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Number of Repetitions Performed Before and After Reaching Velocity Loss Thresholds: First Repetition Versus Fastest Repetition—Mean Velocity Versus Peak Velocity

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Purpose: To explore the effect of several methodological factors on the number of repetitions performed before and after reaching certain velocity loss thresholds (VLTs). ***Method:*** Fifteen resistance-trained men (bench press 1-repetition maximum = 1.25 [0.16] $kg \cdot kg^{-1}$) performed with maximum intent a total of 182 sets (77 short sets [≤12 repetitions] and 105 long sets [>12 repetitions]) leading to failure during the Smith machine bench press exercise. Fifteen percent, 30%, and 45% VLTs were calculated, considering 2 reference repetitions (first and fastest repetitions) and 2 velocity variables (mean velocity [MV] and peak velocity [PV]). ***Results:*** The number of repetitions performed before reaching all VLTs were affected by the reference repetition and velocity variable ($P \leq .001$). The fastest MV and PV during the short sets (75.3%) and PV during the long sets (72.4%) were predominantly observed during the first repetition, while the fastest MV during long sets was almost equally distributed between the first (37.1%) and second repetition (40.0%). Failure occurred before reaching the VLTs more frequently using PV (4, 8, and 33 occasions for 15%, 30%, and 45% VLTs, respectively) than MV (only 1 occasion for the 45% VLT). The participants rarely produced a velocity output above a VLT once this threshold was exceeded for the first time (≈10% and 30% of occasions during the short and long sets, respectively). ***Conclusions:*** The reference repetition and velocity variable are important factors to consider when implementing VLTs during resistance training. The fastest repetition (instead of the first repetition) and MV (instead of PV) are recommended.

Keywords: bench press, fatigue, training prescription, velocity-based training

Resistance training (RT) is an effective method to induce neuromuscular adaptations, which are beneficial for both athletic performance and health.[1,2] It is known that the neuromuscular adaptations induced by RT strongly depend on the manipulation of the RT program variables.[3] The intensity (i.e., load lifted), volume (i.e., number of sets and repetitions performed), and lifting tempo (i.e., maximal velocity or intentionally slower) are all critical variables to consider when designing RT programs.[4,5] Therefore, a recurring problem that practitioners must face is how to accurately prescribe and monitor these variables. A viable solution that is becoming increasingly popular among coaches and sport scientists consists of the recording of movement velocity during RT (i.e., velocity-based training).[6] Many studies have been conducted to refine the procedure for establishing the relationship between movement velocity and the relative load (i.e., percentage of the 1-repetition maximum [1RM]).[7–12] The available literature suggests that individualized load–velocity profiles (instead of group-averaged load–velocity profiles), mean velocity (MV) values (instead of other velocity variables, such as peak velocity [PV] or mean propulsive velocity [MPV]), and linear regressions (instead of polynomial regression models) allow for a more accurate prescription of relative loads during RT.[7–12] However, there is less scientific evidence on how movement velocity should be used to prescribe the training volume (i.e., number of sets and repetitions).

Before the emergence of velocity-based training, the most common approach was to assign a fixed predetermined number of repetitions for all individuals during sets performed against the same relative loads (%1RM).[13] However, given that the number of repetitions that can be completed with a fixed %1RM is both subject- and exercise-dependent,[14] assigning a fixed number of repetitions can result in different levels of effort experienced by individuals. Three different approaches have been proposed within the velocity-based training literature to solve this problem: (1) stopping the training set when a relative velocity loss threshold (VLT) is reached (e.g., 20% reduction in repetition velocity),[15–17] (2) stopping the training set when an absolute velocity threshold is reached (e.g., 0.35 $m \cdot s^{-1}$),[18,19] and (3) determining the relationship between the initial velocity of the set and the maximum number of repetitions that can be completed before failure.[19]

The vast majority of velocity-based training intervention studies have used VLTs to prescribe the volume of training.[16,20,21] An important point to consider is that the number of repetitions performed before reaching a given VLT could be affected by methodological factors, such as the reference repetition (first and fastest repetition of the set) or the velocity variable of choice (MV, MPV, and PV). Note that the initial repetition of the set might not always be the fastest,[22,23] a reduction in the ability to apply force at the beginning of the concentric phase should affect more MV and MPV than PV, and the differences between MV and MPV tend to increase as the movement velocity increases.[24] However,

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to our knowledge, no study has examined whether the reference repetition or the velocity variable has an effect on the number of repetitions performed before exceeding a given VLT.

The use of VLTs is justified by the close relationship between the relative loss of velocity in a set and the percentage of repetitions performed with respect to the total number of repetitions that can be completed before muscular failure.[17,25] In this regard, several equations have been proposed to predict the percentage of performed repetitions from VLTs in exercises such as the bench press,[17] pull-up,[25] and back squat.[26] However, an important point is that the experimental sessions of these studies consisted of a single set of repetitions to failure, which is not common in practice where multiple sets of the same exercise are frequently performed. Although it is known that performing successive sets of the same exercise may decrease the number of repetitions performed before reaching muscular failure regardless of the interset rest periods,[27] no study has explored whether the number of repetitions performed before reaching a given VLT could also be affected by the number of sets performed. Furthermore, all the aforementioned studies have analyzed MPV, and no study has established this relationship for MV or PV. Therefore, given that MV and PV are extensively used in research and practice,[6] it is important to elucidate whether the relationship between the percentage of completed repetitions and the magnitude of velocity loss remains stable when MV and PV are considered.

To address the research gaps outlined above, the velocity data of 182 sets leading to failure were collected during the Smith machine bench press exercise in a group of resistance-trained men. The primary objective of this study was to elucidate whether the number of repetitions performed before reaching a certain VLT is affected by the reference repetition (first vs fastest repetition of the set) and the velocity variable (MV vs PV). The secondary objectives were (1) to determine the repetition number in which the fastest MV and PV were obtained, (2) to explore the number of occasions in which the subjects reached failure before reaching the 15%, 30%, and 45% VLTs, (3) to determine the individual variability in the percentage of completed repetitions before exceeding the 15%, 30%, and 45% VLTs with respect to the total number of repetitions completed, and (4) to report the number of times that the subjects were able to produce an MV or PV above a VLT once this threshold was exceeded for the first time.

Method

Subjects

Fifteen resistance-trained men (age = 23.5 [2.2] y, body mass = 74.6 [8.2] kg, body height = 1.76 [0.08] m, touch-and-go bench press 1RM = 92.6 [12.7] kg, 1.25 [0.16] $kg \cdot kg^{-1}$) participated in this study. All subjects had at least 2 years of RT experience (4.9 [2.1] y) and reported to be experienced with both lifting at maximal velocity and lifting to failure. The subjects did not report any injury or discomfort that could affect bench press performance. All subjects signed a written informed consent form before the commencement of the study. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the University of Granada review board.

Study Design

A descriptive study was conducted to explore the effect of several methodological factors on the number of repetitions performed before and after reaching certain VLTs. All subjects were recreational lifters of a local gym. Data collection took place during a 3-week period in which the subjects followed their regular training. Only the sets performed to failure and with maximal intent from the first to the last repetition during the Smith machine bench press exercise were considered in the present study. Although all subjects reported to have experience with sets to failure during the Smith machine bench press exercise, the first session for each subject only served for familiarization purposes.

A total of 182 sets were recorded. The number of sets performed by each subject ranged from 7 to 17. The subjects were allowed to self-select the loads, and only the sets with a repetition range between 6 and 30 were considered for statistical analyses. For comparative purposes, the sets were divided into 2 groups: short sets (≤12 repetitions; 77 sets) and long sets (>12 repetitions; 105 sets). The bench press has been a staple exercise for both testing and training the upper body strength and power of athletes in many professional sports.[28,29] Short sets (XRM < 12 or %1RM > 70%1RM) are commonly used to increase maximal strength and promote hypertrophy, while longer sets (XRM > 12 or %1RM < 70%1RM) can be useful to develop the ability to repeat maximal power production when the successive repetitions of the set are performed with maximal intent.

Procedures

The warm-up, external loads, number of sets, grip width, and length of the interset rest periods were self-selected by the participants as they commonly do in their usual training. The bench press was the only exercise assessed in this study, and it was performed in a Ffittech Smith Machine (Ffittech, Taiwan, China) using the touch-and-go technique.[19] The subjects were allowed to include the Smith machine bench press exercise at any time of their training. The subjects were strongly encouraged to perform all repetitions of the bench press exercise as fast as possible and to complete the maximum possible number of repetitions before reaching muscular failure. The subjects were forbidden to rest between successive repetitions. A validated linear velocity transducer (T-Force System; Ergotech, Murcia, Spain) was attached to the bar of the Smith machine and sampled the velocity–time data at a frequency of 1000 Hz.[30] The MV and PV of all repetitions were collected. The 15%, 30%, and 45% VLTs were computed considering the velocity of the first repetition and fastest repetition of the set. These VLTs (15%, 30%, and 45%) could be associated with low, medium, and high levels of fatigue, respectively.

Statistical Analyses

The descriptive data are presented as means (SDs), while the CV is indicated as the median value and range. The Shapiro–Wilk test revealed a violation of the normal distribution assumption for all variables ($P > .05$). Consequently, the Friedman test was used to explore the differences among the conditions (fastest MV, first MV, fastest PV, and first PV) on (1) the number of repetitions performed (expressed in absolute values and as a percentage of the total number of repetitions completed in the set) before reaching the 15%, 30%, and 45% VLTs and (2) the number of times that the subjects produced an MV or PV above the 15%, 30%, and 45% VLTs after these VLTs were reached for the first time. The Wilcoxon signed-rank test with Bonferroni post hoc corrections was used for pairwise comparisons. Statistical analyses were performed using the software package SPSS (version 25.0; IBM Corp, Chicago, IL). Statistical significance was set at $P < .05$.

Results

During the short sets (≤12 repetitions), the fastest MV and PV were always observed among the first 3 repetitions (first repetition = 75.3%, second repetition = 22.1%, third repetition = 2.6%; Table 1). During long sets (>12 repetitions), the fastest PV was also predominantly observed at the first repetition (72.4%), but the fastest MV was almost equally distributed between the first (37.1%) and second repetition (40.0%).

Considering the MV values, the subjects never reached failure before reaching the 15% and 30% VLTs, and only in one occasion did they reach failure before reaching the 45% VLT (Table 2). However, considering the PV of the first repetition, the subjects reached failure before the 15%, 30%, and 45% VLTs on 4, 8, and 33 occasions, respectively.

The Friedman tests revealed a significant effect of the condition (fastest MV, first MV, fastest PV, and first PV) on the number of repetitions performed before reaching all VLTs for both the long and short sets ($P \le .001$; Table 3 and Figure 1). The number of repetitions performed before reaching the 15%, 30%, and 45% VLTs was higher for PV than for MV during the short sets, but it was higher for MV than for PV during the long sets. The use of the first repetition as the reference repetition resulted in a greater number of repetitions performed before reaching all VLTs

Table 1 Repetition Number at Which the Fastest Velocity Output Was Achieved

	≤12 repetitions (n = 77)		>12 repetitions (n = 105)		All (N = 182)	
Repetition	MV	PV	MV	PV	MV	PV
1	58 (75.3%)	58 (75.3%)	39 (37.1%)	76 (72.4%)	97 (53.3%)	134 (73.6%)
2	17 (22.1%)	17 (22.1%)	42 (40.0%)	24 (22.9%)	59 (32.4%)	41 (22.5%)
3	2 (2.6%)	2 (2.6%)	13 (12.4%)	3 (2.9%)	15 (8.2%)	5 (2.7%)
4	0 (0.0%)	0 (0.0%)	6 (5.7%)	1 (1.0%)	6 (3.3%)	1 (0.5%)
5	0 (0.0%)	0 (0.0%)	4 (3.8%)	0 (0.0%)	4 (2.2%)	0 (0.0%)
6	0 (0.0%)	0 (0.0%)	1 (1.0%)	1 (1.0%)	1 (0.5%)	1 (0.5%)

Abbreviations: MV, mean velocity; PV, peak velocity.

Table 2 Number of Occasions in Which Participants Reached Failure Before Reaching the 15%, 30%, and 45% Velocity Loss Thresholds

		≤12 repetitions (n = 77)			>12 repetitions (n = 105)			All (N = 182)		
Reference repetition	Variable	15%	30%	45%	15%	30%	45%	15%	30%	45%
First	MV	—	—	1	—	—	—	—	—	1
	PV	3	6	21	1	2	12	4	8	33
Fastest	MV	—	—	1	—	—	—	—	—	1
	PV	2	6	20	1	2	11	3	8	31

Abbreviations: MV, mean velocity; PV, peak velocity.

Table 3 Number of Repetitions Performed Before Reaching the 15%, 30%, and 45% Velocity Loss Thresholds

		≤12 repetitions (n = 77)			>12 repetitions (n = 105)			All (N = 182)		
Reference repetition	Variable	15%	30%	45%	15%	30%	45%	15%	30%	45%
First	MV	4.1 (1.4) [2–8] 33.7%	6.3 (1.4) [3–9] 22.1%	8.0 (1.5) [5–11] 18.5%	8.3 (3.1) [2–19] 36.7%	12.8 (3.5) [5–22] 27.2%	15.8 (3.3) [9–25] 21.0%	6.5 (3.2) [2–19] 49.8%	10.0 (4.3) [3–22] 42.5%	12.5 (4.7) [5–25] 37.7%
	PV	4.5 (1.7) [2–9] 38.5%	6.8 (1.9) [2–12] 28.3%	8.1 (1.9) [2–12] 23.0%	6.2 (2.3) [2–14] 36.3%	11.0 (2.9) [6–24] 26.4%	15.2 (3.5) [7–27] 23.1%	5.5 (2.2) [2–14] 40.3%	9.2 (3.3) [2–24] 35.7%	12.2 (4.6) [2–27] 37.5%
Fastest	MV	4.0 (1.2) [2–8] 31.0%	6.2 (1.3) [3–9] 21.4%	8.0 (1.5) [5–11] 18.6%	7.3 (2.4) [2–14] 32.7%	12.1 (3.2) [5–22] 26.4%	15.4 (3.2) [9–25] 20.8%	5.9 (2.6) [2–14] 43.7%	9.6 (3.9) [3–22] 40.7%	12.3 (4.5) [5–25] 36.8%
	PV	4.2 (1.5) [2–8] 34.9%	6.7 (1.9) [2–12] 28.3%	8.1 (1.9) [2–12] 23.1%	5.8 (1.9) [2–13] 32.1%	10.7 (2.6) [6–19] 24.5%	15.0 (3.4) [7–27] 22.9%	5.1 (1.9) [2–13] 36.6%	9.0 (3.1) [2–19] 34.0%	12.1 (4.5) [2–27] 37.2%

Abbreviations: MV, mean velocity; PV, peak velocity. Note: Values are presented as mean (SD), [range], and coefficient of variation.

compared with using the fastest repetition, with the differences being accentuated for the short sets. Regardless of the reference repetition, velocity variable, and length of the set, the variability in the number of repetitions performed before reaching the VLTs was always high (median coefficient of variance CV [range] = 26.4% [18.5%–38.5%]).

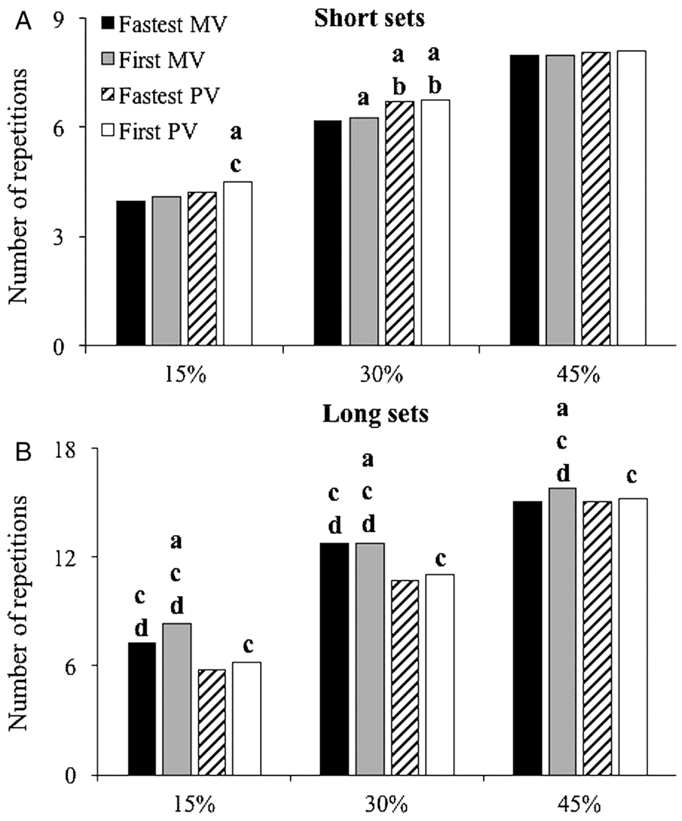

Figure 1 — Number of repetitions performed before reaching the 15%, 30%, and 45% velocity loss thresholds during (A) short sets (≤12 repetitions) and (B) long sets (>12 repetitions) ($P < .05$ with Bonferroni correction). SDs are depicted in Table 3. MV indicates mean velocity; PV, peak velocity. [a]Significantly higher than fastest MV. [b]Significantly higher than first MV. [c]Significantly higher than fastest PV. [d]Significantly higher than first PV.

The Friedman tests revealed significant differences between the conditions (fastest MV, first MV, fastest PV, and first PV) on the percentage of completed repetitions with respect to the maximum before exceeding the 15%, 30%, and 45% VLTs in both the long and short sets ($P \le .001$; Table 4 and Figure 2). The percentage of completed repetitions before reaching all VLTs was higher for PV than for MV during the short sets, but it was higher for MV than for PV during the long sets. Using the first repetition as the reference, repetition resulted in a greater percentage of completed repetitions for all VLTs than using the fastest repetition, with the differences being accentuated for the short sets. The variability in the percentage of repetitions performed with respect to the total number of repetitions completed was high for all VLTs and decreased for higher VLTs: 15% VLT (32.2% [26.2%–41.1%]), 30% VLT (19.1% [14.9%–23.6%], and 45% VLT (12.8% [9.9%–15.6%]).

The subjects rarely produced an MV or PV above a VLT once this threshold was exceeded for the first time (≈10% and 30% of occasions during the short and long sets, respectively; Table 5 and Figure 3). However, the Friedman tests revealed significant differences between the conditions during the short sets for the 15% VLT ($P = .002$) and 30% VLT ($P = .26$) and during the long sets for the 45% VLT ($P = .020$). The significant differences were caused by the higher number of repetitions performed above the VLTs, considering PV compared with MV. However, no significant differences were observed during the short sets for the 45% VLT ($P = 1.000$) and during the long sets for the 15% VLT ($P = .965$) and 30% VLT ($P = .911$).

Discussion

This study was designed to explore the effect of the reference repetition (first repetition vs fastest repetition) and the velocity variable (MV vs PV) on the number of repetitions performed before and after reaching 15%, 30%, and 45% VLTs. This study revealed 5 main findings. First, the fastest MV and PV during the short sets (≤12 repetitions) and PV during the long sets (>12 repetitions) were predominantly observed at the first repetition, while the fastest MV during the long sets was almost equally distributed between the first

Table 4 Percentage of Completed Repetitions Before Exceeding the 15%, 30%, and 45% Velocity Loss Thresholds With Respect to the Total Number of Repetitions Completed in the Set

		≤12 repetitions (n = 77)			>12 repetitions (n = 105)			All (N = 182)		
Reference repetition	Variable	15%	30%	45%	15%	30%	45%	15%	30%	45%
First	MV	45.6 (12.7) [18–80] 27.9%	70.1 (11.2) [43–100] 16.0%	89.6 (9.4) [64–100] 10.5%	44.0 (13.0) [13–73] 29.4%	67.1 (11.6) [38–86] 17.3%	83.7 (8.3) [55–100] 9.9%	44.7 (12.8) [13–80] 28.7%	68.4 (11.5) [38–100] 16.8%	86.2 (9.2) [55–100] 10.7%
	PV	50.8 (18.8) [18–100] 37.0%	75.7 (17.6) [22–100] 23.3%	90.6 (14.0) [22–100] 15.4%	33.8 (13.9) [12–100] 41.1%	58.6 (12.7) [33–100] 21.7%	80.6 (11.8) [54–100] 14.6%	41.0 (18.2) [12–100] 44.3%	65.9 (17.2) [22–100] 26.1%	84.8 (13.7) [22–100] 16.1%
Fastest	MV	44.4 (11.6) [18–67] 26.2%	69.0 (10.3) [43–89] 14.9%	89.5 (9.3) [64–100] 10.4%	39.0 (11.4) [13–62] 29.3%	63.9 (11.0) [38–86] 17.2%	81.9 (9.1) [41–100] 11.1%	41.3 (11.8) [13–67] 28.5%	66.1 (11.0) [38–89] 16.6%	85.1 (9.9) [41–100] 11.6%
	PV	47.8 (16.8) [18–100] 35.1%	75.2 (17.7) [22–100] 23.6%	90.3 (14.1) [22–100] 15.6%	31.8 (12.8) [12–100] 40.2%	57.3 (12.0) [33–100] 21.0%	79.8 (11.7) [54–100] 14.6%	38.6 (16.6) [12–100] 42.9%	64.9 (17.1) [22–100] 26.4%	84.3 (13.7) [22–100] 16.3%

Abbreviations: MV, mean velocity; PV, peak velocity. Note: Values are presented as mean (SD), [range], and coefficient of variation.

and second repetition. Second, MV detects the progressive development of fatigue during a set more precisely than PV. Third, the number of repetitions performed (expressed in absolute values, as well as a percentage of the completed repetitions) before reaching the different VLTs was higher for PV than for MV during the short sets, higher for MV than for PV during the long sets, and higher using the first repetition than using the fastest repetition as the reference repetition during both the short and long sets. Fourth, the interindividual variability in the percentage of repetitions performed before exceeding the VLTs, with respect to the total number of repetitions completed, was generally high and accentuated for lower VLTs (15% > 30% > 45%). Fifth, the number of repetitions during

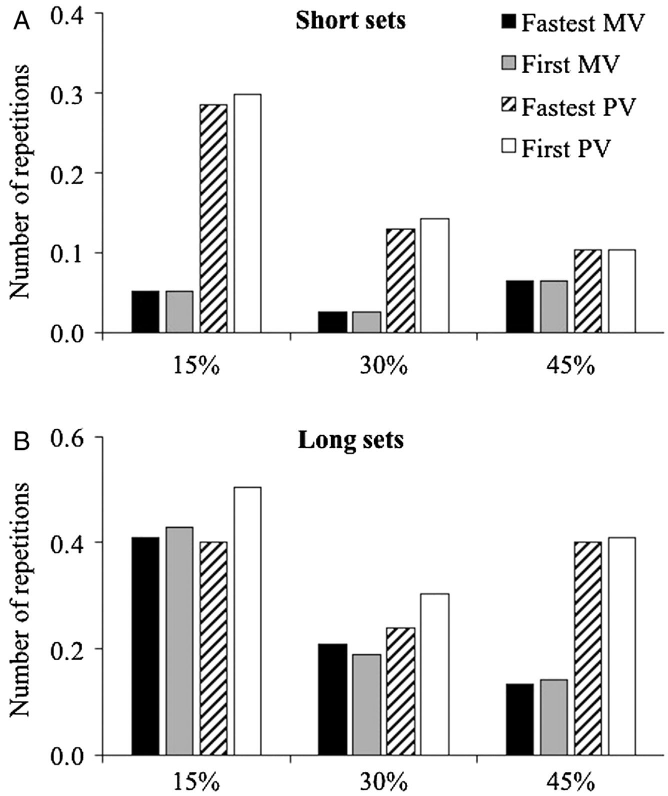

Figure 2 — Number of repetitions performed above the 15%, 30%, and 45% velocity loss thresholds after reaching, for the first time, this threshold during (A) short sets (≤12 repetitions) and (B) long sets (>12 repetitions). SDs are depicted in Table 5. Wilcoxon signed-rank test did not reveal significant differences ($P > .05$ with Bonferroni correction). MV indicates mean velocity; PV, peak velocity.

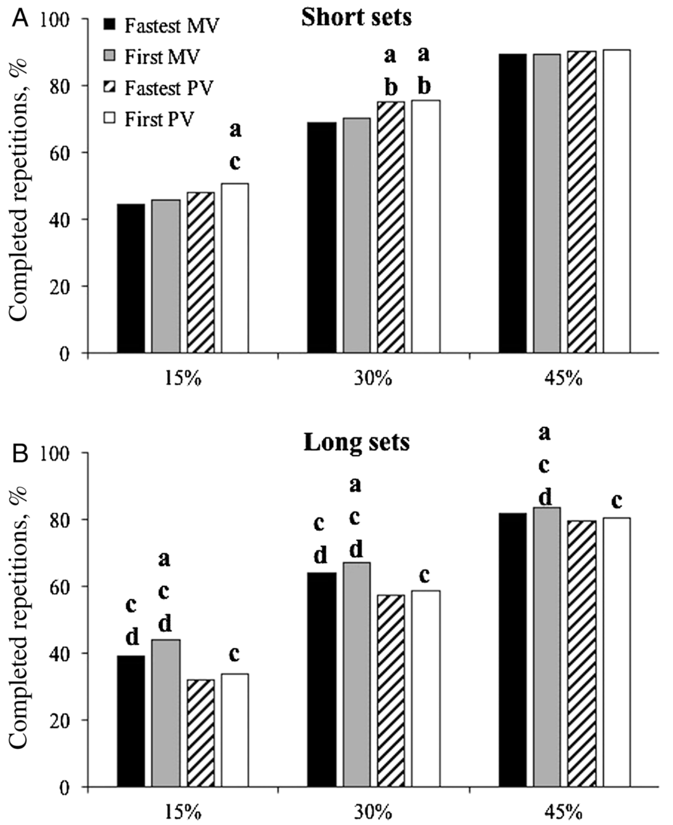

Figure 3 — Percentage of completed repetitions before exceeding the 15%, 30%, and 45% velocity loss thresholds with respect to the total number of repetitions completed during (A) short sets (≤12 repetitions) and (B) long sets (>12 repetitions) ($P < .05$ with Bonferroni correction). SDs are depicted in Table 4. MV indicates mean velocity; PV, peak velocity. [a]Significantly higher than fastest MV. [b]Significantly higher than first MV. [c]Significantly higher than fastest PV. [d]Significantly higher than first PV.

Table 5 Additional Number of Repetitions Performed Above the Thresholds After Reaching, for the First Time, the 15%, 30%, and 45% Velocity Loss Thresholds

		≤12 repetitions (n = 77)			>12 repetitions (n = 105)			All (N = 182)		
Reference repetition	Variable	15%	30%	45%	15%	30%	45%	15%	30%	45%
First	MV	0.1 (0.3) [0–2]	0.0 (0.2) [0–1]	0.1 (0.3) [0–2]	0.4 (1.0) [0–4]	0.2 (0.6) [0–4]	0.1 (0.4) [0–2]	0.3 (0.8) [0–4]	0.1 (0.5) [0–4]	0.1 (0.4) [0–2]
	PV	0.3 (0.9) [0–6]	0.1 (0.5) [0–3]	0.1 (0.5) [0–3]	0.5 (1.3) [0–8]	0.3 (1.0) [0–7]	0.4 (0.9) [0–4]	0.4 (1.2) [0–8]	0.2 (0.9) [0–7]	0.3 (0.8) [0–4]
Fastest	MV	0.1 (0.3) [0–2]	0.0 (0.2) [0–1]	0.1 (0.3) [0–2]	0.4 (0.9) [0–4]	0.2 (0.6) [0–4]	0.1 (0.4) [0–2]	0.3 (0.7) [0–4]	0.1 (0.5) [0–4]	0.1 (0.4) [0–2]
	PV	0.3 (0.8) [0–5]	0.1 (0.5) [0–3]	0.1 (0.5) [0–3]	0.4 (1.0) [0–5]	0.2 (0.8) [0–6]	0.4 (0.9) [0–4]	0.4 (1.0) [0–5]	0.2 (0.7) [0–6]	0.3 (0.8) [0–4]

Abbreviations: MV, mean velocity; PV, peak velocity. Note: Values are presented as mean (SD) and [range].

which the velocity output was above the VLT once this threshold was exceeded for the first time was low, but it was generally higher for PV compared to MV.

The main finding of this study is that, when the volume of RT sets is prescribed using VLTs, the actual number of repetitions performed may differ depending on the reference repetition and the velocity variable from which the VLT is calculated. For instance, during sets in which more than 12 repetitions can be performed, on average, the subjects performed 43% more repetitions before reaching the 15% VLT when this threshold was computed, considering the first repetition and MV (8.3 repetitions) compared with considering the fastest repetition and PV (5.8 repetitions). However, the differences in the number of repetitions performed before reaching the VLTs is reduced during sets in which <12 repetitions can be performed before reaching muscular failure. Several studies have recommended specific VLTs (e.g., 10%, 20%, and 30%) to provoke specific acute perceptual, mechanical, and metabolic responses and, consequently, selectively influence the long-term adaptations induced by RT.[15,31] While this method has been found to induce reliable internal fatigue responses, the present study expands upon the existing literature on VLTs and highlights that a given VLT would be associated with a different number of repetitions based on the reference repetition and velocity variable of choice.

The subjects completed a lower number of repetitions before reaching the different VLTs using the fastest repetition as a reference compared with using the first repetition. This result was expected because the first repetition was not always the fastest repetition, especially when the MV was recorded during long sets in which, in less than 50% of the sets, the first repetition was the fastest. Garcia-Ramos et al[22] also showed that the highest PV in the bench press throw exercise was not always observed during the first repetition, especially when light loads and interrepetition rest periods were implemented. Similarly, Jukic and Tufano[23] found that the fastest or most powerful repetition during clean pulls at various loads generally occurred during repetitions 1 to 3, while some of the subjects had their fifth repetition as their best. The use of light loads and intraset rest periods should alleviate fatigue, and therefore, the chance of obtaining the fastest velocity after the first repetition is increased. The fastest repetition of the set should be recommended for computing VLTs to avoid the accumulation of an excessive number of repetitions caused by a low-velocity performance during the first repetition.

The number of repetitions performed before reaching the 15%, 30%, and 45% VLTs was higher for PV than for MV during the short sets and higher for MV than for PV during the long sets. Although these 2 velocity variables are the most commonly used in practice and research,[32,33] the vast majority of studies using VLTs have considered the MPV.[17,25,26] Our results clearly show that the velocity variable is an important factor to consider when prescribing the training volume using VLTs. The findings of our study suggest that MV could be more appropriate than PV because (1) subjects reached failure before reaching the 15%, 30%, and 45% VLTs in more occasions using PV than MV, (2) the number of times that the subjects produced a velocity output above a VLT once this threshold was exceeded for the first time was higher for PV compared with MV, and (3) the interindividual variability in the percentage of completed repetitions with respect to the total number of repetitions when a VLT is reached was higher for PV (CV = 28.7%) than for MV (CV = 18.8%). Finally, although it was not analyzed in the present study, it should be noted that the number of repetitions that can be performed before reaching a given VLT should be lower (or the same) when using MPV compared with MV because the difference between MV and MPV are accentuated at faster movement velocities.[24]

The use of VLTs has been justified by the close relationship between VLTs and the percentage of repetitions performed with respect to the total number of repetitions that can be completed before muscular failure.[17,25] Several equations have been proposed to predict the percentage of completed repetitions from VLTs in different exercises when using MPV.[17,25,26] It is important to note that, considering the MV in our study, we observed a higher percentage of completed repetitions with respect to the total number of repetitions before exceeding all VLTs in comparison with the results reported by González-Badillo et al[17] in the bench press exercise considering MPV (15% VLT: 44.7% vs 31.2%; 30% VLT: 68.4% vs 52.8%; 45% VLT: 86.2% vs 70.7%). These results suggest that MV and MPV should not be used interchangeably when prescribing the RT volume through VLTs. Furthermore, while González-Badillo et al[17] showed a low interindividual variability (average CV = 8.9%) in the percentage of completed repetitions with respect to the maximum when a given VLT is reached, the interindividual variability in our study was more than twice as large (average CV for MV = 18.8%). The discrepancies in the interindividual variability between the studies are surprising, but they could be at least partially explained by the use of different velocity variables (MPV vs MV) or testing protocols (a single set vs multiple sets in a real training session). In agreement with González-Badillo et al,[17] (CV = 11.0% for the 15% VLT, 8.8% for the 30% VLT, and 6.9% for the 45% VLT), we also observed a greater interindividual variability for lower VLTs (CV for MV = 28.6% for the 15% VLT, 16.7% for the 30% VLT, and 11.2% for the 45% VLT). Future studies should expand this line of research to obtain more robust information about the interindividual variability in the number of completed repetitions when a VLT is reached. Therefore, it could be important to elucidate whether the VLTs prescribed should be subject specific in order to induce specific adaptations.

An important characteristic of the present study is that the subjects were allowed to self-select a number of factors, such as the warm-up, external loads, number of sets, grip width, and length of the interset rest periods. This was done to increase the ecological validity of the study, as not all individuals perform the same warm-up or use the same interset rest periods in real training environments. However, failing to standardize these factors could also be seen as a limitation because they are known to influence RT performance, and we cannot rule out the possibility that this affected the results of the present study. Therefore, it is important that future studies examine the selective influence of these factors on the number of repetitions performed before reaching certain VLTs, as well as the use of VLTs in other exercises and free-weight variants of the bench press exercise. Finally, it is important to note that our subjects were instructed to perform all repetitions within a set as fast as possible, without any rest between successive repetitions. Therefore, the findings of the present study might not be applicable in situations where other pacing strategies are used.

Practical Applications

The fastest repetition of the set (instead of the first repetition) and MV (instead of PV) should be recommended when implementing VLT during RT. The procedure of selecting the fastest repetition could be simplified, considering the fastest velocity of the first 3 repetitions during sets performed against light loads (>12RM), the fastest velocity of the first 2 repetitions during sets performed against moderate loads (6–12RM), and the first repetition during sets performed against heavy loads (≤5RM). This is justified because the higher the load (i.e, lower number of repetitions that can be performed), the more difficult it is to achieve the fastest repetition after the first repetition.

Conclusions

The number of repetitions performed before reaching a specific VLT is influenced by the reference repetition and velocity variable. The first repetition is not always the fastest, especially during sets performed against light loads (≥ 13RM) and when MV is used. MV should be used instead of PV due to a higher precision in detecting the progressive development of fatigue during a set. This is evidenced by the participants' reaching failure before exceeding the VLTs in more occasions using PV, participants' producing a velocity output above a VLT once this threshold was exceeded for the first time in more occasions using PV, and MV demonstrating a lower interindividual variability in the percentage of completed repetitions with respect to the total number of repetitions when a VLT is reached. However, regardless of the reference repetition and velocity variable, the interindividual variability in the percentage of completed repetitions with respect to the total number of repetitions was high. This high interindividual variability in the percentage of completed repetitions when a VLT is reached suggests that subject-specific VLTs may be more appropriate to induce specific long-term training adaptations.

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