Potentiating Effects of Accentuated Eccentric Loading Are Dependent Upon Relative Strength

Justin J. Merrigan,[1,2,3] James J. Tufano,[4] and Margaret T. Jones[3,5]

[1]Human Performance Innovation Center, Rockefellar Neuroscience Institute, West Virginia University, Morgantown, West Virginia; [2]School of Kinesiology, George Mason University, Manassas, Virginia; [3]Patriot Performance Laboratory, Frank Pettrone Center for Sports Performance, George Mason University, Fairfax, Virginia; [4]Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic; and [5]School of Sport, Recreation, and Tourism Management, George Mason University, Fairfax, Virginia

Abstract

Merrigan, JJ, Tufano, JJ, and Jones, MT. Potentiating effects of accentuated eccentric loading are dependent upon relative strength. *J Strength Cond Res* 35(5): 1208–1216, 2021—The purpose was to evaluate the acute effects of accentuated eccentric loading (AEL) on bench press velocity and subsequent perceived effort (ratings of perceived exertion [RPE]) and soreness. Resistance-trained men ($n = 8$) and women ($n = 2$) completed 4 sets of 5 bench press repetitions with AEL and traditional loading (TL) using concentric loads of 50% (AEL50, TL50) and 65% (AEL65, TL65) 1-repetition maximum (1RM). Throughout each TL set, the eccentric load remained identical to the concentric. Variable resistance during the first repetition of AEL equaled 120% 1RM. Hierarchical Linear Modeling was used to evaluate differences between AEL and TL ($p < 0.05$). For the first repetition, AEL50 and AEL65 resulted in slower eccentric and concentric velocities. The increasing slope of eccentric and concentric velocity across repetitions was greater during AEL50 and AEL65 compared with TL50 and TL65, respectively ($p < 0.05$). As an individual's strength increased, AEL50 resulted in slower eccentric velocity and faster concentric velocity than TL50. The AEL65 resulted in faster concentric velocity than TL65 ($p < 0.05$). Mean protocol comparisons revealed trivial to small effects between AEL and TL. There were no differences in RPE or soreness between protocols with soreness ratings remaining unchanged from baseline (1.80 ± 0.20 AU; $p < 0.05$). Overall, AEL was not effective for increasing concentric velocity during the bench press with current loading protocols. Yet, stronger individuals may exhibit increases in concentric velocity from AEL, which may be a result of different pacing strategies employed during the eccentric phase. Furthermore, when using the current AEL protocols, eccentric intensities were increased with no greater RPE or soreness.

Key Words: hierarchical linear modeling, HLM, eccentric training, weight releasers, soreness

Introduction

To complete eccentric actions, lower motor unit recruitment and firing rates are employed compared with concentric actions with the same resistance (24). However, additional resistance during eccentric actions likely results in greater motor unit recruitment (10), which could potentiate subsequent concentric actions. Thus, accentuated eccentric loading (AEL), in which loads during eccentric actions are greater than concentric actions, can potentiate subsequent concentric performance (33). Weight releasers, a common method of employing AEL, attach to a barbell to increase the eccentric load, detach during the eccentric to concentric transition, and remain on the floor. As a result, the subsequent concentric phase is performed with less load, but theoretically, in a potentiated state, possibly resulting in greater concentric forces, power, and velocity (8,19,21,22,30). Yet, divergent findings remain (22,32), and information relative to the traditional bench press is limited (8,22). Although the prescribed eccentric load may not impact responses to AEL, whether concentric performance improvements exist (30) or not (22), the concentric loads used may dictate the efficacy of AEL for improving concentric velocity (19).

Address correspondence to Justin J. Merrigan, justin.merrigan@hsc.wvu.edu.

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In moderately trained men, AEL with 105% 1-repetition maximum (1RM) increased concentric bench press 1RM compared with traditional loaded 1RM (8). However, others reported decreased concentric forces during bench press 1RM testing using AEL with 105–120% 1RM (22). The aforementioned study evaluated all AEL loads on the same day; therefore, it is possible that resultant fatigue inhibited possible potentiation (27,29). When using lighter loads and evaluating explosive bench press performance with concentric loads of 50% 1RM, AEL with 60–90% 1RM did not increase 50% 1RM bench press velocity (22). It is interesting to note that the aforementioned findings were based upon evaluating the concentric phase within the same repetition during AEL, without considering the possible effects of AEL on subsequent repetitions. Heavier loads during AEL may reduce volitional eccentric velocities (9), thereby inhibiting the stretch shortening cycle response (5,26) and blunting potential immediate concentric performance enhancement. This has been demonstrated when eccentric and concentric velocities were slower during the initial repetition with AEL but faster during back squat repetitions 2–5 (19). Thus, the effect of AEL on multiple repetitions following a single AEL repetition should be investigated further to understand the potentiating effects of AEL in everyday training situations, where athletes would likely continue performing repetitions within a single set for multiple sets.

The greater eccentric loads and increased rates of muscle lengthening (33), from performing multiple sets of AEL repetitions may result in greater perceived levels of soreness (12). Previous research has indicated that perceived soreness levels did not exceed mild ratings or differ from traditional loading (TL), following drop jumps (1) and back squats (17). However, information in regard to the bench press exercise is limited, and AEL may result in greater soreness in the upper body compared with the lower body (3). Furthermore, similar to an individual's resistance training status contributing to the extent of perceived soreness following training, an individual's strength level may determine whether or not they would benefit from advanced training methods (31). Yet, it is unclear whether strength may play a role in the efficacy of AEL, which may assist researchers and practitioners in appropriate prescription and implementation of AEL in program design. Thus, the purpose was to evaluate the effect of AEL on velocity over multiple bench press repetitions across multiple sets using different concentric loads. A secondary purpose was to investigate the influence of an individual's relative strength on AEL's effectiveness as and the effects of AEL on perceived effort and soreness. It was hypothesized that repetitions following an AEL repetition would be performed with faster eccentric and concentric velocities, depending upon the concentric load used, and that individuals with more relative strength would benefit from AEL more than weaker individuals.

Methods

Experimental Approach to the Problem

A crossover design was used to examine the acute effect of AEL on bench press velocity using different concentric loads. The first session included anthropometric and body composition measurements, followed by bench press 1RM testing and weight releaser familiarization. After 72 hours of rest, the first of 4 experimental sessions took place. Experimental sessions were separated by 48 hours and occurred at approximately the same time of day, in random order. Subjects completed 2 AEL and 2 TL protocols with the following eccentric and concentric loads: AEL65, 120/65% 1RM; AEL50, 120/50% 1RM; TL65, 65/65% 1RM; TL50, 50/50% 1RM. Subjects were asked to refrain from strenuous physical activity or upper-body resistance exercise from 72 hours before 1RM testing until completion of the study.

Subjects

Subjects included resistance-trained men ($n = 8$; mean ± *SD*; age, 26 ± 4 years, height, 175.0 ± 7.1 cm; body mass, 87.9 ± 11.1 kg; body fat, 18.7 ± 4.5%, 1RM, 131.0 ± 27.0 kg; 1RM per body mass, 1.5 ± 0.2) and women ($n = 2$; age, 23 ± 2 years; height, 157.5 ± 2.8 cm; body mass, 59.1 ± 2.5 kg; body fat, 23.1 ± 3.6%; 1RM, 61.4.0 ± 9.6 kg; 1RM per body mass, 1.0 ± 0.1) with more than 1 year of resistance training experience using the bench press at least once a week. Subjects did not report any upper-body musculoskeletal injury in the past 6 months and had the ability to bench press at least their body mass. Before data collection, the expectations and risks of the study were explained, and written informed consent was obtained for all subjects. This study was conducted according to the Declaration of Helsinki guidelines, and all procedures were approved by George Mason University's Institutional Review Board (#1562520-1).

Procedures

One-Repetition Maximum and Familiarization. Subjects' height, mass, and body composition (air displacement plethysmography) were measured, using previously validated methods (16), before resistance training procedures. A standardized and supervised warm-up, which consisted of 5 minutes of stationary cycling followed by 5 minutes of upper-body dynamic stretches, was completed before all sessions. Then, subjects began the following incremental bench press warm-up based on their self-reported 1RM: 5 repetitions at 40% 1RM, 2-minute rest, 3 repetitions at 60% 1RM, 3-minute rest, and 2 repetitions at 80% 1RM. Three minutes of passive rest was allowed before attempting single maximal repetitions, with progressive incremental loading, until the subject experienced a failed attempt or the inability to continue with correct form. The rest between the maximal attempts was 3–5 minutes. Subjects self-selected their grip width and were instructed to perform the eccentric motion using a self-selected pace, without bouncing the bar off their chest (34). For all bench press testing, the subjects were required to perform a complete repetition from full elbow extension, to the bar touching the chest, back to full elbow extension. The hand placement, rack height, and safety bar settings used during the 1RM test were recorded for use in subsequent experimental sessions.

Following a short rest, subjects were familiarized with the weight releasers (Rogue Weight Releasers, Rogue, Columbus, OH), as well as soreness and ratings of perceived exertion (RPE) scales. Using an unweighted barbell (20 kg), subjects performed no more than 5 single repetitions with the weight releasers (for a total load of 55% 1RM), separated by 30 seconds of rest. The load used for weight releaser familiarization was comparable to weight releaser loads used during experimental testing to demonstrate similar conditions for stabilizing the barbell off of the rack.

Experimental Sessions. For all protocols, subjects completed 4 sets of 5 repetitions. During the TL protocols (TL50, TL65), the eccentric and concentric loads were constant for all repetitions. During the variable resistance protocols (AEL50, AEL65), the eccentric phase of the first repetition of each set equaled 120% 1RM. Thus, AEL50 included an extra load of 70% 1RM and AEL65 included an extra load of 55% 1RM, which was applied via 2 weight releasers placed 12 cm from each end of the barbell. The weight releasers were attached to the barbell before each set, disengaged upon ground contact after completing the first eccentric movement, and remained disengaged for the remaining repetitions within each set. Thus, the concentric portion of the first repetition and the eccentric and concentric actions of the set's subsequent repetitions were performed with only the prescribed load (50% or 65% 1RM). The loading protocols, of implementing AEL on the first repetition only, were based on previous findings of potentiated repetitions following a single AEL repetition during the back squat exercise (19). Three minutes of passive seated rest was permitted between sets. Subjects were instructed to perform the concentric action of each repetition "as explosively as possible" with verbal encouragement throughout all experimental testing to promote maximal effort on each repetition.

Data Acquisition and Analysis. Testing took place with 4 linear position transducers (PT5A-150 Celesco, Measurement Specialties, Chatsworth, CA) attached to the inside of both barbell collars and mounted above in anterior, posterior, left and right positions, forming 2 triangles and enabling measurement of horizontal and vertical bar displacement. Transducers have been shown to be reliable and valid for estimating velocity of movements (4,18,23). Voltage outputs from the transducers were converted into displacement data, which were sampled at 1,600 Hz using a custom-built interface box with an analog-to-digital card (NI cDAQ-9174; National Instruments, Austin, TX). Data were filtered using a 10 Hz low pass Butterworth filter, which was determined through residual analysis by visually identifying the best fit line that did not attenuate peak velocities of various cutoff frequencies (5–25 Hz). The data were analyzed using Matlab version 7.12 software (MathWorks, R2011a, Natick, MA) with methods that are considered reliable during the bench press exercise with the current loading schemes (Intraclass correlation coefficient, ICC ≥0.80; Coefficient of variation, CV ≤5%) (18). For data analysis, the lowest position of the bench press was identified using the *find peaks* function in Matlab to identify the transition phase from eccentric to concentric actions (i.e., end of the lowering phase). From this point, the end of the eccentric phase and start of the concentric phase were identified as the first frame where a positive vertical velocity was noted moving from the left and right on the velocity-time curve, respectively. The start of the eccentric phase and of the concentric phase were next identified as the point where a stagnation or drop in vertical velocity was noted (i.e., the return position). The start and end point of the eccentric and concentric phases were confirmed with visual inspection. The mean and peak values for concentric and eccentric velocity (ES) were calculated, as well as, the length of time taken to reach peak velocity.

Ratings of Perceived Exertion and Soreness. Approximately 5 minutes after completing each experimental session, subjects were shown the CR-10 scale and asked to point to a number, indicating their RPE for the session (7). Self-assessed ratings of soreness were taken at baseline, immediately post, and 24 and 48 hours after testing using a graphic rating scale of (1 = no pain; 7 = worst pain possible). The graphical scales were used because they yield similar results to visual analog scales (15), while also enabling subjects to easily submit the responses from home for the 24- and 48-hour time points.

Statistical Analyses

For the current purposes, the data for each respective repetition were averaged across all sets (i.e., repetition 1 = average for repetition 1 from sets 1 through 4). For evaluation of velocity and time to peak velocity, analyses of variance with repeated measures were run with protocol (AEL50, TL50, AEL65, TL65) by repetition (1–5). However, individual subject performances varied with some experiencing faster, slower, or unchanged velocities because ofAEL protocols (Figures 1 and 2). Hierarchical linear modeling approaches were also conducted, to evaluate the main dependent variables of interest and account for the individual differences, using the *nlme package* in *R* version 3.6.2 (R Foundation, Vienna, Austria, https://www.R-project.org) (25). An a priori power analysis for longitudinal multilevel modeling was performed using Optimal Design (28), with the following parameters: variability of level-1 residual 0.10, variability of level-1 coefficient = 0.05; treatment effect = 0.4. Because this modeling has not been conducted previously to analyze the effects of AEL, using exact effect size estimates from the prior literature was not possible; however, we expected at least moderate effects as seen in the prior literature using repeated-measures analysis of variance (19). The repeated measures were assessed over time (level 1; repetitions) and were nested within subjects (level 2). Explanatory predictor variables (REPETITION, PROTOCOL, STRENGTH) were added to the model, which was run separately for each dependent velocity variable (i.e., eccentric and concentric; mean and peak velocity), in the following manner:

$$\text{Velocity} = \pi_{0j} + \pi_{1j}(\text{REPETITION}_{tj}) + \varepsilon_{tjk}$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{PROTOCOL}) + \beta_{02}(\text{STRENGTH}) + \beta_{03}(\text{PROTOCOL} \times \text{STRENGTH})r_{0j}$$

$$\pi_{1j} = \beta_{01} + \beta_{11}(\text{PROTOCOL}),$$

where the performance variables were velocity of repetition *t* in the jth subject; π_{0j} is the intercept that was coded as the first repetition so that β_{00} is a constant, β_{01} (PROTOCOL) is the influence of protocol on repetition one, β_{02} (STRENGTH) is the influence of relative strength (i.e., bench press 1RM divided by body mass) on the first repetition, β_{03} (PROTOCOL × STRENGTH) is the influence of relative strength on the effect protocol had on the first repetition, and r_{0j} is the random effects of subjects; π_{1j} is the slope of velocity over repetitions for the jth individual with β_{01} as the constant and β_{01} (PROTOCOL) as the effect of protocol (AEL = 1 versus TL = 0) on slope. Additionally, a 3-way interaction effect evaluated whether an individual's strength influenced the effect of protocol on the change in velocity over repetitions but was not significant.

Friedman tests were used, followed by Wilcoxon signed rank tests to assess soreness. A Kruskal-Wallis test was performed to analyze session RPE comparisons. Additionally, effect sizes were calculated using Cohen's *d*, and ranges were defined according to Hopkins as trivial, d = 0–0.2; small, d = 0.2–0.6; moderate, d = 0.6–1.2; large, d = 1.2–2.0; and very large, $d > 2.0$ (11). All statistical tests were performed in *R* version 3.6.2 (R Foundation, Vienna, Austria, https://www.R-project.org) with an alpha level of $p \le 0.05$.

Results

Findings from the multilevel models suggested, for the first repetition, AEL50 resulted in slower mean and peak concentric velocity and mean ES than TL50, and AEL65 resulted in slower mean and peak concentric velocity compared with TL65 (Table 1 and Figures 1–2). The change across repetitions demonstrated a greater increase in mean eccentric and concentric velocity for AEL50 compared with TL50 and a greater increase in mean ES and peak concentric velocity for AEL65 compared with TL65 (Table 1). As an individual's relative strength increased, mean and peak concentric velocity were faster because of AEL50 and AEL65 compared with TL50 and TL65. Mean ES was slower in AEL50 compared with TL50 (Table 1 and Figures 1–2).

There were no main protocol effects or protocol by repetition interactions for average and peak concentric velocity, peak ES, and time to reach peak velocity during eccentric or concentric actions ($p > 0.05$). Average ES for the entire protocol was no different between AEL50 (-0.52 ± 0.14 m·s^{-1}) and TL50 (-0.46 ± 0.11 m·s^{-1}; $p = 0.051$), whereas AEL65 (-0.48 ± 0.11 m·s^{-1}) resulted in faster ES compared with TL65 (-0.43 ± 0.11 m·s^{-1}; $p = 0.003$), but no protocol by repetition interaction was noted. Effect sizes denoting the magnitude of differences for velocity data between protocols collapsed across 4 sets are in Table 2. Average values for each repetition collapsed across all sets and subjects are located in Figures 3 and 4.

Session RPE for AEL50 and AEL65 were not different from TL50 ($p = 0.125$) and TL65 ($p = 0.196$), respectively. Finally,

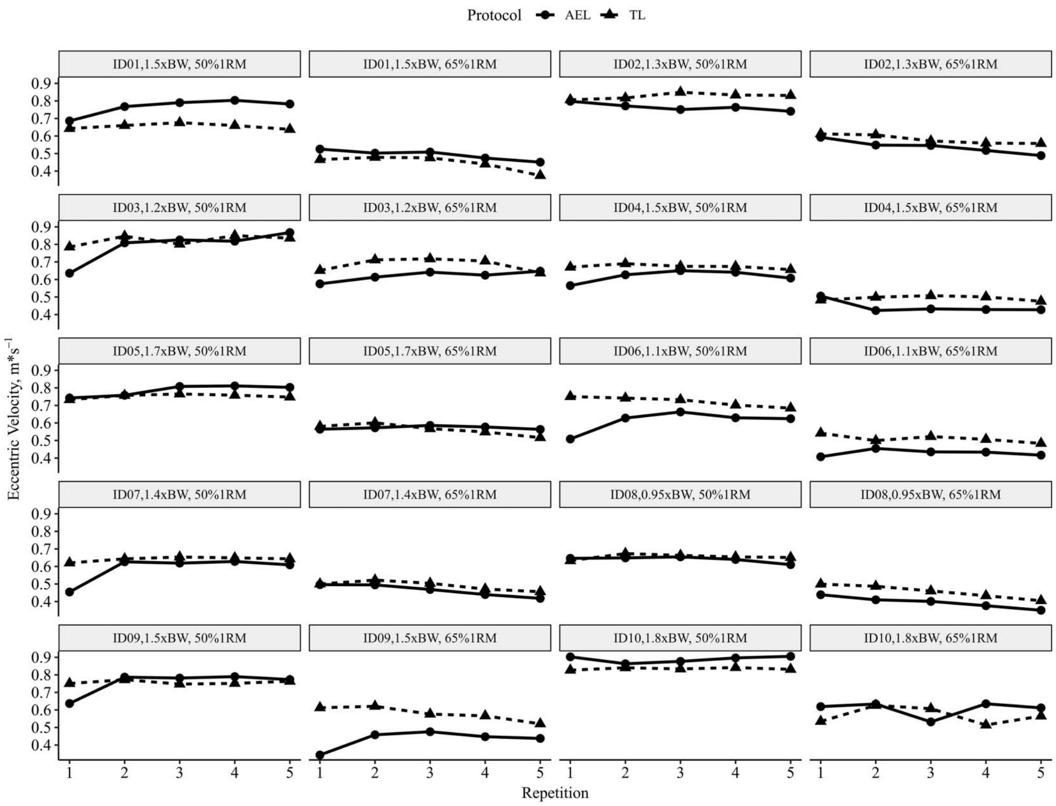

Figure 1. Eccentric velocity comparisons between accentuated eccentric (AEL) and traditional loading (TL). Comparisons are made for each individual with 50 and 65% 1RM protocols (i.e., ID#, relative strength [bench 1-repetition maximum per body mass], concentric load). 1RM = 1-repetition maximum.

perceived soreness was unaffected by TL50 (χ^2 (3) = 1.38; p = 0.711), TL65 (χ^2 (3) = 6.42; p = 0.093), and AEL65 (χ^2 (3) = 7.73; p = 0.052) but did exist following AEL50 (χ^2 (3) = 12.50; p = 0.006). Wilcoxon signed-rank test post hoc analysis, with a Bonferroni correction applied, revealed that soreness at post-exercise time points did not differ from baseline (1.80 ± 0.20 AU; $p < 0.05$). Furthermore, no soreness ratings rose above mild levels following training.

Discussion

The primary purpose was to evaluate the effect of AEL on bench press velocity over multiple repetitions across multiple sets using different concentric loads. A secondary purpose was to investigate the influence of an individual's strength on AEL's effectiveness and the effects of AEL on perceived effort and soreness. It was hypothesized that repetitions following an AEL repetition would be performed with faster eccentric and concentric velocities. During the initial repetition of a set, mean ES was slower for AEL50 compared with TL50, whereas concentric velocity was slower during AEL50 and AEL65 than TL50 and TL65. However, in later repetitions, ES during AEL50 and AEL65 were faster than TL50 and TL65, respectively. Contrary to our hypothesis and according to effect sizes, concentric velocities were not affected during AEL50 because only trivial increases in performance were noted. During AEL65, the mean concentric velocity of later repetitions was slower than TL65. Furthermore, as an individual's relative strength increased, performance on the initial AEL repetition yielded slower mean ES and faster mean and peak concentric velocity. These findings on performance alterations from AEL coincided with no differences in perceived effort of the training session or soreness following training with AEL50 or AEL65. Therefore, AEL did not increase concentric performances with loads of 50% or 65% 1RM, but individuals with higher relative strength may experience increases in concentric performances.

When comparing the initial repetition, the eccentric and concentric velocities were slower during AEL50 and AEL65 compared with TL50 and TL65. The slope of mean ES across repetitions was greater for AEL protocols, concomitantly with moderate increases in mean ES in later repetitions for AEL protocols. However, the effect of AEL on the slope of mean concentric velocity across repetitions was noted during AEL50, but not AEL65, resulting in trivial concentric performance benefits of AEL50 and small decreases in mean concentric velocity because of AEL65 during repetitions 2–5. In agreement, others found thatmean concentric back squat velocity was unaffected by AEL despite greater eccentric rate of force development because of overload (32). A possible explanation of the lack of concentric performance benefits in the current study is the moderate effect on ES (≤ 1.00), as prior research has demonstrated that concentric velocity is improved when large increases in ES from AEL are demonstrated (ES = 1.33–1.40) (19). Some have attempted to control for differences in ES by using controlled eccentric tempos of 3 seconds for both protocols (21), which may assist in controlling mechanics between protocols but limits the use of the stretch shortening cycle and potential for practical application.

Furthermore, the concentric and eccentric load combinations that improve acute performance are equivocal and may depend upon the exercise used. Some have suggested that the specific concentric load

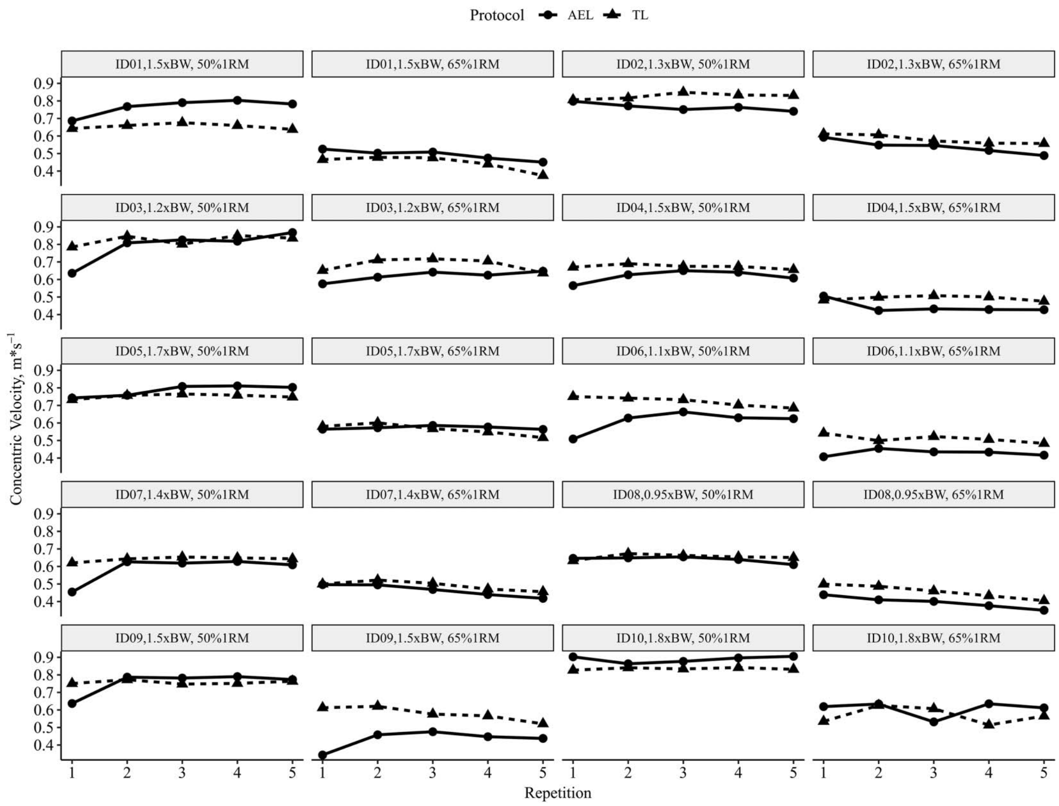

Figure 2. Concentric velocity comparisons between accentuated eccentric (AEL) and traditional loading (TL). Comparisons are made for each individual with 50 and 65% 1RM protocols (i.e., ID#, relative strength [bench one repetition maximum per body mass], concentric load). 1RM = 1-repetition maximum.

or larger gaps between the eccentric and concentric load may yield positive effects from AEL during the back squat (19). Although no prior literature has evaluated similar concentric loads in the bench press exercise, AEL with 105% 1RM has increased bench press 1RM performances (8) but not bench press performances with 80% 1RM (13). The result of improved concentric performances during the bench press may be subject to the eccentric load used during AEL because 110 and 120% 1RM AEL protocols have reduced concentric force production (22). Thus, it is possible that eccentric loads over 100% during the bench press may result in either no effect or a negative effect upon concentric performances. In support, the differing responses to AEL50 and AEL65 demonstrate the lack of effect when using 120% 1RM during AEL for the bench press and the importance of the concentric load used. Although not significant, small-to-moderate effect sizes of shorter time to reach peak velocity may suggest alterations in mechanics as a recult of AEL. By reaching peak velocity later in a repetition, it is possible that a greater velocity may be achieved, according to correlations with current data (r = 0.29–0.49). The effect sizes on time to reach peak concentric velocity of AEL65 compared with TL65 were greater than AEL50 to TL50

Table 1

Longitudinal multilevel models with fixed effects for velocity comparisons.

	Mean concentric estimate (*SE*)	Mean eccentric estimate (*SE*)	Peak Concentric Estimate (*SE*)	Peak eccentric estimate (*SE*)
AEL50 vs.. TL50				
Intercept	0.645 (0.135)*	−0.028 (0.148)	1.002 (0.221)*	−0.475 (0.383)
Repetition	0.001 (0.004)	−0.018 (0.007)*	−0.012 (0.006)	−0.047 (0.011)*
Protocol	0.016 (0.007)*	−0.031 (0.010)*	0.027 (0.008)*	0.002 (0.016)
Protocol	−0.247 (0.051)*	−0.185 (0.083)*	−0.362 (0.071)*	−0.136 (0.130)
Strength	0.063 (0.095)	−0.285 (0.104)*	0.066 (0.156)*	−0.303 (0.270)
Protocol × Strength	0.144 (0.035)*	0.137 (0.057)*	0.190 (0.048)*	0.058 (0.089)
AEL65 vs. TL65				
Intercept	0.520 (0.121)*	−0.105 (0.135)	0.816 (0.177)*	−0.491 (0.327)
Repetition	−0.014 (0.004)*	−0.008 (0.007)	−0.028 (0.005)*	−0.031 (0.009)*
Protocol	0.007 (0.006)	−0.024 (0.009)*	0.015 (0.007)*	0.017 (0.013)
Protocol	−0.194 (0.046)*	−0.119 (0.079)	−0.262 (0.058)*	0.017 (0.109)
Strength	0.032 (0.085)	−0.221(0.095)*	−0.014 (0.125)	−0.214 (0.230)
Protocol × Strength	0.101 (0.032)*	0.084 (0.054)	0.124 (0.040)*	−0.069 (0.075)

*Significant explanatory variable of the following meanings: Repetition is the slope of velocity over repetitions; repetition indented protocol, the effect of protocol on the slope of velocity over repetitions; protocol, the effect of protocol on repetition 1; strength, the effect of strength on repetition 1; protocol × strength, the effect of strength on the influence of protocol on repetition 1.

Table 2

Effect sizes of mean comparisons of velocity data between protocols.*†

Phase	Repetition	AEL50 vs.. TL50 Mean	Peak	T2P
ES (CI 95%)	ES (CI 95%)	ES (CI 95%)		
Eccentric	1	0.81 (−0.14 to 1.68)	−0.43 (−1.29 to 0.48)	0.83 (−0.12 to 1.70)
	2	−0.65 (−1.51 to 0.28)	—	−0.45 (−1.31 to 0.46)
	3	−0.88 (−1.76 to 0.07)	—	−0.33 (−1.20 to 0.56)
	4	−0.72 (−1.59 to 0.21)	—	−0.35 (−1.22 to 0.55)
	5	−0.66(−1.53 to 0.27)	—	—
Concentric	1	−0.59 (−1.46 to 0.33)	−0.77 (−1.64 to 0.17)	−0.30 (−1.17 to 0.60)
	2	—	−0.31 (−1.18 to 0.58)	—
	3	—	—	−0.27 (−1.13 to 0.63)
	4	—	—	—
	5	—	—	—

Phase	Repetition	AEL65 vs.. TL65 Mean ES (CI 95%)	Peak ES (CI 95%)	T2P ES (CI 95%)
Eccentric	1	—	−0.64 (−1.51 to 0.29)	1.32 (0.30 to 2.22)
	2	−0.65 (−1.52 to 0.28)	—	−0.52 (−1.39 to 0.39)
	3	−0.47 (−1.34 to 0.44)	—	−0.43 (−1.29 to 0.48)
	4	−0.61 (−1.48 to 0.31)	—	−0.54 (−1.40 to 0.38)
	5	−0.94 (−1.82 to 0.02)	—	−0.68 (−1.55 to 0.25)
Concentric	1	−0.36 (−1.23 to 0.54)	−0.47 (−1.34 to 0.44)	−0.51 (−1.37 to 0.41)
	2	−0.49 (−1.36 to 0.42)	−0.45 (−1.32 to 0.46)	−0.35 (−1.22 to 0.55)
	3	−0.43 (−1.30 to 0.47)	−0.37 (−1.23 to 0.54)	−0.75 (−1.62 to 0.19)
	4	—	−0.27 (−1.14 to 0.62)	−0.36 (−1.23 to 0.54)
	5	—	—	−0.45 (−1.31 to 0.46)

*CI = confidence interval; AEL = accentuated eccentric loading; TL = traditional loading.

†Effect size cut points: trivial, d = 0–0.2; small, d = 0.2–0.6; moderate, d = 0.6–1.2; large, d = 1.2–2.0; and very large, d > 2.0; T2P, time to peak velocity during concentric and eccentric phases. For concision and simplicity, only effect sizes that are small or greater appear within the table.

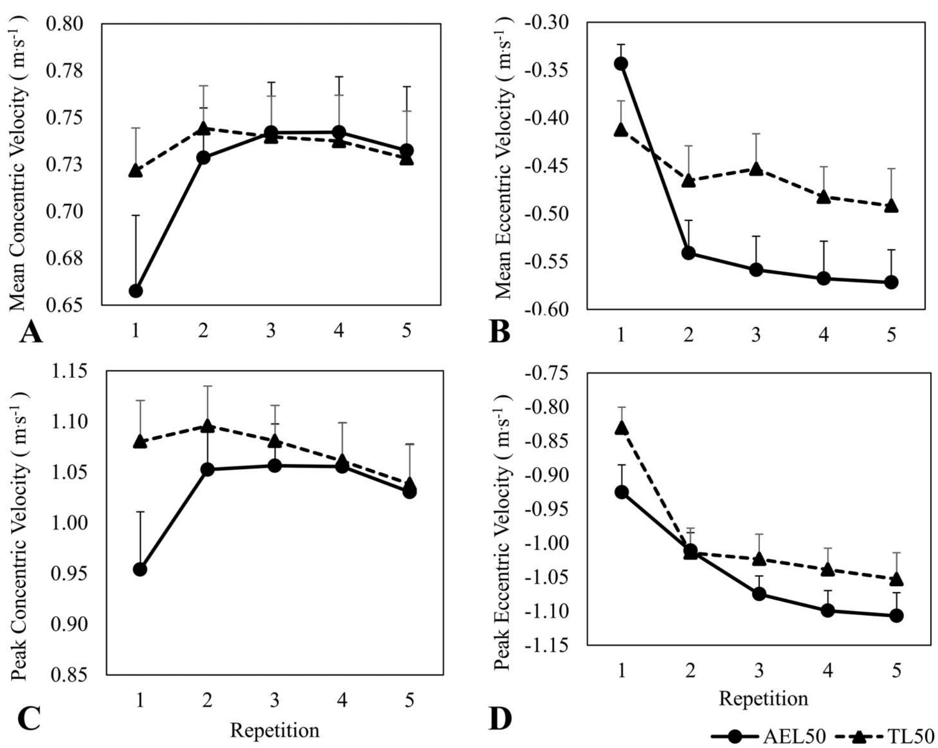

Figure 3. Mean concentric (A) and eccentric (B) velocity and peak concentric (C) and eccentric (D) velocity during bench press repetitions collapsed across 4 sets of accentuated eccentric loading (AEL50) and traditional loading (TL50) protocols with 50% 1RM concentric loads. 1RM = 1-repetition maximum.

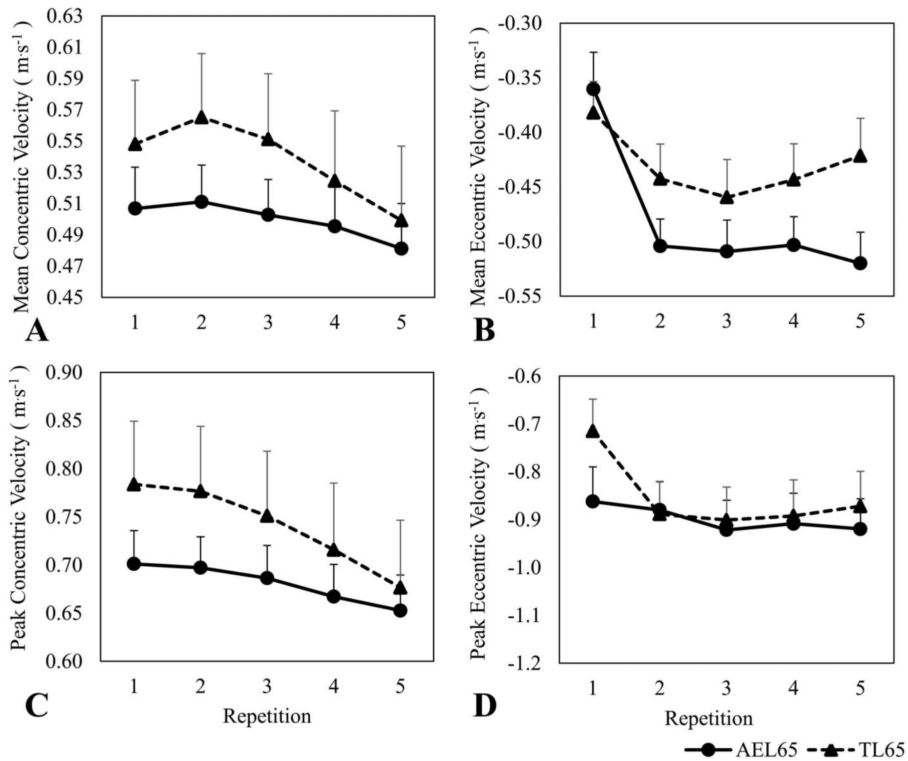

Figure 4. Mean concentric (A) and eccentric (B) velocity and peak concentric (C) and eccentric (D) velocity during bench press repetitions collapsed across 4 sets of accentuated eccentric loading (AEL65) and traditional loading (TL65) protocols with 65% 1RM concentric loads. 1RM = 1-repetition maximum.

comparisons, which may explain the small decrement in concentric performance during AEL65. Yet, when performing a bench press throw in a Smith machine, AEL of 20–40 kg elicited greater throw heights by achieving greater accelerations (30). However, it is difficult to compare these findings because bench throws do not require deceleration to cease movement, allowing acceleration throughout the concentric phase, and Smith machines control motion via fixed bar paths resulting in different performance capabilities (6).

It is also important to note that as an individual's relative strength increased, the slower eccentric velocities from AEL50 were exacerbated. It is possible that the stronger individuals were more accustomed to heavier loads and were better able to control the loads during AEL. As a result, for every single unit increase in relative strength, there was a smaller negative impact on concentric performance from AEL. Thus, individual's with greater relative strength levels may experience positive concentric performance responses to AEL. Although these findings require further exploration, they are the first to show that strength may play a role in response to AEL. Furthermore, current findings are in line with prior literature stating that stronger individuals may benefit more from advanced resistance training techniques (31), which may be a result of specific neuromuscular adaptations. It is important to consider the known upper extremity strength differences between sexes (20), which likely resulted in more variance in relative strength of the current sample. However, the women were included in the current sample because preliminary results showed little influence of sex on the effects of AEL. These findings are not included in the current article because of largely uneven sample size differences between sexes. Thus, further research is warranted to determine whether the effect of AEL is influenced by sex, relative strength, or both.

The session RPE was not different between AEL and TL protocols. In prior research, AEL of 100% 1RM with concentric loads of 40% 1RM resulted in higher session RPE than TL with a 52.5% 1RM constant load (35). However, the aforementioned study controlled the tempo for each repetition, and the eccentric overload was used on all 18 repetitions, compared with 4 repetitions in the current study, which would likely result in greater exertion. In conjunction with the lack of differences in perceived exertion over the entire session, AEL did not result in additional muscle soreness following exercise. This supports prior literature, as soreness following AEL during the back squat and drop jumps did not exceed mild levels (17). Subjects in the current study were resistance trained and regularly training the bench press, which may have led to reduced perceptions of soreness following AEL (36). Thus, the supramaximal loads used during the initial bench press repetition with AEL may increase eccentric intensities during training without increasing perception of effort during training or soreness following training.

Finally, it is important to consider the differences in findings from the repeated-measures analysis of variance and the hierarchical multilevel modeling analyses because there are distinct differences between them (14). In the current study, the analysis of variance compared group means and deviations to assess whether the dependent variables and their change over time (i.e., repetitions) differed between protocols. However, not all athletes will have the same responses to resistance training techniques, for various biological or environmental reasons, which casts doubt on using mean comparisons (14). Multilevel modeling, also known as hierarchical linear modeling, may allow for several advantages, with the main advantage being the ability to estimate individual responses to protocols and changes over time (i.e., Does velocity of specific repetitions or change in velocity across several repetitions, i.e., slopes, differ due to protocols?). This individual-centered analysis using nested time points within individuals found that the variance in individual performances was in part because of differing protocols (i.e., AEL versus TL), whereas analysis of variance in procedures found no group mean differences between protocols. Furthermore, the multilevel model enabled the inclusion of other explanatory variables, which illuminated that AEL responses differed according to relative strength levels. Thus, the multilevel model more closely represented the data than traditional group level analysis procedures (i.e., analysis of variance), by creating a more individual-centered analysis. Despite limited studies in the field of health and human performance, using such data analysis techniques may be beneficial and permits further examination of data from a unique perspective.

In conclusion, AEL, via weight releasers (120% 1RM), did not increase concentric velocity during 4 sets of 5 bench press repetitions with concentric loads of 50 and 65% 1RM. Yet, stronger individuals may experience increases in concentric performances from AEL, which may be a result of different pacing strategies during the eccentric phase. Although mechanics were not directly measured in the current study, the small changes in time to reach peak velocity suggest differing movement strategies as a result of AEL, which may explain the lack of findings. Likewise, a recent study has suggested that the slightly lower acute bench press performances because of AEL with 100% 1RM, compared with TL using concentric loads of 30 and 80% 1RM, were a result of altered mechanics during AEL (2). Therefore, during the bench press exercise, AEL with 100–120% 1RM does not seem to provide further acute training benefit to concentric performance compared with TL because the loads may be too heavy resulting in altered mechanics. However, according to greater eccentric loads and velocities, the eccentric intensities were increased, which warrants future longitudinal investigation. Finally, neither the perceived effort nor ratings of muscle soreness were different between AEL and TL.

Practical Applications

Accentuated eccentric loading, via weight releasers, may not be appropriate for relatively weaker individuals because they are more likely to adapt different pacing strategies to handle the heavier loads and resultantly perform repetitions with slower concentric velocities. The current protocols may implement high-intensity eccentric actions via supramaximal concentric loads and faster eccentric velocities with alike recovery patterns to TL. Therefore, AEL with 120% 1RM during bench press repetitions with 50–65% concentric loads may be used to progress the intensity of eccentric actions without extended recovery periods but may not provide maximal concentric velocity performances for that training session. Finally, because of individual variations in responses to AEL, individual-centered statistical analyses, such as hierarchical linear modeling, may be preferred over traditional group mean comparison procedures.

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