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Research article

Monitoring Resistance Training Intensity Using Load-Intercept from The Load-Velocity Relationship Variables: The Case of Deadlift

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Abstract
This study aimed to investigate the feasibility of using deadlift load-velocity (L-V) relationship variables, specifically the load-intercept (L_0), to monitor resistance training intensity. Fifteen well-trained male and fifteen well-trained female athletes completed two incremental load tests, recording movement mean velocity (MV) until reaching one repetition maximum (1RM) in two sessions. Although L_0 (CV = 4.98%, ICC = 0.974) demonstrated lower between-session reliability than 1RM (CV = 3.48%, ICC = 0.989), its reliability was still at an acceptable level. Furthermore, the 1RM/L_0 ratio showed acceptable between-subjects variability (CV = 6.39%). Consequently, L_0 could serve as an alternative reference for prescribing training intensity in place of the 1RM. Both the %1RM-MV and %L_0-MV relationships were found to be valid for monitoring training intensity in the high-intensity range (absolute error ≤ 4.05%, at around 80% and 90%1RM) but not in the low-intensity range (absolute error ≥ 6.31%, from 40% to 70%1RM). Although not a complete replacement for the 1RM, the %L_0 - MV relationship still offers a practical and convenient method for monitoring deadlift training in high-intensity range (above 80%1RM), particularly in settings where frequent assessments are required.

Key words: Exercise intensity, neuromuscular function, physical training, training intensity, velocity-based training.

Introduction

Neuromuscular adaptations to resistance training are influenced by several factors, including exercise selection, training intensity, number of repetitions performed, lifting velocity, and other related variables (Andersen et al., 2010; Iglesias-Soler et al., 2021; Kraemer and Ratamess, 2004). Among these factors, training intensity, commonly defined as the load lifted relative to an individual's maximal dynamic strength, plays a crucial role in determining long-term training adaptations (Suchomel et al., 2021; Wernbom et al., 2007). Traditionally, resistance training intensity has been regulated and monitored using a percentage of one repetition maximum (%1RM). However, directly measuring the 1RM involves an incremental load testing procedure until failure, which is time-consuming and may induce additional neuromuscular fatigue that could hinder subsequent training performance (Chen et al., 2023; 2025; Fonseca et al., 2020). Additionally, fluctuations in 1RM could occur as a result of training- and non-training-related stressors such as nutrition, sleep, or daily stress, potentially resulting in inaccurate short-term %1RM monitoring (Byrd and Bergstrom, 2018; Grgic et al., 2020). Therefore, there is a need to develop alternative methods to overcome the limitations of the traditional %1RM-based approach.

Given the limitations of the traditional %1RM approach, the individual load-velocity (L-V) relationship has been proposed as an alternative (González-Badillo and Sánchez-Medina, 2010; García-Ramos, 2024). This approach leverages the nearly perfect linear relationship between mean velocity (MV) and training intensity (i.e., the %1RM-MV relationship) (Benavides-Ubric et al., 2020; Greig et al., 2023; García-Ramos, 2024). It enables real-time adjustments, potentially ensuring a more precise alignment between the intended and actual resistance training stimulus compared with the traditional %1RM approach (Banyard et al., 2019; Weakley et al., 2020). However, this method still requires direct 1RM measurement to determine the relative load. Although some researchers have proposed predictive models for estimating 1RM, their accuracy remains a topic of debate (Greig et al., 2023), which complicates the monitoring process. Developing a method to accurately monitor training intensity without relying on 1RM measurement or prediction remains an active research goal.

L-V relationship variables may provide a solution to monitoring training intensity. These variables were initially introduced to assess key indicators of maximal neuromuscular capacities, including maximal force generation through the load-intercept (L_0), maximal velocity generation via the velocity-intercept (v_0), and maximal power generation, represented by the area under the L-V relationship line (A_{line}) (Miras-Moreno et al., 2023; Pérez-Castilla et al., 2022; Pérez-Castilla et al., 2021b). Since L_0 is the load-intercept derived from the regression of submaximal loads, it could potentially serve as an alternative to 1RM for prescribing training intensity. Jidovtseff et al. found a nearly perfect correlation between L_0 and 1RM during the bench press in Paralympic athletes (2011). Fitas et al. (2024a; 2024b; 2025) demonstrated high between-session reliability of L_0 in the free-weight back squat. Furthermore, Aidar et al. (2022) and Hughes et al. (2019) reported that 1RMs estimated by L_0 through the ratio between 1RM and L_0 have acceptable between-session reliability in the free-weight bench press for Paralympic athletes and in the back squat for well-trained males. These findings support the potential use of the %L_0 - MV relationship for prescribing and monitoring training intensity in different populations.

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This approach may further simplify testing and data processing procedures, as constructing a %1RM-MV relationship still requires either direct measurement or indirect prediction of 1RM (Gomes et al., 2024). The feasibility of using L_0 in place of 1RM for prescribing training intensity depends on its stability as a reference metric, indicated by consistent 1RM/L_0 ratios across sessions and individuals (Aidar et al., 2022; Hughes et al., 2019; Jidovtseff et al., 2011).

Therefore, the main aims of this study were (1) to explore the between-session reliability and between-subjects variability of deadlift L-V relationship variables (L_0, v_0, and 1RM/L_0 ratio); (2) to compare the between-session reliability and validity of prescribing training intensity using the %L_0 - MV relationship and %1RM-MV relationship in the conventional deadlift. Based on previous research, we hypothesized that (1) all L-V relationship variables would demonstrate acceptable between-session reliability; (2) the %L_0 - MV relationship and %1RM-MV relationship would be equally effective in monitoring the training intensity.

Methods

Participants

A priori sample size calculation was conducted using G*Power 3.1.9.6. The calculation used an effect size (ES) of 0.25, an alpha level of 0.05, a statistical power of 0.80, two groups, five measurements, and a correlation among repeated measures of 0.5. The calculation revealed that a total sample size of 22 participants was sufficient for the postulated effects. Fifteen males (age = 23.7 ± 3.1 years; body mass = 80.3 ± 7.8 kg; body height = 1.80 ± 0.06 m; self-reported 1RM = 177.0 ± 31.1 kg; measured 1RM in the Session 1 = 176.5 ± 35.5 kg; Session 2 = 174.3 ± 36.6 kg) and fifteen females (age = 22.4 ± 2.2 years; body mass = 61.7 ± 6.0 kg; body height = 1.72 ± 0.05 m; self-reported 1RM = 103.5 ± 11.5 kg; measured 1RM in the Session 1 = 103.9 ± 11.7 kg; Session 2 = 108.7 ± 13.4 kg) were recruited to participate in this research. All participants had previously undergone professional sports training, including track and field, basketball, and football. All participants had a minimum of three years of resistance training experience, with a verified deadlift 1RM exceeding 1.5 times their body mass, tested within the previous month. Participants reported no physical limitations, health issues, or musculoskeletal injuries that could affect testing. Participants were instructed to refrain from additional strenuous exercise throughout the study. Before participation, all participants provided written informed consent, and the study protocol was approved by the Institutional Review Board of the local ethics committee, adhering to the principles of the Declaration of Helsinki.

Study design

A repeated-measures design was employed to examine the feasibility of the %L_0 - MV relationship in monitoring training intensity during the conventional deadlift. Participants completed two experimental sessions, performing lifts at approximately 40%, 60%, 70%, 80%, and 90%1RM, followed by actual 1RM attempts. The rest period between sessions ranged from three to seven days. Each testing session was conducted at the same time of day for each participant (±1 hour) under consistent environmental conditions (~21°C and ~60% humidity).

Testing procedure

All testing sessions utilized a 20 kg Olympic barbell and standard weight plates with a diameter of 45 cm. Body height and body mass were measured at the beginning of the first visit. Participants then completed a standardized warm-up, consisting of 3 minutes of cycling, a series of lower-limb dynamic stretching exercises, and light-load deadlifts. After a 3-minute rest, participants performed an incremental load testing protocol using five loads (40%, 60%, 70%, 80%, and 90%1RM) at maximal intended velocity. This load range was selected because it represented the commonly reported reliable intensity zone for the deadlift exercise (Benavides-Ubric et al., 2020; Jukic et al., 2020). Two repetitions were performed at light loads (40%, 60%, and 70%1RM), while a single repetition was performed at heavy loads (80% and 90%1RM). Following the incremental load test, participants were given up to five attempts to determine their 1RM, lifting progressively heavier loads in increments of 0.5 to 5 kg until their actual 1RM was reached or the technique deviated significantly from the technical model (i.e., a rounded lower or upper back, or no full extension of hips and knees at the top position, or initial full knee followed by hip extension). The conventional deadlift technique was performed by all participants. If participants failed an attempt, they were allowed to retry. The reference 1RM in Session 1 was based on participants' self-reported current 1RM, whereas that of Session 2 was determined from the 1RM test conducted in Session 1. This selection was made to examine whether the training intensity predicted by the %L_0 - MV relationship differed from that determined using the %1RM - MV relationship, particularly in situations where the actual 1RM was unknown. The difference between self-reported 1RM and the 1RM measured in Session 1 was less than 12 kg for all participants (the absolute difference was 3.9 ± 4.4 kg for male participants and 5.0 ± 3.9 kg for female participants). The testing loads and velocity were listed in Table 1. Rest intervals were set at 10 seconds between repetitions and 3 to 5 minutes between different loads.

Data acquisition and analysis

The MV (i.e., the mean velocity from the beginning of the concentric phase until the load reached its maximum height) of the barbell was measured with a linear position transducer (GymAware PowerTool, Kinetic Performance Technologies, Canberra, Australia) (Weakley et al., 2021). The fastest MV for each load was recorded to establish, for each testing session and each individual, three linear regression models: (i) Absolute load-MV relationship: Absolute testing loads were regressed against their corresponding MVs; (ii) %1RM-MV relationship: Absolute testing loads were first converted to training intensities (%1RM) based on the measured 1RM within the same session, using the formula *absolute testing load/1RM × 100*, and then regressed against the corresponding MVs; (iii) %L_0 - MV relationship: Absolute testing loads were first converted to

Table 1. Characteristics of the testing load and different load-velocity relationship models.

			Load 1	Load 2	Load 3	Load 4	Load 5	1RM	Model	%1RM-MV relationship	%L_0-MV relationship
Male	Session 1	Load (kg)	63.3 ± 13.7	92.5 ± 10.9	117.0 ± 18.3	137.3 ± 24.0	159.3 ± 28.0	176.5 ± 35.5	Slope (s· m^{-1})	-0.85 ± 0.17	-0.67 ± 0.09
		Velocity (m·s^{-1})	1.05 ± 0.15	0.88 ± 0.12	0.73 ± 0.10	0.58 ± 0.08	0.40 ± 0.08	0.25 ± 0.06	Intercept (%L_0)	1.26 ± 0.11	1.00 ± 0.00
	Session 2	Load (kg)	65.8 ± 10.8	95.0± 10.0	120.8 ± 21.5	139.0 ±24.1	162.9 ± 25.4	174.3 ± 36.6	Slope (s· m^{-1})	-0.79 ± 0.07	-0.63 ± 0.07
		Velocity (m·s^{-1})	1.06 ± 0.10	0.88 ± 0.08	0.71 ± 0.08	0.58 ± 0.06	0.40 ± 0.05	0.25 ± 0.06	Intercept (%L_0)	1.24 ± 0.09	1.00 ± 0.00
Female	Session 1	Load (kg)	40.0 ± 3.7	58.5 ± 5.0	73.2 ± 8.4	82.7 ± 10.1	93.4 ± 10.3	103.9 ±11.7	Slope (s· m^{-1})	-0.90 ± 0.10	-0.70 ± 0.06
		Velocity (m·s^{-1})	0.98 ± 0.09	0.81 ± 0.08	0.65 ± 0.06	0.53 ± 0.07	0.40 ± 0.05	0.27 ± 0.03	Intercept (%L_0)	1.28 ± 0.05	1.00 ± 0.00
	Session 2	Load (kg)	41.8 ± 4.4	61.5 ± 6.7	72.0 ± 7.8	81.0 ± 10.4	93.2 ± 10.8	108.7 ± 13.4	Slope (s· m^{-1})	-0.87 ± 0.11	-0.68 ± 0.06
		Velocity (m·s^{-1})	1.01 ± 0.07	0.82 ± 0.07	0.71 ± 0.08	0.60 ± 0.08	0.47 ± 0.08	0.28 ± 0.04	Intercept (%L_0)	1.28 ± 0.07	1.00 ± 0.00

1RM, one repetition-maximum; MV, mean velocity; L_0, load-intercept.

training intensities (%L_0) based on L_0, using the formula *absolute testing load/L_0 × 100*, and then regressed against the corresponding MVs.

For the reliability analysis of the L-V relationship variables, we selected L_0, v_0, and the 1RM/L_0 ratio as the primary indicators, while A_{line} was excluded because it was less relevant to the present topic of training intensity monitoring. L_0 represented the intercept on the load axis, v_0 was calculated as L_0/*slope*, and the 1RM/L_0 ratio was calculated as (1RM/L_0) × 100%.

The reliability of the velocity-based methods in monitoring training intensity was assessed by calculating the MVs corresponding to a series of predefined training intensities (%1RM or %L_0). Specifically, intensities ranging from 40% to 90%1RM and from 30% to 70%L_0 in 5% increments were entered into the respective %1RM-MV and %L_0-MV regression equations to obtain predicted MVs. The 40 - 90%1RM range was selected because it represents the most commonly used training-intensity zone for the conventional deadlift, whereas the 30 - 70%L_0 range was chosen to reflect the corresponding relative-load range observed in the present dataset when expressed as %L_0.

For the validity analysis, absolute testing loads from Session 2 were converted to %1RM and %L_0 using the Session 2 measured 1RM and calculated L_0, respectively. The MVs corresponding to these testing loads were then entered into the %1RM-MV and %L_0 - MV regression equations derived from Session 1 to estimate training intensity. The validity was evaluated by comparing the predicted training intensity with the actual training intensity from Session 2 for the same testing loads (from Load 1 to Load 5). This analytical strategy was adopted because it mirrors the practical application of velocity-based methods for monitoring training intensity, in which the measured MV was entered into a pre-established regression equation to estimate the corresponding training intensity.

Statistical analysis

The normal distribution of the variables was confirmed by the Shapiro-Wilk test ($p > 0.05$). The within-subject coefficient of variation (within-subject CV = standard error of measurement/subjects' mean score × 100) and intraclass correlation coefficient (ICC; model 3.1) with their corresponding 95% confidence intervals were used to assess the between-session reliability of measured 1RM, L-V relationship variables (L_0, v_0, and 1RM/L_0 ratio), and velocity-based training intensity prescribing methods (%1RM-MV relationship and %L_0-MV relationship). The goodness of fit for the individual load-velocity regression models was quantified by the coefficient of determination (R^2).A two-way repeated-measures analysis of variance (ANOVA) with the factors Load [Load 1 vs. Load 2 vs. Load 3 vs. Load 4 vs. Load 5] and Method [%1RM-MV relationship vs. %L_0 - MV relationship] was applied to compare the absolute difference between the actual and predicted training intensities of the absolute testing loads from Session 2. The absolute percentage difference was calculated as: *|(actual intensity - predicted intensity)/ actual intensity|* × *100*, with an acceptable predictive validity defined as an average value below 5%. The Greenhouse-Geisser correction was used when Mauchly's sphericity test was violated, and pairwise differences were identified using Bonferroni *post hoc* corrections. The accuracy of velocity-based methods in prescribing training intensity was assessed using Bland-Altman analysis. Acceptable reliability was determined as a CV < 10% and ICC > 0.700 (Hopkins et al., 2009, Miras-Moreno et al., 2023). Low between-subject variability was set as CV < 10%. The smallest important ratio between 2 CVs was considered to be higher than 1.15 (Miras-Moreno et al., 2023). All statistical analyses were performed using SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA), and statistical significance was set at an alpha level of 0.05.

Results

The %L_0-MV and %1RM-MV relationships demonstrated a very high goodness of fit across sessions and sexes ($R^2 = 0.98 \pm 0.02$) (Table 2). Figure 1 illustrates all the tested points of %L_0 and the corresponding MV. Figure 2 shows the position of 1RM on the L-V relationship.

All variables demonstrated acceptable reliability (CV ≤ 4.98% and ICC ≥ 0.817). 1RM and 1RM/L_0 ratio demonstrated a better reliability compared with L_0 and v_0 based on within-subject CV (CV_{ratio} = 1.33 to 1.65). The %1RM-MV relationship (Table 3) and the %L_0-MV relationship also revealed acceptable reliability (CV ≤ 5.97% and ICC ≥ 0.841). The between-session reliability of the %L_0-MV relationship remained consistent. Generally, the %1RM - MV relationship showed a better reliability at moderate loads compared with lighter and heavier loads. The %1RM - MV relationship demonstrated the highest reliability at the 65%1RM intensity (CV = 3.43%) and the lowest reliability at 90%1RM (CV = 5.97%)(Table 4). However, the %L_0 - MV relationship showed poorer reliability compared with the %1RM - MV relationship from 40% to 80%1RM (CV_{ratio} = 1.18 to 1.45), while it showed better reliability at 90%1RM (CV_{ratio} = 1.20).

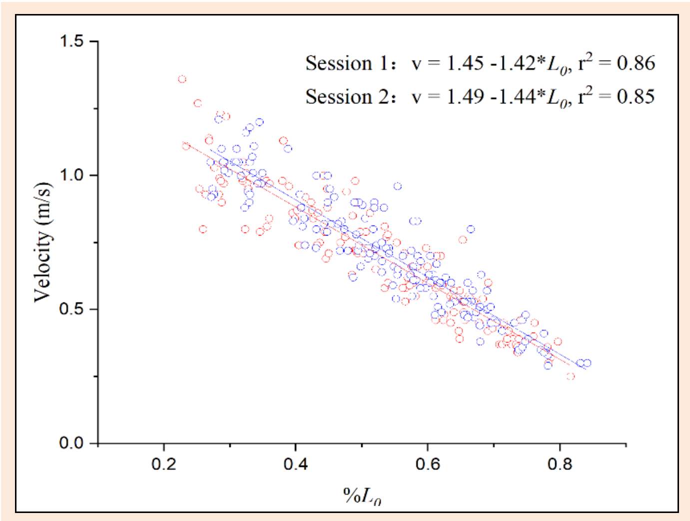

Figure 1. The load-velocity relationship in different sessions (red line and point for Session 1, blue line and point for Session 2).

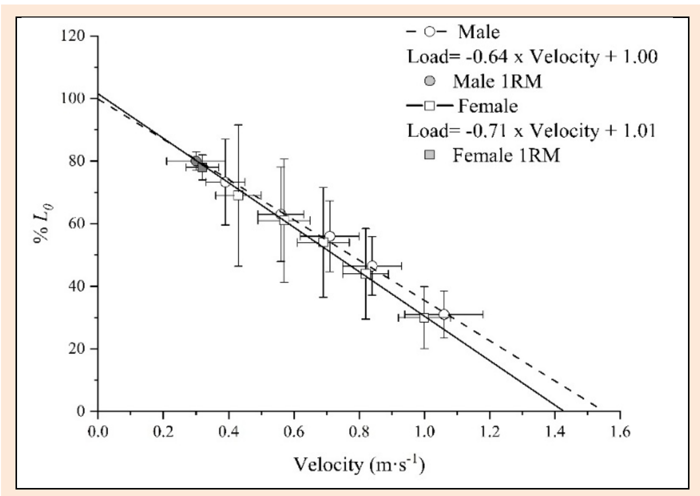

Figure 2. Load-intercept (L_0)-mean velocity relationship and the position of one repetition maximum (1RM) on the load-velocity relationship profile.

Table 2. Between-session reliability of load-velocity (L-V) relationship variables and one-repetition maximum (1RM) during the deadlift exercise.

Variables	Session 1	Session 2	Within-subjects CV (95% CI) (%)	ICC (95% CI)	Between-subjects CV (%)
1RM (kg)	140.5 ± 45.3	141.5 ± 43.0	3.48 (2.77, 4.68)	0.989 (0.976, 0.995)	**30.70**
L_0 (kg)	177.9 ± 54.7	176.8 ± 50.0	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	**28.86**
v_0 (m·s^{-1})	1.49 ± 0.17	1.55 ± 0.17	4.64 (3.69, 6.23)	0.838 (0.687, 0.919)	**10.52**
1RM/L_0 ratio (kg·kg^{-1})	78.9 ± 5.4	79.9 ± 5.5	3.01 (2.40, 4.05)	0.817 (0.651, 0.908)	6.39

CV = coefficient of variation; 95% CI = 95% confidence interval; ICC = intraclass correlation coefficient;1RM, one repetition maximum; L_0, load-intercept; v_0, velocity-intercept. Bold numbers indicate an unacceptable reliability (ICC < 0.70) or variability (CV > 10%).

Table 3. The percentage of one-repetition maximum (%1RM) and mean velocity (MV) relationship and its between-session reliability.

Variables	Session 1 ($m \cdot s^{-1}$)	Session 2 ($m \cdot s^{-1}$)	Within-subjects CV (95% CI) (%)	ICC (95% CI)	SDC ($m \cdot s^{-1}$)	Between-subjects CV (%)
40%	1.02 ± 0.10	1.05 ± 0.10	3.80 (3.02, 5.10)	0.853 (0.714, 0.927)	0.16	9.13
45%	0.96 ± 0.09	0.99 ± 0.09	3.68 (2.93, 4.95)	0.856 (0.719, 0.929)	0.10	8.95
50%	0.90 ± 0.08	0.93 ± 0.08	3.57 (2.85, 4.80)	0.859 (0.725, 0.930)	0.09	8.81
55%	0.84 ± 0.08	0.86 ± 0.08	3.48 (2.77, 4.68)	0.862 (0.730, 0.932)	0,08	8.71
60%	0.78 ± 0.07	0.80 ± 0.07	3.44 (2.73, 4.61)	0.864 (0.735, 0.933)	0.07	8.70
65%	0.72 ± 0.07	0.74 ± 0.07	3.43 (2.73, 4.61)	0.866 (0.738, 0.934)	0.07	8.84
70%	0.66 ± 0.06	0.68 ± 0.06	3.53 (2.81, 4.74)	0.866 (0.737, 0.934)	0,06	9.18
75%	0.60 ± 0.06	0.62 ± 0.06	3.76 (3.00, 5.06)	0.863 (0.732, 0.932)	0.06	9.84
80%	0.55 ± 0.06	0.55 ± 0.06	4.20 (3.34, 5.64)	0.857 (0.721, 0.929)	0.06	**10.95**
85%	0.49 ± 0.06	0.49 ± 0.06	4.90 (3.91, 6.59)	0.849 (0.707, 0.925)	0.06	**12.69**
90%	0.43 ± 0.06	0.43 ± 0.06	5.97 (4.76, 8.03)	0.841 (0.692, 0.921)	0.07	**14.93**

CV = coefficient of variation; 95% CI = 95% confidence interval; ICC intraclass correlation coefficient; SDC, Smallest Detectable Change; Bold numbers indicate an unacceptable reliability (ICC < 0.70) or variability (CV > 10%).

Table 4. The percentage of load-intercept (%L_0) and mean velocity (MV) relationship and its between-session reliability.

Intensity	Session 1 ($m \cdot s^{-1}$)	Session 2 ($m \cdot s^{-1}$)	Within-subjects CV (95% CI) (%)	ICC (95% CI)	SDC ($m \cdot s^{-1}$)	Between-subjects CV (%)
30%	1.04 ± 0.12	1.08 ± 0.12	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0.06	10.52
35%	0.97 ± 0.11	1.00 ± 0.11	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0.05	10.52
40%	0.89 ± 0.10	0.93 ± 0.10	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0.05	10.52
45%	0.82 ± 0.09	0.85 ± 0.10	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0.04	10.52
50%	0.74 ± 0.09	0.77 ± 0.09	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0.04	10.52
55%	0.67 ± 0.08	0.69 ± 0.08	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0.04	10.52
60%	0.60 ± 0.07	0.62 ± 0.07	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0.03	10.52
65%	0.52 ± 0.06	0.54 ± 0.06	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0,03	10.52
70%	0.45 ± 0.05	0.46 ± 0.05	4.98 (3.97, 6.69)	0.974 (0.945, 0.987)	0,02	10.52

CV = coefficient of variation; 95% CI = 95% confidence interval; ICC = intraclass correlation coefficient; SDC, Smallest Detectable Change. Bold numbers indicate an unacceptable reliability (ICC < 0.70) or variability (CV > 10%).

Table 5. Comparison of the validity of %load-intercept (L_0)-mean velocity (MV) relationship and %one repetition maximum (1RM)-MV relationship in monitoring training intensity.

Testing load	%1RM-MV relationship (%)	%L_0-MV relationship (%)
Load 1	10.09 ± 9.05	11.84 ± 10.09#
Load 2	6.36 ± 4.75	7.75 ± 5.86#
Load 3	6.31 ± 3.69	7.35 ± 3.97#
Load 4	3.40 ± 2.92	4.05 ± 3.08
Load 5	2.44 ± 2.90	2.39 ± 2.04

significantly higher percentage errors compared with %1RM-MV relationship in the give load.

Significant effects of load ($F = 14.509$, $p < 0.001$) and method ($F = 9.085$, $p = 0.005$) were found, though there was no significant interaction effect ($F = 1.851$, $p = 0.124$). The pairwise comparisons between the methods under different loads revealed that the %1RM-MV relationship produced significantly smaller percentage differences than the %L_0- MV relationship for Loads 1, 2, and 3 ($p \leq 0.031$), but not for Loads 4 and 5 ($p \geq 0.139$) (Table 5). Loads 4 and 5 were the only two loads that showed acceptable predictive validity. Specifically, both the %L_0- MV relationship (absolute percentage difference ≤ 4.05%) and %1RM - MV relationship (absolute percentage difference ≤ 3.40%) methods were valid at high intensities (from 80% to 90%1RM), but not at lower intensities (from 40% to 70%1RM). Bland-Altman plots for the two methods are presented in Figure 3. Proportional bias was observed in Load 1 for both methods, but not in the heavier loads.

Discussion

This study explored the feasibility of using L-V relationship variables for monitoring resistance training intensity in the deadlift exercise. The main findings support the application of deadlift L-V relationship variables: (1) the L-V relationship demonstrated a very high goodness of fit across sessions; (2) L-V relationship variables and 1RM showed acceptable reliability; (3) while both %L_0- MV relationship and %1RM-MV relationship showed acceptable reliability, the %L_0- MV relationship showed better reliability at 90%1RM but poorer reliability from 40% to 80%1RM; (4) the predictive validity based on the %L_0- MV and the %1RM-MV relationships was only acceptable and comparable at Loads 4 and 5, when the load was above 80%1RM and 65%L_0, respectively.

Ensuring that the variables used to monitor an athlete's training intensity demonstrate acceptable reliability is crucial (Hopkins, 2000). Specifically, the within-subject CV reflects absolute reliability, indicating the consistency of an individual's scores across repeated measurements, while the ICC assesses the reliability of ranking within a group (Miras-Moreno et al., 2023). All variables demonstrated acceptable reliability, which underpins the application of the deadlift %L_0- MV relationship for monitoring training intensity. These findings suggest that L_0 could potentially be used to determine training intensity. Furthermore, compared to 1RM testing, the L_0 test induced less fatigue and carried a lower risk of injury. However, L_0 demonstrated inferior between-session reliability compared to 1RM. A possible explanation is that the absolute loads used during the two testing sessions were not perfectly identical, which might have introduced variability in the modeling of the L-V relationship and consequently affected the value of the L_0 estimate. Previous studies have similarly reported that L_0 was highly sensitive to the specific load selection and the number of data points included when modeling the L-V relationship (Li et al., 2025). In contrast, the 1RM measure was not susceptible to such methodological influences. It should be noted, however, that although the between-session reliability of L_0 was lower than that of 1RM, it still provided sufficient reliability for monitoring training intensity in practice. This method could still be a good option for athletes who are comfortable with a little more variation in measurements (within-session CV < 5%), since it did not require direct 1RM testing and still offered reliable results. The 1RM/L_0 ratio could be used to accurately convert intensity levels between these two testing methods. The 1RM/L_0 ratio exhibited consistently low within-subject and between-subject CVs, further suggesting that 1RM could serve as a general fixed reference point within the L-V relationship between different individuals.

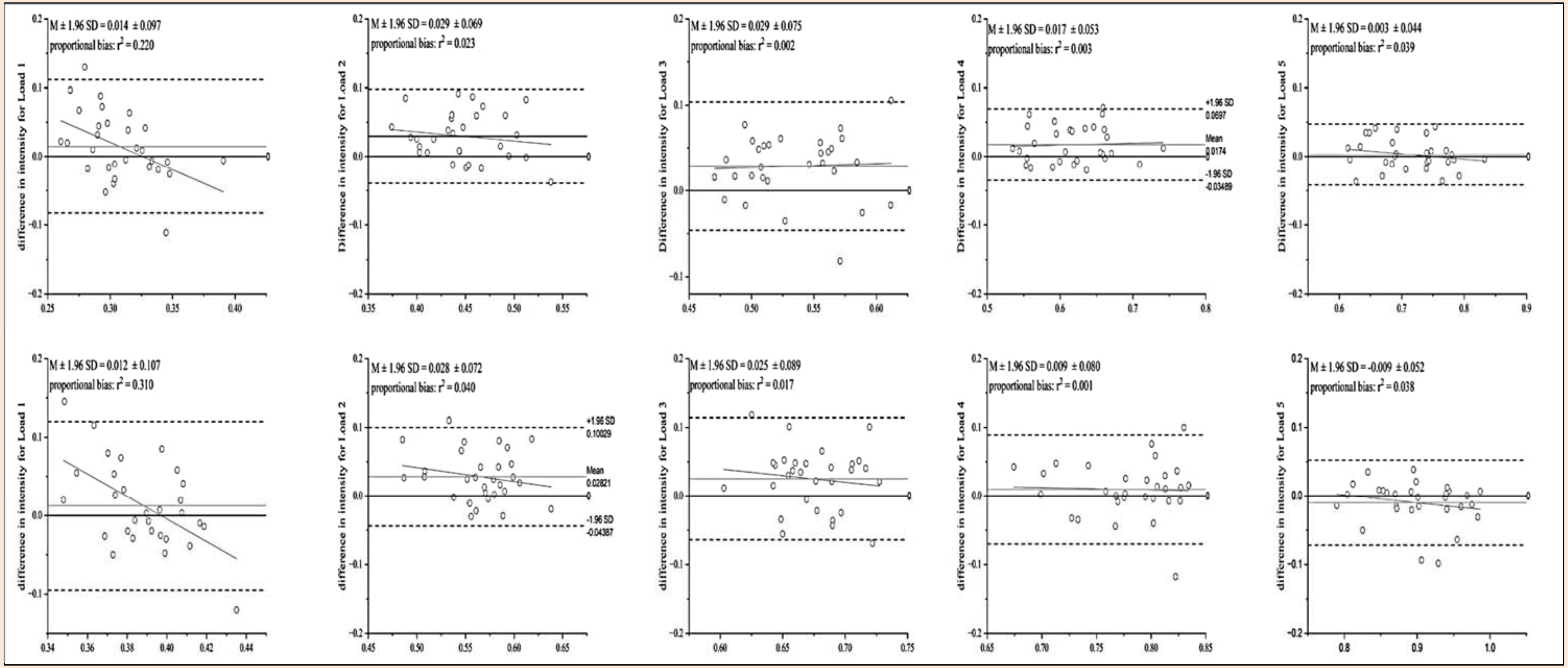

Figure 3. Bland-Altman plots illustrating the agreement between predicted and actual loads for the %1RM-MV relationship (upper panel) and the %L_0-MV relationship (lower panel) across progressively increasing load intensities (left to right). L_0, load-intercept; 1RM, one repetition maximum; R^2, coefficient of determination.

Previous studies have shown that the theoretical velocity corresponding to the 1RM point remains reliable within the L-V relationship (García-Ramos, 2023a) and demonstrated low between-subject variability (8.5% for the squat in male athletes) (Chen et al., 2025). This stability indicated that the distance between 1RM and L_0 could be represented as a stable value on the velocity-axis, reinforcing the notion that the 1RM/L_0 ratio remained stable. Our findings further supported this by demonstrating that the ratio of 1RM/L_0 could be considered a relatively stable value. This consistency suggested that L_0 was not only an indicator of maximal force but could also be used, in conjunction with its ratio to 1RM, as a basis for prescribing training intensity.

Both the %1RM-MV and %L_0 - MV relationships demonstrated acceptable reliability. Since L_0 could be considered one endpoint of the %1RM - MV relationship, its reliability remained consistent across both low and high intensities. This represented an advantage over the %1RM-MV relationship, where the within-session CV increased markedly by a factor of 1.74 as the load increased from 65% to 90%1RM. This phenomenon had been previously observed in studies on exercises such as the bench pull (García-Ramos et al., 2019) and bench press (García-Ramos et al., 2018). A plausible explanation is that the 1RM itself is inherently variable. As the intensity approached maximum effort, this variability exerted a greater influence. In contrast, the variability in the %1RM-MV relationship at lower intensities was more affected by the intercept L_0, while heavier intensities were affected by both the variability of 1RM and L_0. Consequently, the %1RM-MV relationship demonstrated lower reliability than the %L_0 - MV relationship at higher intensities, whereas it retained an advantage in reliability at lower intensities. This indicates that both the %L_0 - MV and %1RM-MV relationships possess distinct advantages: the %1RM-MV relationship offers greater reliability for monitoring low to moderate intensities, whereas the %L_0 - MV relationship demonstrates superior stability at higher intensities and does not require direct 1RM testing.

Regarding the validity of monitoring training intensity, we found acceptable validity at high intensities rather than at lower intensities, with the %1RM-MV relationship demonstrating superior validity over the %L_0 - MV relationship. Specifically, at approximately 40% to 70%1RM (corresponding to around 32% to 57%L_0), the errors exceeded acceptable limits. This discrepancy could be attributed to the closer proximity of higher training intensities to the target point, resulting in smaller velocity errors, whereas lighter training intensities, being farther from the target point, led to larger errors (García-Ramos, 2023b). A similar rationale could be applied to explain why the 1RM-based method demonstrated greater validity and accuracy than the L_0-based method, as 1RM was closer to the target intensity compared with L_0. However, all methods demonstrated acceptable validity and no significant difference was found between these two methods at higher intensities above 80%1RM and 65%L_0. A possible explanation is that under high-intensity conditions, the training intensity was sufficiently close to both target points, which resulted in minimal and negligible error originating from these reference values. Consequently, both the %L_0 -MV and %1RM - MV relationships could be effectively used for monitoring training intensity at high intensities above 80%1RM and 65%L_0. However, velocity-based methods may not be ideal for monitoring training at low intensities.

When interpreting the findings of this study, the following limitations should be considered. This study aimed to determine training intensity through L-V relationship variables, especially L_0. However, our L-V relationship modeling was still anchored to the 1RM. Future research should explore the validity of establishing L-V relationship variables without relying on 1RM testing to determine training intensity. Additionally, as the findings of this study were derived from well-trained athletes, caution should be exercised when generalizing the results to other populations, such as resistance training enthusiasts or untrained individuals. Lastly, the application of L_0 in monitoring training intensity has only been established for the conventional deadlift exercise, and its applicability to other exercises remains unclear.

Conclusion

Both 1RM and L_0 were reliable for prescribing training intensity and demonstrated effectiveness in monitoring deadlift training intensity at high intensities. Importantly, the %L_0 - MV relationship offered a practical advantage, as it could be established via an incremental load test without requiring a separate 1RM assessment. Consequently, L_0 could serve as a practical substitute for the traditional %1RM approach in settings where maximal strength testing is impractical.

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Key points

- The one repetition maximum (1RM)/load-intercept (L_0) ratio demonstrates acceptable between-subject variability in deadlift, which supports its usefulness as a general reference metric for intensity prescription at high intensities (above 80%1RM and 65%L_0).
- Both the %1RM-mean velocity (MV) and %L_0-MV relationships can be applied to accurately predict training intensity during the deadlift at higher intensities above 80%1RM and 65%L_0, whereas their predictive accuracy diminishes at lower intensities
- Although L_0 was not as reliable as the 1RM, L_0 can still be used to reliably and practically monitor training intensity in male and female athletes at high intensities, offering an alternative method to traditional 1RM testing.

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