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Research article

Analysis of the Load-Velocity Relationship in Deadlift Exercise

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Abstract

The aim of this study was to analyze the relationship between movement velocity and relative load (%1RM) in the deadlift exercise. Fifty men (age = 23.8 ± 3.6 years, body mass = 78.2 ± 8.3 kg, height = 1.78 ± 0.06 m) performed a first evaluation (T1) consisting of a one-repetition maximum (1RM) test. Forty-two subjects performed a second evaluation (T2) after 6 weeks. Mean (MV), mean propulsive (MPV) and peak (PV) velocity measures of the concentric phase were analyzed. Load-velocity relationships were studied by fitting first order equations to the data using loads from 30-100% of 1RM. A comprehensive set of statistics for assessing bias and level of agreement to estimate the 1RM value from the different models was used. Stability of these relationships was assessed using the coefficient of variation (CV) and the intraclass correlation coefficient (ICC). General load-velocity equations provided good adjustments ($R^2 \sim 0.91$-0.93), however individual load-velocity regressions provided better adjustments ($R^2 \sim 0.97$). Individual estimations also showed higher agreement and more regular variation than general equations. Moreover, MPV showed smaller bias than the other velocity parameters (MV and PV). The stability analysis of the load-velocity relationships resulted in ICC values higher than 0.82 and CV lower than 3.0%. Monitoring repetition velocity allows estimation of the %1RM in the deadlift exercise. More accurate predictions of relative load can be obtained when using individualized regression equations instead of general equations.

Key words: Loading intensity, velocity-based training, maximal strength, one-repetition maximum, athletic performance.

Introduction

Resistance training (RT) is an effective approach to improve athletic performance (Beattie et al., 2014; Pareja-Blanco et al., 2017; Suchomel et al., 2016). According to Fry (2004), one of the fundamental challenges in describing resistance exercise is how to quantify the intensity employed, which has a profound impact on the resulting performance, and on cellular and molecular adaptations.

A way to define the RT intensity is as a percentage of the one-repetition maximum (1RM). One of the main problems is the mismatch over time with the theoretical percentage, since the value of 1RM can fluctuate on a day-to-day basis, or change throughout a training program, which means that the relative intensities (%1RM) actually performed do not correspond with the scheduled %1RM (González-Badillo and Sánchez-Medina, 2010). Another way to define training intensity is to perform the maximum number of repetitions with a given load (XRM: 5RM, 10RM, etc.). However, a given XRM does not necessarily constitute the same %1RM for every participant, since the XRM against a given relative load has shown a coefficient of variation (CV) of about 20% between individuals (González-Badillo et al., 2017). This variability may be due to gender, training experience and type of exercise (Hoeger et al., 1990). Therefore, there is a need for an alternative approach that accurately estimates %1RM, and consequently 1RM, while minimizing the accumulation of fatigue.

The movement velocity of the concentric phase of a resistance exercise has been proposed as a valid alternative to quantify and adjust training intensity with great precision from the first repetition performed (González-Badillo et al., 2011). This statement is based on the fact that each %1RM has its own velocity for each exercise, since it has been observed an extremely close relationship between %1RM and barbell velocity ($R^2 = 0.98$) in the bench press exercise (González-Badillo and Sánchez-Medina, 2010). In addition, this relationship is very stable regardless of the level of strength performance (González-Badillo and Sánchez-Medina, 2010). Afterwards, it has been shown that individual load-velocity relationships could provide more accurate predictions of %1RM from barbell velocity than general equations (Garcia-Ramos et al., 2018; Pestana-Melero et al., 2018), suggesting that the individual determination of the load-velocity relationship could be recommended to prescribe the RT intensity on an individual basis with appropriate accuracy.

A growing body of literature has investigated the different load-velocity relationships in diverse exercises (García-Ramos et al., 2019; Loturco et al., 2017; Martinez-Cava et al., 2018; Sanchez-Medina et al., 2014; Sanchez-Moreno et al., 2017). However, the load-velocity relationship in the deadlift (DL) exercise has not been extensively studied (Lake et al., 2017; Ruf et al., 2018). The DL exercise is a compound full-body exercise that is essential in RT. In fact, any sport that places high demands on strengthening the trunk, hip, and knee extensors can benefit from DL exercise (Hales, 2010), which reduces the risk of injury in athletes due to the strength gains (Malone et al., 2019). DL exercise is a suitable exercise, with positive effects on strength, in obese and overweight people (Zemková et al., 2017) and is even suitable in many cases for people with back pain partly due to the activation of the erector spinal muscles (Berglund et al., 2015). However, aberrant DL biomechanics have been shown to increase load shear forces in the lower back (Cholewicki et al., 1991), potenti-

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ating the injury risk (O'Reilly et al., 2017). Therefore, reliable assessment of DL performance is necessary. Lake et al. (2017) compared the actual 1RM and the predicted 1RM from individualized load-velocity relationships in the DL exercise from 12 resistance-trained athletes. These authors concluded that individualized load-velocity relationships should not be used to predict 1RM in DL (Lake et al., 2017). Therefore, if bar velocity can be used to predict the intensity employed in the DL exercise is still unclear. Notably, previous literature analyzing load-velocity relationship in DL (Lake et al., 2017; Ruf et al., 2018) examined a small sample size (n = 11-12) compared to those examined in other exercises (sample size of approximately 50 subjects) (González-Badillo and Sánchez-Medina, 2010; Loturco et al., 2017; Martínez-Cava et al., 2018; Sánchez-Medina et al., 2014; Sánchez-Moreno et al., 2017). It therefore seemed pertinent to undertake a detailed analysis of the load-velocity relationship of the DL exercise in a larger sample of strength-trained men in order to confirm the possibility of using bar velocity to estimate loading magnitude (%1RM), as well as to provide normative data for this population.

Therefore, the aims of the present study were: 1) to analyze the relationships between bar velocity and relative load (%1RM) in DL exercise; and 2) to analyze whether this relationship is stable for the same subject on different days. Based on previous results, the following hypotheses were formulated: 1) there is a close relationship between the percentages of 1RM and bar velocity in the concentric phase of DL exercise; and 2) there are no differences between velocities associated with each %1RM on different days.

Methods

Participants

Fifty men (mean ± standard deviations [SD]: age = 23.8 ± 3.6 years, body mass = 78.2 ± 8.3 kg, height = 1.78 ± 0.06 m) volunteered to take part in this study. Inclusion criteria were: 1) being a young, physically active man capable of performing a technically correct DL exercise; 2) having at least 2 years of RT background; and 3) having a 1RM strength/body mass ratio higher than 1.5 in DL exercise. After being informed of the purpose and testing procedures, subjects signed a written informed consent form prior to participation. The present investigation was approved by the Research Ethics Committee of the University of Almeria and was conducted in accordance with the Declaration of Helsinki.

Study Design

Subjects underwent a preliminary session during which they were familiarized with the testing equipment and exercise protocol. During the familiarization, subjects performed an incremental test until getting a mean propulsive velocity (MPV) lower than 1 $m \cdot s^{-1}$, while researchers emphasized proper technique. In addition, this session was used for body composition assessment, medical examination and personal data and health history questionnaire administration. A week later, all 50 subjects performed a progressive loading test up to 1RM for individual determination of the full load-velocity relationship (T1). Finally, after 6 weeks, a subset of the total sample (42 subjects) performed the same experimental protocol on a second occasion (T2) with the aim to analyze the stability in the load-velocity relationship. During T1 and T2, subjects were not advised about following any specific training plan.

Three velocity outcome measures were used as performance variables in this study:

1) Mean velocity (MV): average of the bar velocity values for the whole concentric phase of each repetition,

2) MPV: average of the bar velocity values of the propulsive phase, it was defined as that portion of the concentric phase during which the measured acceleration is greater than acceleration due to gravity (i. e. $a \geq -9.81$ $m \cdot s^{-2}$) (Sanchez-Medina et al., 2010),

3) Peak velocity (PV): the highest instantaneous bar velocity value registered at a particular instant (ms) during the concentric phase.

Procedures

All DL tests were performed on a wooden platform with rubber on the sides, using a 20 kg barbell (Eleiko, Halmstad, Sweden). To be counted as a complete DL repetition, the subject had to lift the bar avoiding countermovement with the hips, ending in a full-arm-knee-hip extension with shoulders blocked. A self-selected width with a pronated grip was used. It was performed starting from the floor, stance approximately shoulder-width apart with both feet positioned flat on the floor in parallel or slightly externally rotated, while keeping a natural lower back arch, chest up and head in line with the spine. Then, subjects were instructed to pull the bar in a vertical direction at maximal intended velocity until their body was fully erect and to maintain a static position for ~1 s. Re-bend the knees prior to full extension or lifting the heels from the floor was not allowed (Ruf et al., 2018). All repetitions were recorded with a linear velocity transducer (T-Force System, Ergotech, Murcia, Spain). The stability of this system has been reported elsewhere (Sánchez-Medina and González-Badillo, 2011). The warm-up protocol consisted of 5 minutes of jogging at a self-selected easy pace, 2 minutes of joint mobilization exercises, two 20 m running accelerations and 2 progressive-loaded sets of 5 repetitions of DL (0.3 and 20 kg). Individual load-velocity relationships and 1RM strength were determined using a progressive loading test. The initial load was set at 20 kg and was gradually increased, initially in 20 kg increments until an MPV of 0.8 $m \cdot s^{-1}$ was reached, carrying out 3 repetitions with each load. Two repetitions were performed when the MPV was between 0.8 and 0.6 $m \cdot s^{-1}$ (10 kg increments), and only one repetition for higher loads. Increments of 5 kg were used when the MPV ranged from 0.6 to 0.5 $m \cdot s^{-1}$ and 2.5 kg increments were used when the MPV was less than 0.5 $m \cdot s^{-1}$ to 1RM. The heaviest load that each subject could properly lift while completing a full range of movement and without any external help was considered to be his 1RM. Inter-set rests were 3 min. Only the best repetition (fastest and executed correctly) at each load was considered for subsequent analysis. Testing sessions were performed at the same place and time of day (± 1 h) for each subject, under the same environmental conditions. Strong verbal encouragement was provided during all tests to motivate subjects to give maximal effort.

Statistical analyses

Standard statistical methods were used for the calculation of means, SD, standard error of the estimate (SEE), 95% confidence intervals (CI), coefficient of determination (R^2) and between-participant coefficient of variation (CoV = 100 SD·mean^{-1}). Load-velocity relationships were studied by fitting first order equations to the data following the suggestions of previous literature (Garcia-Ramos et al., 2019; Pestana-Melero et al., 2018). General and individualized load-velocity relationships for each velocity parameter (MV, MPV, and PV) were obtained. The data of the closest load to 80% 1RM and loads from 30% to 80% 1RM were used to estimate the 1RM values from general and individual load-velocity relationships, respectively. The 1RM was estimated from the individual load-velocity relationships as the load associated with the velocity at 1RM (García-Ramos et al., 2020) (i.e. 0.33 m·s^{-1} for MPV and MV, and 0.59 m·s^{-1} for PV). Information about the level of agreement and the magnitude of errors incurred when comparing actual 1RM and predicted 1RM from different equations was obtained from the calculation of a set of statistics (Atkinson and Nevill, 1998). The differences between actual 1RM and predicted 1RM were assessed using a repeated measures analysis of variance (ANOVA) with Bonferroni´s post hoc adjustments when appropriated. In addition to this null hypothesis testing, data were assessed using an approach based on the magnitude of change (Hopkins et al., 2009). Effect sizes (ES) were calculated using *Hedge´s g* on the pooled SD. Linear regression analysis and Pearson's correlation coefficient (r) were used to assess the extent of the linear relationship between measured and predicted 1RM values. Linear equations (Y = aX + b) were fitted assuming that ideal values for the slope (a) should be close to 1 whilst the constant (b, intercept) should be close to zero to minimally alter the explanatory variable (X). The standard SEE was calculated as the standard deviation of the residuals as a measure of variation around the regression line. The level of agreement between measured and predicted 1RM from the different equations was also assessed using Bland–Altman plots and the calculation of systematic bias and its 95% limits of agreement (LoA = Bias ± 1.96 SD) (Bland and Altman, 1986). Stability of load-velocity relationship and velocity at 1RM was also examined. T1 and T2 absolute stability was assessed using the standard error of measurement (SEM), which was calculated from the root mean square of the intrasubject total mean square (Atkinson and Nevill, 1998), which was expressed in relative terms as a within-participant coefficient of variation (CV = 100 SEM·mean^{-1}). Relative stability was calculated with the intraclass correlation coefficient (ICC) using a two-way mixed effects model. A related sample t-test was used to analyze intragroup changes between T1 and T2. Significance was accepted at the P ≤ .05 level. ES with 90%CI were calculated using a purpose-built spreadsheet for the analysis of controlled trials (Hopkins, 2006). The rest of analyses were performed using SPSS software version 23.0 (SPSS, Chicago, IL, USA). Figures were designed using SigmaPlot 12.0 (Systat Software Inc, San Jose, California, USA).

Results

For the 50 subjects who performed T1, 1RM strength for the DL was 140.2 ± 18.9 kg (i.e., 1.81 ± 0.21 kg normalized per kg of body mass) completing a total of 14.0 ± 2.8 increasing loads up to the 1RM in the progressive loading test. For the subjects who performed T1 and T2, 1RM strength was 139.3 ± 16.4 and 140.0 ± 16.1 kg, completing a total of 14.1 ± 2.8 and 13.6 ± 2.1 loads, respectively.

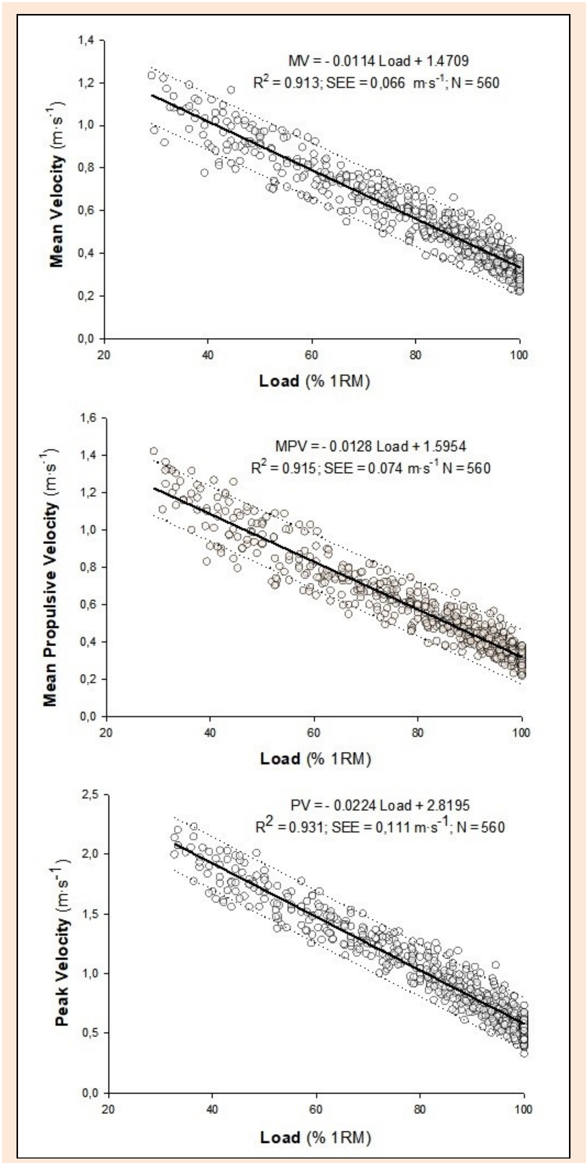

Figure 1. Relationship between relative load (% 1RM) and the different velocity variables obtained. First order polynomials were fitted to the remaining load-velocity pairs; R2, coefficient of determination; SEE, standard error of the estimate.

Relationship between relative load and velocity

The three velocity variables were plotted against %1RM, producing a total of 560 raw load-velocity data pairs. Loads lower than 30% 1RM were then eliminated from further analyses. This was done because there is an intrinsic limitation in the DL exercise to maximally apply force to the ground when using lights loads (i.e., in order to obtain the maximum possible velocity, the subject has to jump off the ground, which was not permitted because the DL is not a jump). This fact results in considerable inter-subject variability in velocities developed against loads lighter than 30% 1RM, together with the fact that such loads are seldom used in the actual practice of DL training. First order equations were fitted to the remaining load-velocity pairs.

A strong relationship was found between MV (R^2 = 0.913; SEE = 0.066 m·s^{-1}), MPV (R^2 = 0.915; SEE = 0.074 m·s^{-1}) and PV (R^2 = 0.931; SEE = 0.111 m·s^{-1}) and 1RM percentages. The average value of the coefficient of determination of the individual adjustments for each subject was R^2 = 0.972 ± 0.018, CI95% = 0.969 – 0.977; CoV = 1.80%) for MV, R^2 = 0.976 ± 0.015 (CI95% = 0.972 – 0.980; CoV = 1.50%) for MPV and R^2 = 0.975 ± 0.019 (CI95% = 0.970 – 0.980; CoV = 1.92%) for PV (Figure 1). The values of MV, MPV and PV for each 1RM percentage were obtained from these adjustments, from approximately 30% 1RM onwards, in increments of 5% (Table 1).

Validity of 1RM prediction from different velocity parameters

Table 2 shows the results between 1RM values (measured and predicted) comparing the magnitude of error for each predictive model. Significant differences (P<0.001-0.05) were observed between actual 1RM values and predicted 1RM obtained from general PV equation and individualized MV and PV equations. For each velocity parameter, ES and SEE values were lower for individualized estimations compared to general equations. By contrast, Pearson's correlation coefficients were higher for individualized predictions than those observed for general equations. Figure 2 shows the Bland–Altman plots of predicted and measured 1RM value from each predictive model (general and individualized load-velocity relationships for each velocity parameter). Individual estimations showed higher agreement and more regular variation than general equations. Moreover, MPV showed smaller bias than the other velocity parameters (MV and PV).

Predicting relative load from velocity data

Because in practice we are normally interested in estimating load (%1RM) from velocity measurements, if we take the velocity values as the independent variable, a prediction equation to estimate relative load (Load, %1RM) from velocity (MV, MPV or PV, in m·s^{-1}) can be obtained:

Load (%1RM) = -80.188 MV + 124.929 (R^2 = 0.913; SEE = 5.55%)
Load (%1RM) = -71.681 MPV + 121.118 (R^2 = 0.915; SEE = 5.57%)
Load (%1RM) = -41.517 PV + 122.625 (R^2 = 0.931; SEE = 4.70%)

Table 1. Mean velocity (MV), mean propulsive velocity (MPV) and peak velocity (PV) attained with each %1RM in the deadlift exercise (n = 50).

Load (%1RM)	MV	95%CI	MPV	95%CI	PV	95%CI
40	1.02 ± 0.09	1.00 - 1.05	1.09 ± 0.12	1.05 - 1.12	1.92 ± 0.14	1.89 - 1.96
45	0.97 ± 0.09	0.94 - 0.99	1.02 ± 0.11	0.99 - 1.05	1.81 ± 0.13	1.78 - 1.85
50	0.91 ± 0.08	0.89 - 0.93	0.96 ± 0.10	0.93 - 0.99	1.70 ± 0.12	1.67 - 1.74
55	0.85 ± 0.07	0.83 - 0.87	0.90 ± 0.09	0.87 - 0.92	1.59 ± 0.11	1.56 - 1.56
60	0.80 ± 0.07	0.78 - 0.81	0.83 ± 0.08	0.81 - 0.86	1.48 ± 0.10	1.45 - 1.51
65	0.74 ± 0.06	0.72 - 0.76	0.77 ± 0.07	0.75 - 0.79	1.37 ± 0.09	1.34 - 1.40
70	0.68 ± 0.06	0.66 - 0.70	0.71 ± 0.07	0.69 - 0.73	1.26 ± 0.09	1.23 - 1.28
75	0.62 ± 0.05	0.61 - 0.64	0.64 ± 0.06	0.63 - 0.66	1.15 ± 0.08	1.12 - 1.17
80	0.57 ± 0.05	0.55 - 0.58	0.58 ± 0.05	0.57 - 0.60	1.04 ± 0.08	1.01 - 1.06
85	0.51 ± 0.05	0.50 - 0.52	0.52 ± 0.05	0.50 - 0.53	0.93 ± 0.08	0.90 - 0.95
90	0.45 ± 0.04	0.44 - 0.47	0.45 ± 0.04	0.44 - 0.47	0.81 ± 0.09	0.79 - 0.84
95	0.39 ± 0.04	0.38 - 0.41	0.39 ± 0.04	0.38 - 0.40	0.70 ± 0.09	0.68 - 0.73
100	0.33 ± 0.04	0.33 - 0.35	0.33 ± 0.04	0.32 - 0.34	0.59 ± 0.10	0.57 - 0.62

Values are mean ± SD; 95%CI: 95% confidence interval.

Table 2. Agreement between actual and predicted 1RM from different methods.

Method	1RM (kg, actual value: 140.2 ± 18.9)	ES (90%CI)	SEE (kg, 90%CI)	Pearson correlation (r)	slope	intercept
General MV	143.8 ± 19.7	0.19 (0.07; 0.31)	8.9 (7.7; 10.8)	0.88	0.847	18.321
General MPV	141.9 ± 19.3	0.09 (-0.01; 0.20)	8.2 (7.1; 9.9)	0.90	0.884	14.801
General PV	144.1 ± 19.1*	0.21 (0.11; 0.31)	8.0 (6.9; 9.7)	0.91	0.896	11.049
Individual MV	142.7 ± 20.3*	0.14 (0.07; 0.20)	4.8 (4.1; 5.8)	0.97	0.897	12.042
Individual MPV	140.9 ± 20.0	0.04 (-0.02; 0.10)	4.4 (3.8; 5.3)	0.97	0.917	11.022
Individual PV	143.7 ± 19.8**	0.19 (0.13; 0.24)	4.1 (3.5; 5.0)	0.98	0.929	6.651

Values are mean ± SD; MV: mean velocity; MPV: mean propulsive velocity, PV: peak velocity; General: data obtained from general equations; Individual: data obtained from individual equations; 1RM: one-repetition maximum; ES: effect size compared to actual 1RM values; 90%CI: 90% confidence interval; SEE: standard error of estimation; Pearson correlation, slope and intercept values were obtained from relationships between actual and predicted 1RM data. Significant differences compared to actual 1RM values: * p < 0.05; ** p < 0.001.

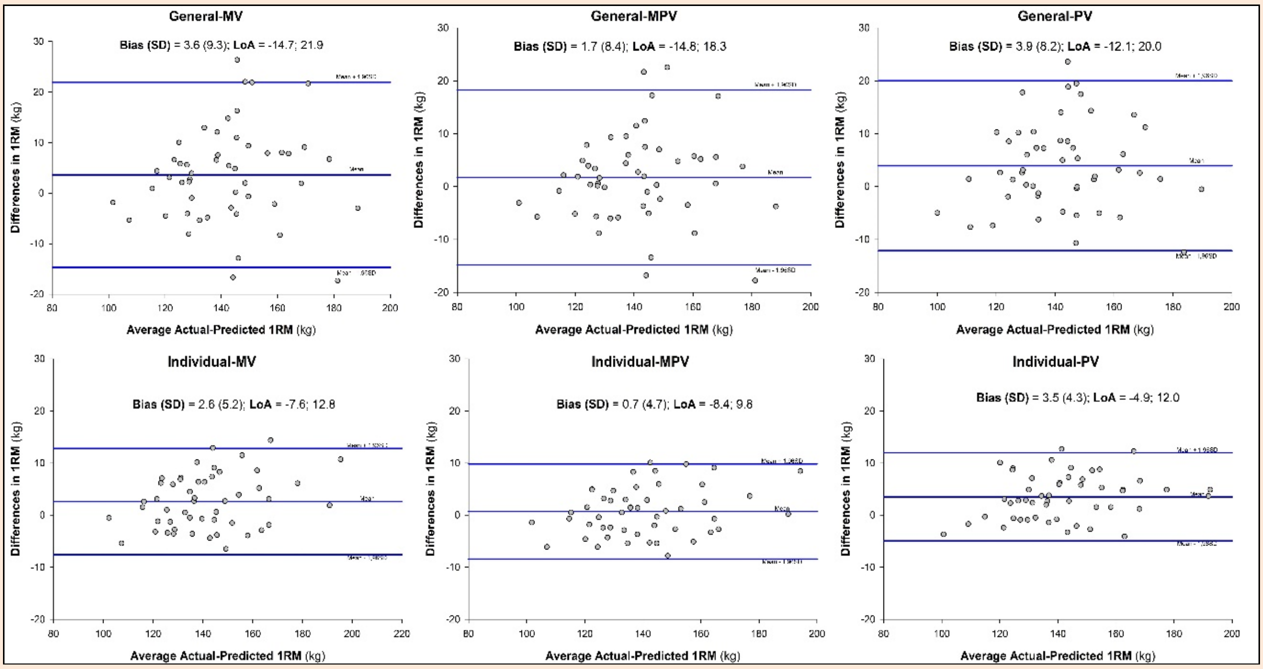

Figure 2. Bland–Altman plots between measured and predicted 1RM values obtained from different equations. General-MV: general prediction from mean velocity; General-MPV: general prediction from mean propulsive velocity; General-PV: general prediction from peak velocity; Individual-MV: individualized prediction from mean velocity; Individual-MPV: individualized prediction from mean propulsive velocity; Individual-PV: individualized prediction from peak velocity; SD: standard deviation; LoA: Level of agreement.

Stability in the load-velocity relationship

No significant differences were observed between the 1RM strength in T1 and T2 (139.3 ± 16.4 and 140.0 ± 16.1 kg). For the analysis of stability in the relationship between the different variables of velocity and relative intensity (%1RM), the average estimated velocity for each subject in T1 and T2 was compared for each variable (MV, MPV and PV). Estimated velocities were used from 30% of the 1RM, in increments of 5%. Only the data from subjects who performed both tests were selected (n = 42). No significant differences were observed in the velocity attained against each %1RM between T1 and T2.

The repeatability analysis resulted in following stability values: ICC: 0.870 (95%CI = 0.758 - 0.930) and CV = 2.0% for MV, ICC: 0.865 (95%CI = 0.748 - 0.927) and CV = 2.6% for MPV, and ICC: 0.828 (95%CI = 0.681 - 0.908) and CV = 2.1% for PV. Moreover, velocity at 1RM showed the following values: ICC: 0.763 (95%CI = 0.565 - 0.871) and CV = 9.4% for MV and MPV, and ICC: 0.718 (95%CI = 0.483 - 0.847) and CV = 11.5% for PV.

Discussion

The findings of this study confirm the assumption that the lifting velocity in the DL exercise is highly associated with the relative load (%1RM) used by the athlete. Data suggest that lifting velocity in DL allows the determination of the real intensity of the effort that the athlete engages in when using loads from 30% of the 1RM, at maximum voluntary velocity. Although general predictions provided good adjustments (R2 ~ 0.91-0.93), individual load-velocity regressions provided better adjustments (R2 ~ 0.97-0.98). Moreover, individualized predictions showed lower bias and higher level of agreement than general equations for predicting the 1RM. Therefore, more accurate predictions of relative load can be obtained when using individualized regression equations instead of general equations. A practical implementation of these findings is the possibility of monitoring, in real-time, the actual load by measuring the velocity during the DL exercise. This allows prescription and monitoring of strength training according to the velocity achieved during the repetitions, providing a more accurate individualization of the weight used for the DL exercise.

In the analysis of the R2 of the different velocity variables and the relative load (%RM), the 3 velocity variables showed a close relationship to %1RM (MV: R2 = 0.913, MPV: R2 = 0.915 and PV: R2 = 0.931). However, when conducting T2 and observing the stability of these relationships, PV showed lower relative stability values compared to MV and MPV. Previous studies have shown a high stability of the load-velocity relationship obtained from the three velocity variables (MV, MPV and PV) in bench press (García-Ramos et al., 2018) and bench-pull (García-Ramos et al., 2019). However, to our knowledge, no previous study has compared the stability of the load-velocity relationship obtained from different velocity outcomes (MV, MPV and PV) in lower limb exercises. An earlier study showed a high stability of the load-velocity relationship in predicting the 1RM in DL exercises (Ruf et al., 2018). However, that study only analyzed the stability of the load-velocity relationship obtained from MV (Ruf et al., 2018). The present data suggest that both mean velocity measures (MV and MPV) provided more reliable predictions of relative load than PV values. It should be noted that between-session stability is typically assessed with shorter time periods between assessments than the time period employed in the current study (6 weeks later). These findings suggest that load-velocity relationship is stable after 6 weeks when subjects are not exposed to any change in their training routine.

When comparing general and individualized regression models, both showed strong relationships. However, in agreement with previous literature (Garcia-Ramos et al., 2018; Pestana-Melero et al., 2018), the 1RM estimated by the individual load-velocity relationships presented lower systematic bias and higher level of agreement with the actual 1RM than the generalized equations. Therefore, the individual load-velocity relationships provide more accurate predictions of %1RM than general equations. These findings were expected since the generalized group equations do not take into account the individual differences in the load-velocity relationship, which could be induced by a myriad of factors (i.e. limb lengths and muscle fiber types).

Although using the Smith machine may reduce movement variability and produce stronger load-velocity relationships compared with free-weight exercises, it may limit the ecological validity of free-weight exercises and it may be less applicable to typical strength and conditioning coaches. DL exercise is normally performed with free weights. Accordingly, previous studies have reported high levels of agreement between predicted and actual 1RM in dynamic free-weight bench press exercise (CV = 1.2%) (Loturco et al., 2017). As can be observed in Table 1, differences in velocity between each 5% increment in relative load (from 40–100 % 1RM) vary between 0.05 and 0.06 m·s-1. Moreover, the velocity of 1RM for DL was 0.33 ± 0.06 m·s-1, which was similar to the velocities previously reported for 1RM (~0.30 $m \cdot s^{-1}$) in other lower limb exercises such as full, parallel and half squat (Martínez-Cava et al., 2018). However, these values were faster than the previously reported (~0.14 $m \cdot s^{-1}$) by Helms et al. (2017). The fact that these authors did not give any specific instructions to lift at maximal velocity may influence on these differences (Helms et al., 2017). Moreover, Helms et al. (2017) utilized powerlifters, who had relative DL strength values of 2.6 ± 0.5, while our subjects had relative DL strength values of 1.8 ± 0.2. Indeed, previous research has demonstrated stronger lifters to have slower velocities at 1RM compared to weaker lifters (Gonzalez-Badillo and Sanchez-Medina, 2010). Likewise, velocity of 1RM showed moderate stability values for all velocity parameters (MV, MPV and PV). In agreement with the present findings, Ruf et al. (2018) observed considerable variation in velocity at 1RM between sessions (ICC: 0.63 and CV: 15.7%). Therefore, as previously suggested (Garcia-Ramos et al., 2018), given the day-to-day variability of the velocity at 1RM, a fixed velocity at 1RM should be used for all subjects in order to predict the 1RM from the individual load-velocity relationship. Taken together, our results suggest that the reliable and close load-velocity relationships observed in the free-weight DL exercise allow strength and conditioning coaches to use movement velocity to accurately monitor their athletes on a daily basis and accurately determine their actual 1RM without the need to perform demanding, time-consuming and interfering 1RM or repetition to failure (XRM) assessments.

Conclusion

In line with the previous studies that have analyzed the load-velocity relationship in different exercises, this study suggests that by monitoring repetition velocity during the DL exercise, it is possible to determine whether the proposed load (kg) for a given training session actually represents the effort (%1RM) that was intended. A reasonably good estimation of loading magnitude (40-100% 1RM) can be obtained from velocity measurements, eliminating the need to perform exhausting and time-consuming 1RM or XRM assessments. In addition, our data suggest that mean velocities (MV and MPV) provide more reliable predictions of relative load in DL exercise. Lastly, our findings suggest that in DL exercise, more accurate predictions of relative load can be obtained using individualized regression equations (R^2 ~ 0.97-0.98) instead of general equations (R^2 ~ 0.91-0.93). Therefore, individual load-velocity relationships should be recommended to prescribe the RT intensity on an individual basis with appropriate accuracy.

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Key points

- The movement velocity of the concentric phase is a valid alternative to quantify and adjust training intensity with great precision from the first repetition performed in the deadlift (DL) exercise.
- Exists a relationship between movement velocity and relative load (%1RM) in the DL exercise
- Mean velocities provide more reliable predictions of relative load in DL exercise instead of peak velocities.
- In DL exercise, using individualized linear regression equations instead of general equations can be obtained more accurate predictions of relative load.

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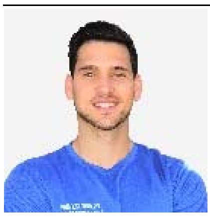

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