & McCaulley, 2009; Jiménez-Reyes, et al., 2017)force-, and velocity-time curves of the countermovement jump (CMJ. In this regard, recent studies have identified the necessity of looking for new alternative variables versus traditional ones for CMJ analyses during both acute and chronic adaptations (Gathercole, et al., 2015; Gathercole, Sporer, Stellingwerff, & Sleivert, 2015)but the test with optimal validity remains to be established. The current investigation examined the suitability of vertical jump (countermovement jump [CMJ], squat jump [SJ], drop jump [DJ]. Different mechanical strategies used by athletes in different conditions (e.g., fatigued vs. non-fatigued; after a training period), and the noise-to-signal ratio in every specific condition, are the main factors behind this necessity. Therefore, while jump height represents the reference value for performance analysis, other kinetic parameters should also be considered for a complete analysis of the acute and chronic adaptations of athletes.

Rate of force development (RFD) refers to the slope in a force-time curve, although a variety of calculation methods have been described in literature (e.g, peak values, force gradients between specific time points, absolute vs. normalized values) (Maffiuletti, et al., 2016). Previously, RFD has been extensively studied in dynamic and isometric conditions, confirming that it is affected by a number of neural and structural factors (Earp, et al., 2011; Maffiuletti, et al., 2016)the relationships between muscle and tendon structure to performance are highly dependent on the speed and intensity of the movement. The purpose of this study was to determine if muscle and tendon structure is associated with the rate of force development (RFD. Interestingly, some of these previous studies have reported some relationships between different RFD indices in isometric conditions with various dynamic performances (Maffiuletti, et al., 2016). In contrast, to the best of our knowledge, only two studies (Laffaye, Wagner, & Tombleson, 2014; McLellan, Lovell, & Gass, 2011) have reported a correlation between RFD during CMJ and jump height, confirming the expected influence of RFD during impulse on the CMJ height. However, another study (Ugrinowitsch, Tricoli, Rodacki, Batista, & Ricard, 2007) did not find this relationship with the evaluation of individuals of different training backgrounds (i.e., power athletes vs. bodybuilders vs. physically active subjects). Methodological differences such as the selection of kinetic variables and their calculations (Gathercole, et al., 2015; Maffiuletti, et al., 2016), and differences between populations could account for this divergence in literature. For instance, the study of McLellan et al. (2011) with recreational sportsmen used peak and average RFD values, whereas the study of Ugrinowitsch et al. (2007) used the slope of the ground reaction force (i.e., average RFD). Thus, comparison of different RFD calculations could help for better identifying differences in jumping performance between athletes of different training backgrounds.

Therefore, the aim of this study was to examine differences in the selected kinetic parameters-including different calculations of RFD, between athletes of different training backgrounds and to look for correlations between these parameters that would explain jumping mechanics and subsequent CMJ performance.

Methods

Participants

Fourteen male endurance athletes (eight endurance runners and six triathletes), 12 male sprinters, and 13 male fire-fighter aspirants (controls) volunteered for the participation on this study. All the athletes trained specifically for their activity during at least one year, more than four days a week, and were familiarized with CMJ performance. They were advised to avoid strenuous physical activity 72 hours before evaluation. All of them provided informed written consent. The study was approved by the local Ethics Committee.

Procedures

On the day of evaluation, the athletes ran 10 min at a submaximal pace and thereafter performed 2-3 CMJs on the force plate, with the rest pauses of at least 15 s, as a part of the warm-up. Two minutes after the warm-up, the participants performed two maximum attempts (> 15 s of rest) on a force plate (Quattro Jump, Kistler, Switzerland) that recorded vertical forces with a sampling rate of 500 Hz. Before each jump, participants were instructed to stand up straight and still on the center of the force plate with their hands on the hips. The athletes were encouraged to jump "as high as possible". The best jump was selected for further analyses. The mechanical parameters of the best jump were obtained with the corresponding software or calculated from the raw data in a custom-made Excel® spreadsheet: jump height (h) that was determined from the difference between the maximum height of the center of mass (apex) and the last contact of the toe on the ground during the take-off; peak power (PP) during the push-off phase ($W \cdot kg^{-1}$); normalized vertical stiffness (*Kvert*) ($N \cdot m^{-1} \cdot kg^{-1}$) (*Kvert* = $Fmax \cdot \Delta Y^{-1}$; where Fmax is peak vertical force minus body weight, and ΔY is the maximum vertical displacement of the center of mass) (Lake, Lauder, Smith, & Shorter, 2012; Linthorne, 2001; McMahon & Cheng, 1990; Morin, Dalleau, Kyröläinen, Jeannin, & Belli, 2005)(2; average normalized rate of force development (RFD) was calculated between the minimum force recorded and Fmax ($N \cdot kg^{-1} \cdot s^{-1}$); peak rate of force development (pRFD) during the concentric phase was calculated as the highest increment between two consecutive force recordings during the concentric phase ($N \cdot ms^{-1}$); and iRFD (pRFD/tRFD; where tRFD is the time [ms] taken to achieve pRFD during the concentric phase). The typical location of pRFD in a force-time recording is showed in Figure 1.

Statistical analyses

To check the normality of distribution of variables and the homogeneity of variances, Kolmogorov-Smirnov and Levene's tests were performed. Statistical descriptives are shown as means (SD). A one-way ANOVA with the Tukey's *post-hoc* test was performed to look for differences in kinetics parameters between the groups. Pearson product-moment correlation coefficient (r) was employed for

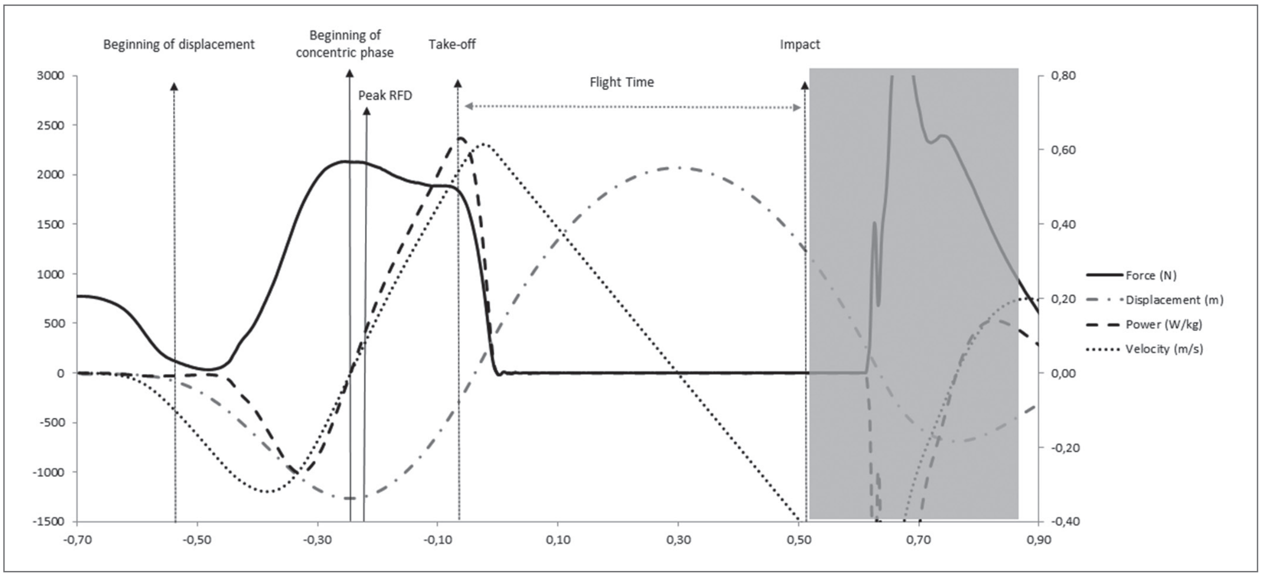

Figure 1. Simultaneous recording of kinetic and kinematic parameters during the countermovement jump. Note. peak RFD = peak rate of force development during the concentric phase.

the analysis of the relationships among the selected parameters. Statistical significance was set at p<.05.

Results

Mean values (± SD) of the mechanical parameters recorded during the best jumping attempt in all groups are shown on Table 1. There were the significant differences between sprinters and the other two groups in h, PP, K*vert* and RFD (see Table 1).

Table 1. Kinetic parameters during countermovement jump in all groups

Variables	Mean ± SD		
	Endurance (n=14)	Controls (n=13)	Sprinters (n=12)
h (cm)	32.33±4.15	34.93±3.89	42.72±5.97*#
Peak power (W/kg)	50.91±7.02	52.24±5.16	63.79±7.87*#
Kvert (N/m/kg)	52.54±23.73	50.78±14.23	70.69±18.51*@
RFD (N/kg/s)	64.41±29.29	63.9±22.19	121.06±35.13*#
pRFD (N/ms)	4.04±3.12	3.96±3.83	1.71±1.72
tRFD (ms)	63.57±74.41	60.00±82.82	51.83±58.95
iRFD (N/ms^2)	0.29±0.42	0.57±0.77	0.20±0.35

Note. h = jump height; Kvert = normalized vertical stiffness; RFD = rate of force development (RFD); pRFD = peak rate of force development during concentric action; tRFD = time to peak concentric rate of force development; iRFD = pRFD/tRFD. * Significantly different (p<.01) from Endurance. # Significantly different from Controls (p<.01). @ Significantly different (<0.05) from Controls.

The relationships between different kinetic parameters for every group are shown in Table 2. The significant correlations were revealed between h and PP, and between K*vert*, pRFD and iRFD in all groups. Of note, the correlations between iRFD and K*vert* were systematically stronger than the correlations between pRFD and K*vert* in all groups. In contrast, RFD was only correlated to h in endurance athletes and sprinters but not in controls.

Discussion and conclusions

The main finding of the current study was that the relationships between the selected kinetic parameters during CMJ could be dependent on the training background of athletes and independent of jump performance. More specifically, different RFD indices may provide different information about jumping mechanics in every group of athletes, with the new iRFD ratio being related to vertical stiffness in all groups. These findings reinforce the necessity of evaluating not only jump height, but also jumping mechanics from force-time (F-t) curves for a better characterization of acute and chronic adaptations of athletes of different training backgrounds.

The only correlations observed in the three groups were between h and PP, and between K*vert* and concentric RFD indices (i.e., pRFD and iRFD).

Table 2. Correlations among kinetic parameters in all groups

Variables - GROUPS	Peak power	Kvert	pRFD	iRFD	RFD
ENDURANCE					
h	0.785 **	0.350	0.214	0.289	0.549 *
Peak power		0.786 **	0.553 *	0.714 **	0.609 *
Kvert			0.690 **	0.920 **	0.634 *
CONTROLS					
h	0.812 **	0.008	-0.209	-0.423	0.259
Peak power		0.498	0.258	0.081	0.177
Kvert			0.566 *	0.740 **	0.328
SPRINTERS					
h	0.823 **	0.049	-0.186	-0.130	0.770 **
Peak power		0.378	0.240	0.134	0.705 **
Kvert			0.667 *	0.721 **	0.257

Note. h = jump height; Kvert = normalized vertical stiffness; RFD = rate of force development (RFD); pRFD = peak rate of force development during concentric action; tpRFD = time to peak concentric rate of force development; iRFD = pRFD/tRFD. * p<.05; ** p<.01.

The relationship between h and PP was expected and is in agreement with previous literature (Cormie, et al., 2009; Dowling & Vamos, 1993)but the best three-predictor model, not including maximum power, could only explain 66.2% of the height variance. A high maximum force (> 2 body weights. As the combination of force and velocity at the end of the impulse strongly determines jump height, with vertical velocity at take-off being directly related to jump height (Cormie, et al., 2009; Linthorne, 2001)(2. However, the relationships between K*vert* and both pRFD and iRFD as calculated in the current study are novel and have not been previously reported in literature. Moreover, an interesting finding was that the correlations between K*vert* and iRFD (from 0.721 to 0.920) were systematically greater than between K*vert* and pRFD (from 0.566 to 0.690). That is, strength of the relationships of peak concentric RFD with vertical stiffness was greater when considering both their values along with the time of its occurrence. In other words, those individuals producing a higher vertical stiffness at the end of the eccentric phase were able to produce higher and earlier RFD values during the concentric phase. These findings are novel and interesting and would be providing evidence of an elastic energy transfer between eccentric and concentric phases that warrants further investigation. Furthermore, these correlations were always greater in the endurance athletes group (see Table 2), which were the only group that exhibited a relationship between K*vert* and PP, thus reinforcing the energy transfer hypothesis between eccentric and concentric actions.

Previous studies have reported a relationship between different RFD calculations and unloaded jump performance on a force plate, thus suggesting that rapid force production is a prerequisite for higher jumps (Laffaye, et al., 2014; McLellan, et al., 2011). However, it should be pointed out that these previous calculations were related to force production rates recorded during the eccentric phase of the countermovement as the greater force increments are typically observed during this phase (Floría, Gómez-Landero, Suárez-Arrones, & Harrison, 2016; Sole, Mizuguchi, Sato, Moir, & Stone, 2017). Moreover, these previous studies (Laffaye, et al., 2014; McLellan, et al., 2011) used the Vertec apparatus and therefore the countermovement jump was performed with arm swing. This is an important difference from our study, as our sample performed the CMJ without arm swing. Thus, in our study, only endurance and sprint athletes exhibited a relationship between a classic RFD calculation and jump performance, whereas the control group did not. This is a novel and interesting finding as RFD levels did not differ between endurance athletes and controls (see Table 1). Therefore, divergence with previous literature regarding the possible influence of RFD on jump height could be explained not only by differences in RFD calculations but also by differences on CMJ evaluations and training background of athletes. In this regard, apart from obvious differences in training methods between athletes and controls, it would be also suggested the possible influence of muscle fiber type on these results with endurance athletes probably presenting the type I phenotype and sprinters the type II phenotype. Of note, a previous study of Marques et al. (2015) also described a strong relationship between h and maximum RFD during the concentric phase; however in this study the athletes performed a loaded jump (17 kg of the bar of a Smith machine) and the F-t curve was estimated from a linear transducer. Further studies are needed to clarify the influence of these factors on the relationship between RFD and CMJ capacity under different conditions.

To the best of our knowledge, there are only two studies comparing the influence of training background on unloaded CMJ performance on a force plate (Laffaye, et al., 2014; Ugrinowitsch, et al., 2007). Previously, Ugrinowitch et al. (2007) found that RFD did not influence CMJ height when comparing power athletes vs. bodybuilders vs. physically active subjects. In contrast, these authors found that 1RM in leg press was highly correlated to jump height in both power athletes and bodybuilders (Ugrinowitsch, et al., 2007). More recently, Laffaye et al. (2014) examined the influence of sex and sport on CMJ kinetics and showed higher jumps for outdoor sporting athletes. In this previous study, the kinetic variables that better predicted jump performance were eccentric RFD and concentric force (Laffaye, et al., 2014). As previously commented, differences between studies could be due to methodological differences as CMJ execution technique (e.g., with or without arm swing) and RFD calculations (e.g., average vs. peak values). However, other important differences that could influence our results should not be disregarded. For instance, Earp et al. (2011)the relationships between muscle and tendon structure to performance are highly dependent on the speed and intensity of the movement. The purpose of this study was to determine if muscle and tendon structure is associated with the rate of force development (RFD showed that Achilles tendon and lateral gastrocnemius lengths were predictors of RFD during earlier CMJs therefore linking long-term adaptations of muscle-tendon complex with fast force production during stretch-shortening activities. In our study, it would be expected that sprinters, endurance runners and controls had very different muscle and tendon structures. In this regard, endurance runners and sprinters exhibited significant differences in kinetic parameters that could be partially due to structural differences (see Table 1). However, endurance runners and controls did not exhibit significant differences in jumping capacity or kinetic parameters. In contrast, as previously commented, there were important differences in the matrix of correlations (see Table 2) for every group. These differences may be suggesting the possible influence of such structural characteristics (Earp, et al., 2011) the relationships between muscle and tendon structure to performance are highly dependent on the speed and intensity of the movement. The purpose of this study was to determine if muscle and tendon structure is associated with the rate of force development (RFD, different jumping strategies (Laffaye, et al., 2014), or a combination of both. Further studies should elaborate on these differences for a better understanding of the long-term adaptations that influence jumping mechanics.

The current study presents a number of limitations that should be acknowledged. Firstly, this is a cross-sectional study, therefore some of the differences identified between the groups could be due to athlete selection and not to chronic adaptations. This consideration is remarkable given the modest reliability previously reported for different RFD calculations (McLellan, et al., 2011; Moir, Garcia, & Dwyer, 2009; Nibali, Tombleson, Brady, & Wagner, 2015). Secondly, the current study only evaluated male athletes, therefore our results cannot be extrapolated to females (Laffaye, et al., 2014). Finally, the athletes of our study only used jumping for training or evaluations and not during competitions. This is an important consideration as differences between athletes could be debt to different jumping strategies as a consequence of their competitive demands (Laffaye, et al., 2014). Therefore, further studies should differentiate between athletes who jump or not during their competitive activities. In this regard, the study of jumping profiles along with peak values of kinetic parameters could be also recommended (Cormie, et al., 2009)force-, and velocity-time curves of the countermovement jump (CMJ. Moreover, following a recent study (Jiménez-Reyes, Pareja-Blanco, Rodríguez-Rosell, Marques, & González-Badillo, 2016)mean and maximal power (Pmean, Pmax, the use of a force plate synchronized with a linear transducer could be also recommended for a more precise assessment of jumping kinetics and kinematics.

These findings provide important practical applications, which include the selection of appropriate jump protocols and kinetic parameters as the same jump height could be achieved with different jumping strategies. More specifically, it seems that all RFD calculations used in the current study could help for a better understanding of neuromuscular characteristics of athletes of different training backgrounds. However, as previously commented, more chronic studies are needed for identifying which parameters are more appropriate in each population when identifying the noise-to-signal ratio in every case.

The current results support the notion that different training backgrounds could influence jumping kinetics despite similar jumping performances. The new index, iRFD, should be considered along with other RFD measures when evaluating CMJ kinetics in different samples, and more specifically in endurance athletes. Further studies should elaborate on the relative influence of muscle–tendon characteristics and sport demands on the kinetics of CMJ under different conditions (loaded vs. unloaded) with different vertical jump protocols (with or without arm swing).

References

Bosco, C., & Komi, P.V. (1979). Mechanical characteristics and fiber composition of human leg extensor muscles. *European Journal of Applied Physiology and Occupational Physiology*, *41*(4), 275-284.

Bosco, C., Komi, P.V., & Ito, A. (1981). Prestretch potentiation of human skeletal muscle during ballistic movement. *Acta Physiologica Scandinavica*, *111*(2), 135-140.

Bosco, C., Viitasalo, J.T., Komi, P.V., & Luhtanen, P. (1982). Combined effect of elastic energy and myoelectrical potentiation during stretch-shortening cycle exercise. *Acta Physiologica Scandinavica*, *114*(4), 557-565.

Boullosa, D.A., Tuimil, J.L., Alegre, L.M., Iglesias, E., & Lusquiños, F. (2011). Concurrent fatigue and potentiation in endurance athletes. *International Journal of Sports Physiology and Performance*, *6*(1), 82-93.

Cormie, P., McBride, J.M., & McCaulley, G.O. (2009). Power-time, force-time, and velocity-time curve analysis of the countermovement jump: Impact of training. *Journal of Strength and Conditioning Research*, *23*(1), 177-186.

Dowling, J.J., & Vamos, L. (1993). Identification of kinetic and temporal factors related to vertical jump performance. *Journal of Applied Biomechanics*, *9*(2), 95-110.

Earp, J.E., Kraemer, W.J., Cormie, P., Volek, J.S., Maresh, C.M., Joseph, M., & Newton, R.U. (2011). Influence of muscle-tendon unit structure on rate of force development during the squat, countermovement, and drop jumps. *Journal of Strength and Conditioning Research*, *25*(2), 340-347.

Floría, P., Gómez-Landero, L.A., Suárez-Arrones, L., & Harrison, A.J. (2016). Kinetic and kinematic analysis for assessing the differences in countermovement jump performance in rugby players. *Journal of Strength and Conditioning Research*, *30*(9), 2533-2539.

Gathercole, R.J., Sporer, B.C., Stellingwerff, T., & Sleivert, G.G. (2015). Comparison of the capacity of different jump and sprint field tests to detect neuromuscular fatigue. *Journal of Strength and Conditioning Research*, *29*(9), 2522-2531.

Gathercole, R., Sporer, B., Stellingwerff, T., & Sleivert, G. (2015). Alternative countermovement-jump analysis to quantify acute neuromuscular fatigue. *International Journal of Sports Physiology and Performance*, *10*(1), 84-92.

Jiménez-Reyes, P., Pareja-Blanco, F., Rodríguez-Rosell, D., Marques, M.C., & González-Badillo, J.J. (2016). Maximal velocity as a discriminating factor in the performance of loaded squat jumps. *International Journal of Sports Physiology and Performance*, *11*(2), 227-234.

Jiménez-Reyes, P., Samozino, P., Pareja-Blanco, F., Conceição, F., Cuadrado-Peñafiel, V., González-Badillo, J.J., & Morin, J.-B. (2017). Validity of a simple method for measuring force-velocity-power profile in countermovement jump. *International Journal of Sports Physiology and Performance*, *12*(1), 36-43.

Laffaye, G., Wagner, P.P., & Tombleson, T.I.L. (2014). Countermovement jump height. *Journal of Strength and Conditioning Research*, *28*(4), 1096-1105.

Lake, J., Lauder, M., Smith, N., & Shorter, K. (2012). A comparison of ballistic and nonballistic lower-body resistance exercise and the methods used to identify their positive lifting phases. *Journal of Applied Biomechanics*, *28*(4), 431-437.

Linthorne, N.P. (2001). Analysis of standing vertical jumps using a force platform. *American Journal of Physics*, *69*(11), 1198-1204.

Maffiuletti, N.A., Aagaard, P., Blazevich, A.J., Folland, J., Tillin, N., & Duchateau, J. (2016). Rate of force development: Physiological and methodological considerations. *European Journal of Applied Physiology*, *116*(6), 1091-1116.

Markovic, G., Dizdar, D., Jukic, I., & Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. *Journal of Strength and Conditioning Research*, *18*(3), 551.

Marques, M.C., Izquierdo, M., Marinho, D.A., Barbosa, T.M., Ferraz, R., & González-Badillo, J.J. (2015). Association between force-time curve characteristics and vertical jump performance in trained athletes. *Journal of Strength and Conditioning Research*, *29*(7), 2045-2049.

McLellan, C.P., Lovell, D.I., & Gass, G.C. (2011). The role of rate of force development on vertical jump performance. *Journal of Strength and Conditioning Research*, *25*(2), 379-385.

McMahon, T.A., & Cheng, G.C. (1990). The mechanics of running: How does stiffness couple with speed? *Journal of Biomechanics*, *23*(Suppl 1), 65-78.

Moir, G.L., Garcia, A., & Dwyer, G.B. (2009). Intersession reliability of kinematic and kinetic variables during vertical jumps in men and women. *International Journal of Sports Physiology and Performance*, *4*(3), 317-330.

Morin, J.B., Dalleau, G., Kyröläinen, H., Jeannin, T., & Belli, A. (2005). A simple method for measuring stiffness during running. *Journal of Applied Biomechanics*, *21*(2), 167-180.

Nibali, M.L., Tombleson, T., Brady, P.H., & Wagner, P. (2015). Influence of familiarization and competitive level on the reliability of countermovement vertical jump kinetic and kinematic variables. *Journal of Strength and Conditioning Research*, *29*(10), 2827-2835.

Sole, C.J., Mizuguchi, S., Sato, K., Moir, G.L., & Stone, M.H. (2017). Phase characteristics of the countermovement jump force-time curve: A comparison of athletes by jumping ability. *Journal of Strength and Conditioning Research*. Epub ahead of print.

Ugrinowitsch, C., Tricoli, V., Rodacki, A.L.F., Batista, M., & Ricard, M.D. (2007). Influence of training background on jumping height. *Journal of Strength and Conditioning Research*, *21*(3), 848.

Young, W., Cormack, S., & Crichton, M. (2011). Which jump variables should be used to assess explosive leg muscle function? *International Journal of Sports Physiology and Performance*, *6*(1), 51-57.

Correspondence to:
Daniel A. Boullosa, Ph.D.
Post-Graduate Program in Physical Education
QS 07, LT1 S/N - Sala 119 - Bloco G
Catholic University of Brasilia
71966-700 Águas Claras, DF, Brazil
Phone: +55 61 3356 9489
Fax: +55/61/3356 9350
E-mail: daniel.boullosa@gmail.com