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Research article

Strength and Jump Responses to Distinct Repetition Volumes Produced by Peak-Velocity-Decline and Failure-Based Set Termination during Low-Load Blood-Flow-Restriction Full Back Squat Training

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Abstract

Blood flow restriction (BFR) training is commonly prescribed with fixed repetition targets or sets to volitional failure, but these approaches may not individualize repetition exposure. This study compared strength and jump responses to the distinct working-set repetition volumes produced by two session-reference peak-velocity-decline thresholds and volitional failure during low-load BFR full back squat training. Forty-five resistance-trained males (22.9 ± 0.7 years) were allocated to a 10% peak-velocity-decline condition (VL10%), a 40% condition (VL40%), or volitional failure (FAIL; n = 15 each). All groups trained twice weekly for 8 weeks at 30% of the current one-repetition maximum (1RM) with BFR; the assigned set-termination strategy determined working-set repetition volume. Primary outcomes were full back squat 1RM and isometric mid-thigh pull net peak force; jump height and standing broad-jump distance were secondary outcomes. The strategies produced distinct working-set repetition volumes (55.91 ± 0.61, 74.26 ± 0.89, and 94.08 ± 0.93 repetitions per session in VL10%, VL40%, and FAIL, respectively; all adjusted $p < 0.001$). No statistically significant between-group difference was detected between VL40% and FAIL for the primary strength outcomes, while VL40% involved lower repetition volume and perceived exertion. VL10% reduced repetition volume further and showed favorable changes in countermovement-jump height and standing broad-jump distance, but smaller strength-oriented adaptations than VL40%. Under this low-load BFR protocol, no statistically significant differences were detected between VL40% and FAIL for the primary strength outcomes, whereas VL10% showed smaller improvements in both primary strength outcomes than VL40% and FAIL. Jump responses were outcome-specific: both VL10% and VL40% showed greater CMJ improvements than FAIL, VL40% showed greater SJ improvement than both VL10% and FAIL, and VL10% showed greater SBJ improvement than FAIL.

Key words: Blood flow restriction, full back squat, jump performance, maximal strength, repetition volume, set termination.

Introduction

Resistance training enhances muscular strength and power across athletic and general populations (Cormie et al., 2011; Suchomel et al., 2016). Blood flow restriction (BFR) training can also induce meaningful adaptations with relatively low external loads, which makes it attractive when heavy loading is undesirable or when training stress must be managed alongside other strength and power work (Centner et al., 2019; Patterson et al., 2019; Pearson and Hussain, 2015; Scott et al., 2015). The amount of repetition exposure used to deliver this low-load stimulus remains an important programming consideration.

BFR repetition volume is commonly prescribed through a fixed scheme, such as 30 - 15 - 15 - 15, or by continuing sets to volitional failure (Pearson and Hussain, 2015; Scott et al., 2015). Fixed schemes may not accommodate individual differences in fatigue tolerance, whereas failure-based sets can increase repetition exposure, fatigue, and discomfort (Morán-Navarro et al., 2017; Pareja-Blanco et al., 2017; Sieljacks et al., 2019). Nonfailure BFR can produce some chronic adaptations with less discomfort than failure protocols, and broader syntheses report mixed myoelectric findings when failure and nonfailure conditions are compared (Cerqueira et al., 2022; Sieljacks et al., 2019). Thus, comparing the adaptations associated with different repetition volumes is practically relevant when external load, set number, and BFR prescription are otherwise standardized.

Velocity-regulated set termination offers a practical method for individualizing the number of repetitions completed within a set. Higher velocity-decline thresholds generally permit more repetitions and greater fatigue, whereas lower thresholds reduce repetition exposure and may preserve performance qualities (Galiano et al., 2022; Pareja-Blanco et al., 2017; 2020). In this role, the velocity signal defines when a set ends, while the resulting repetitions quantify the volume actually performed. This distinction is particularly relevant in low-load BFR, where modest external loads can still produce substantial local fatigue and discomfort (Patterson et al., 2019; Pearson and Hussain, 2015; Scott et al., 2015).

Recent BFR studies have examined acute and chronic responses to velocity-decline thresholds, but their loading schemes, pressure prescriptions, devices, and velocity metrics differ (Sánchez-Valdepeñas et al., 2024; 2026). Moreover, conventional full-squat research generally uses mean concentric or mean propulsive velocity and a set-internal reference, whereas the present protocol used peak velocity relative to a pre-session calibration (Rodríguez-Rosell et al., 2020; Sánchez-Medina et al., 2017). The thresholds therefore served as protocol-specific tools for producing different working-set repetition volumes rather than as assumed equivalents of established

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mean-propulsive-velocity prescriptions. Comparing the resulting repetition exposure, perceived exertion, and training adaptations may clarify the practical trade-offs among these termination strategies.

We compared the distinct working-set repetition volumes produced by VL10%, VL40%, and volitional failure (FAIL) during 8 weeks of low-load BFR full back squat training. Primary outcomes were full back squat 1RM and isometric mid-thigh pull (IMTP) net peak force, whereas countermovement-jump (CMJ) height, squat-jump (SJ) height, and standing broad-jump (SBJ) distance were secondary outcomes. We hypothesized that VL40% would produce larger primary strength improvements than VL10% while requiring less repetition volume and perceived exertion than FAIL.

Methods

Study design

A parallel-group trial compared three set-termination strategies during 8 weeks of low-load BFR training. Forty-five participants were allocated equally to VL10%, VL40%, or volitional failure (FAIL; n = 15 per group) using computer-generated allocation numbers returned by an online randomization system. All groups performed full back squats at 30% of the current 1RM with BFR and differed in set-termination strategy. The termination strategy produced the observed working-set repetition volume; participants were not independently randomized to prespecified low-, moderate-, or high-volume doses. Movement velocity regulated only within-set repetition exposure and was not used to estimate or prescribe the external relative load. Primary outcomes were full back squat 1RM and IMTP net peak force, and jump outcomes were secondary.

Participants

Forty-eight resistance-trained male university students volunteered for screening. Three were excluded before allocation because they were unable to complete the scheduled testing and training sessions, leaving 45 participants for randomization (Figure 1). Baseline characteristics were VL10%: age 22.50 ± 0.93 years, height 178.88 ± 4.94 cm, and body mass 75.75 ± 5.26 kg; VL40%: 23.00 ± 0.53 years, 179.25 ± 5.29 cm, and 79.00 ± 6.44 kg; and FAIL: 23.22 ± 0.44 years, 180.22 ± 4.52 cm, and 77.22 ± 3.80 kg. One-way ANOVA detected no significant between-group differences in age (p = 0.095), height (p = 0.843), or body mass (p = 0.471). Inclusion criteria required: (a) at least 1 year of resistance-training experience; (b) proficiency in the full back squat and jump techniques; and (c) no musculoskeletal injuries or cardiovascular contraindications within the previous 6 months. No participant withdrew after allocation; all randomized participants completed the intervention, posttesting, and all 16 supervised training sessions (100% attendance) and were included in the final analyses. No adverse events related to BFR were reported. Participants were instructed to abstain from vigorous exercise for 48 hours, alcohol for 12 hours, and caffeine for 6 hours before testing. The study was approved by the University of Physical Education and Sports ethics committee (approval No. 2026A075) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Testing procedures

Testing Schedule. All assessments were conducted during the week before and the week after the 8-week intervention in the following order: full back squat 1RM, IMTP, CMJ, SJ, and SBJ, with standardized warm-up procedures. Staff not involved in the training sessions conducted outcome assessments with the same equipment and standardized procedures at pretesting and posttesting.

Full back squat 1RM was assessed following NSCA guidelines (Haff and Triplett, 2016), with progressive loading until a single maximal repetition was achieved within 3 - 5 attempts.

IMTP was performed on a force plate with a fixed barbell positioned at mid-thigh height (knee angle: 120 - 145°; hip angle: 140 - 150°). Participants performed 3 maximal 5-second pulls with 1-minute rest intervals. The highest net peak force (peak force minus body weight force) was used for analysis.

CMJ and SJ were assessed using an accelerometer-based device (Myotest Pro2). For CMJ, participants performed a rapid countermovement from standing before jumping maximally. For SJ, participants descended to a parallel-squat position, paused, and then jumped maximally without countermovement. Three valid trials were recorded for each test, and the best jump height was analyzed. Previous work has reported acceptable validity and reliability of Myotest-derived jump-height estimates in field settings (Casartelli et al., 2010; Choukou et al., 2014).

SBJ was performed on an indoor track surface. After one practice trial, participants completed 3 maximal attempts with 2-minute rest intervals. The best distance was recorded.

Training Program

Blood flow restriction protocol

BFR was applied bilaterally using 5-cm-wide pneumatic cuffs connected to a portable intelligent pressure-training device (Yidongkang Intelligent BFR Training Device, model ZNJY-01, China) and positioned at the proximal portion of each thigh. Right-thigh circumference was measured with a flexible tape 48 hours before the intervention. Restriction pressure was selected using the published thigh-circumference-based scheme corresponding to 50% of estimated arterial occlusion pressure: 100 mmHg for thigh circumferences below 51.0 cm, 130 mmHg for 51.0 - 55.9 cm, 150 mmHg for 56.0 - 59.9 cm, and 180 mmHg for 60.0 cm or greater (Loenneke et al., 2015). The pressure assigned from right-thigh circumference was applied to both thighs. Because individual arterial occlusion pressure was not directly determined using Doppler ultrasound, the assigned pressures represent estimated rather than confirmed 50% arterial occlusion pressure. Before formal occlusion at each session, participants underwent a staged pressure-familiarization sequence at 50%, 75%, and 100% of the assigned pressure.

Training and set-termination protocol

All groups performed 4 sets of full back squats with BFR twice weekly for 8 weeks, with 3-minute inter-set rest periods. Participants descended until the top surface of the thighs was below the horizontal plane and then initiated the concentric phase with maximal intended velocity. During sessions 1 - 8, the absolute load corresponded to 30% of baseline full back squat 1RM. The 1RM was reassessed after session 8, and the absolute load for sessions 9 - 16 was updated to 30% of the reassessed 1RM. The relative load was maintained at 30% of the current 1RM so that working-set repetition volume varied as a consequence of the set-termination strategy rather than a difference in prescribed relative intensity. A 4-session familiarization period preceded the intervention. Peak bar velocity was monitored using an accelerometer-based device (Enode Pro), which was magnetically attached to one side of the barbell and calibrated before each training session according to the manufacturer's instructions. Peak velocity was used because this metric had been prospectively configured for real-time set-termination feedback. Device-specific evidence includes between-session reliability for a peak vertical velocity measure during weightlifting (ICC = 0.954; Chavda et al., 2024) and agreement between EnodePro maximum velocity and a criterion displacement sensor during deep squats at 30% 1RM (ICC = 0.900), with a systematic overestimation of 0.129 $m \cdot s^{-1}$ and a mean absolute percentage error of 9.99% in the latter study (Behrmann et al., 2025). At each training session, participants first completed 5 maximal-intent repetitions at the target load with the cuffs inflated to the assigned pressure; the highest peak bar velocity in this calibration sequence was defined as the session-reference peak velocity. The cuffs were deflated immediately after calibration and remained deflated during the subsequent 3-minute seated rest. They were reinflated to the assigned pressure before the first working set and remained inflated continuously throughout all 4 working sets and the three 3-minute inter-set rest intervals. The 5 calibration repetitions were standardized across groups and excluded from working-set repetition totals. VL10% sets ended immediately after the first completed repetition below 90% of session-reference peak velocity, and VL40% sets ended immediately after the first completed repetition below 60%. The threshold-crossing repetition was included in the working-set repetition count. FAIL sets continued to volitional failure, defined as inability to complete another concentric repetition with acceptable technique despite maximal intended effort. All sessions were supervised by the research team with two spotters.

RPE was assessed using the Borg 6 - 20 scale after each set during all supervised training sessions. Session-averaged set RPE was defined as the mean of the 4 set-specific RPE scores recorded within each supervised session.

Statistical analysis

Data are presented as mean ± SD. Normality was assessed using the Shapiro-Wilk test, and homogeneity of variance was examined using Levene's test. A 3 (group) × 2 (time) mixed-design ANOVA was performed for each outcome.
When significant group × time interactions were detected, Bonferroni-adjusted post hoc comparisons of between-group pre-to-post changes were performed. For full back squat 1RM change scores, which violated normality, the Kruskal-Wallis test was additionally performed as a sensitivity analysis. For SJ height and IMTP change scores, which violated homogeneity of variance, Welch's ANOVA and Games-Howell post hoc tests were used. Cohen's d for between-group change-score contrasts was calculated using the pooled standard deviation of the individual change scores, and partial eta squared quantified ANOVA effects. Multiple secondary outcomes were interpreted cautiously. For each working set, the best peak velocity was defined as the highest valid velocity, terminal peak velocity as the velocity of the final completed repetition, and mean repetition peak velocity as the repetition-weighted mean across all working repetitions. Decline from the session reference and best-to-terminal decline were calculated at the set level and then averaged across the 64 working sets for each participant. Participant-level values were used to calculate group means and SDs. Between-group differences in the continuous Table 4 variables were assessed using one-way ANOVA with Tukey HSD post hoc comparisons when variances were homogeneous. Welch's ANOVA with Games-Howell comparisons was used for best-to-terminal decline, decline from the session reference, and session-averaged set RPE because their variances were heterogeneous. Prescribed design variables were not tested. Total working repetitions were calculated as the participant's mean repetitions per session × 16 and were not analyzed separately because they are a deterministic rescaling of repetitions per session. Statistical significance was set at alpha = 0.05. The original outcome analyses were performed in SPSS Statistics 27.0 (IBM Corp., Armonk, NY, USA); the additional Table 4 analyses were conducted in Python 3.9 using SciPy 1.7.3 and statsmodels 0.13.2.

Results

Participant flow and baseline characteristics

Forty-eight volunteers were screened, and 3 were excluded before allocation because they could not complete the scheduled testing and training requirements (Figure 1). The remaining 45 participants were allocated equally to VL10%, VL40%, and FAIL (n = 15 each), and all completed the intervention and posttesting. Baseline age, height, and body mass did not differ significantly among groups, as detailed in the Participants section.

Pre-to-Post Changes

A significant main effect of time was observed for all primary and secondary outcomes (all $p < 0.001$; Table 1 and 2). Significant group x time interactions were observed for full back squat 1RM ($F = 7.77$, $p = 0.001$, partial eta squared = 0.270), IMTP net peak force ($F = 10.76$, $p < 0.001$, partial eta squared = 0.339), CMJ height ($F = 12.46$, $p < 0.001$, partial eta squared = 0.372), SJ height ($F = 15.52$, $p < 0.001$, partial eta squared = 0.425), and SBJ distance ($F = 5.47$, $p = 0.008$, partial eta squared = 0.207). Full mixed-model ANOVA results are shown in Table 2.

Between-Group Comparisons of Change Scores

Primary strength outcomes

VL10% showed smaller 1RM improvements than VL40%

(mean difference = -8.53 kg, 95% CI = -12.35 to -4.72, adjusted $p < 0.001$, d = -1.67) and FAIL (mean difference = -6.20 kg, adjusted $p = 0.049$, d = -0.93). No statistically significant difference was detected between VL40% and FAIL (mean difference = 2.33 kg, 95% CI = -2.58 to 7.25, adjusted $p = 1.000$). For IMTP, VL10% showed smaller improvements than VL40% (mean difference = -115.7 N, 95% CI = -167.50 to -63.96, adjusted $p < 0.001$, d = -1.67) and FAIL (mean difference = -185.9 N, 95% CI = -282.38 to -89.49, adjusted $p = 0.002$, d = -1.48), whereas no statistically significant difference was detected between VL40% and FAIL (mean difference = -70.2 N, 95% CI = -167.48 to 27.08, adjusted $p = 0.442$). Complete pairwise comparisons are presented in Table 3.

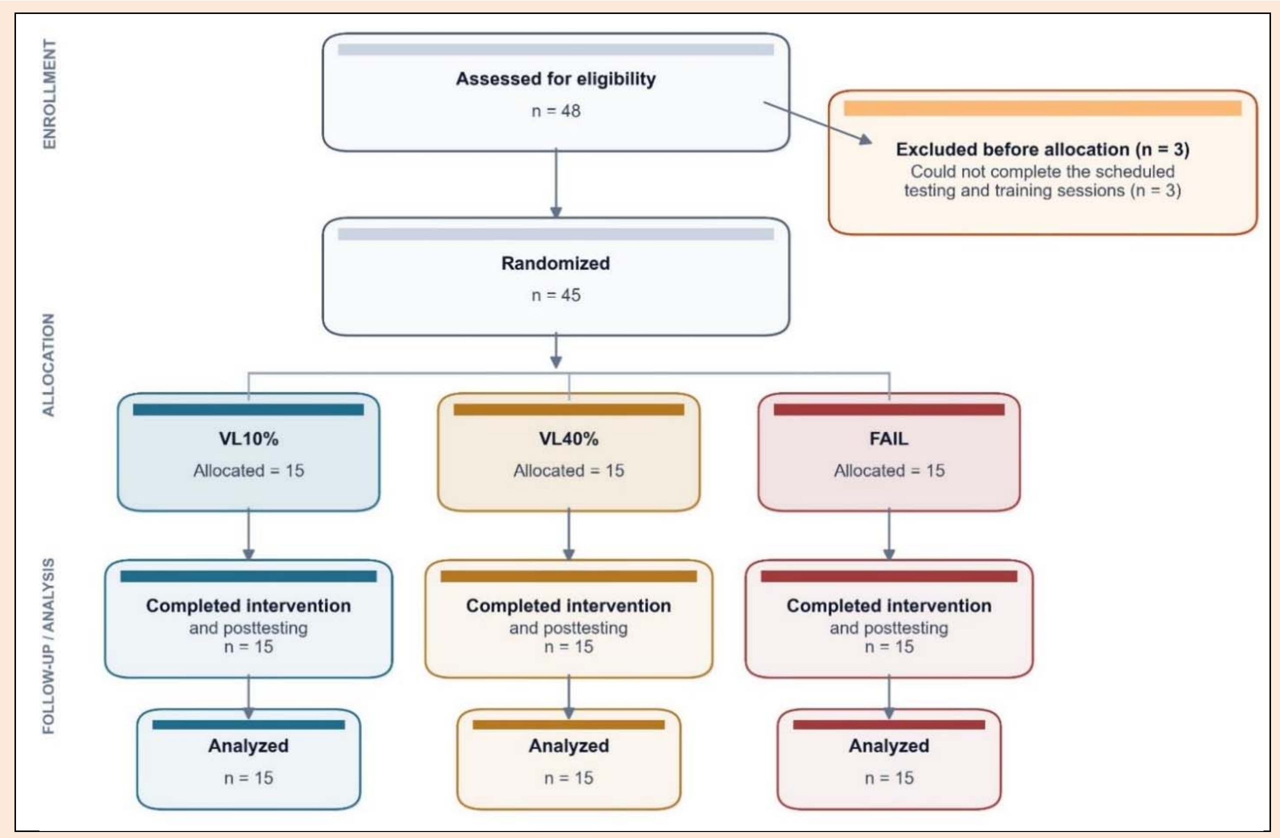

Figure 1. Flow of participants through screening, allocation, intervention completion, and analysis.

Table 1. Pre- and post-training outcome values and descriptive relative changes. Values are mean ± SD.

Outcome	Group	Pre	Post	Relative change, %
Full back squat 1RM, kg	VL10%	127.00 ± 10.66	144.00 ± 8.49	13.39
	VL40%	125.13 ± 5.36	150.67 ± 6.51	20.40
	FAIL	128.47 ± 6.78	151.67 ± 5.88	18.06
IMTP net peak force, N	VL10%	1905.27 ± 109.43	2080.33 ± 132.02	9.19
	VL40%	1840.33 ± 106.97	2131.13 ± 137.37	15.80
	FAIL	1792.80 ± 103.92	2153.80 ± 122.10	20.14
CMJ height, cm	VL10%	41.98 ± 1.41	46.05 ± 0.88	9.69
	VL40%	41.90 ± 1.32	45.63 ± 0.74	8.91
	FAIL	41.79 ± 1.35	44.26 ± 0.88	5.92
SJ height, cm	VL10%	34.85 ± 1.39	37.52 ± 0.92	7.65
	VL40%	34.54 ± 1.10	39.36 ± 0.52	13.95
	FAIL	34.99 ± 1.07	38.37 ± 0.92	9.66
SBJ distance, cm	VL10%	246.33 ± 2.74	271.53 ± 2.00	10.23
	VL40%	244.47 ± 5.46	269.00 ± 2.48	10.04
	FAIL	245.40 ± 5.33	265.60 ± 3.42	8.23

Relative change was calculated from group-level pre- and post-training means and is presented descriptively. 1RM = one-repetition maximum; IMTP = isometric mid-thigh pull; CMJ = countermovement jump; SJ = squat jump; SBJ = standing broad jump.

Jump performance

Both VL10% (mean difference = 1.59 cm, adjusted $p < 0.001$, d = 1.90) and VL40% (mean difference = 1.26 cm, adjusted $p = 0.004$, d = 1.30) showed greater CMJ-height improvements than FAIL, with no statistically significant difference between VL10% and VL40% (adjusted $p = 1.000$). For SJ height, VL40% showed greater improvements than FAIL (mean difference = 1.44 cm, adjusted $p = 0.009$, d = 1.20) and VL10% (mean difference = 2.15 cm, adjusted $p < 0.001$, d = 2.48). For SBJ distance, VL10% showed greater improvement than FAIL (mean difference = 5.00 cm, adjusted $p = 0.012$, d = 1.14), whereas VL40%

showed no statistically significant difference from either comparator. Complete pairwise comparisons are presented in Table 3, and individual pre-to-post change scores are shown in Figure 2.

Table 2. Summary of the mixed-model ANOVA results.

Outcome	Time effect, F	Time effect, p	Group effect, F	Group effect, p	Group × time, F	Group × time, p	Group × time partial η2
Full back squat 1RM	574.972	< 0.001	1.672	0.200	7.765	0.001	0.270
IMTP net peak force	278.219	< 0.001	0.131	0.878	10.762	< 0.001	0.339
CMJ height	620.901	< 0.001	3.744	0.032	12.464	< 0.001	0.372
SJ height	507.720	< 0.001	2.996	0.061	15.520	< 0.001	0.425
SBJ distance	1210.372	< 0.001	4.754	0.014	5.472	0.008	0.207

1RM = one-repetition maximum; IMTP = isometric mid-thigh pull; CMJ = countermovement jump; SJ = squat jump; SBJ = standing broad jump.

Table 3. Pairwise comparisons of pre-to-post change scores.

Outcome	Comparison	Mean difference	Adjusted p	Effect size (d)	Follow-up test
Full back squat 1RM, kg	VL10% vs VL40%	-8.53	< 0.001	-1.67	Bonferroni
	VL10% vs FAIL	-6.20	0.049	-0.93	Bonferroni
	VL40% vs FAIL	2.33	1.000	0.36	Bonferroni
CMJ height, cm	VL10% vs VL40%	0.33	1.000	0.35	Bonferroni
	VL10% vs FAIL	1.59	< 0.001	1.90	Bonferroni
	VL40% vs FAIL	1.26	0.004	1.30	Bonferroni
SJ height, cm	VL10% vs VL40%	-2.15	< 0.001	-2.48	Games-Howell
	VL10% vs FAIL	-0.71	0.298	-0.63	Games-Howell
	VL40% vs FAIL	1.44	0.009	1.20	Games-Howell
SBJ distance, cm	VL10% vs VL40%	0.67	1.000	0.18	Bonferroni
	VL10% vs FAIL	5.00	0.012	1.14	Bonferroni
	VL40% vs FAIL	4.33	0.102	0.81	Bonferroni
IMTP net peak force, N	VL10% vs VL40%	-115.73	< 0.001	-1.67	Games-Howell
	VL10% vs FAIL	-185.93	0.002	-1.48	Games-Howell
	VL40% vs FAIL	-70.20	0.442	-0.55	Games-Howell

Mean differences represent change-score contrasts in the listed comparison order. The Kruskal-Wallis sensitivity analysis for full back squat 1RM change scores did not alter interpretation of the primary findings.

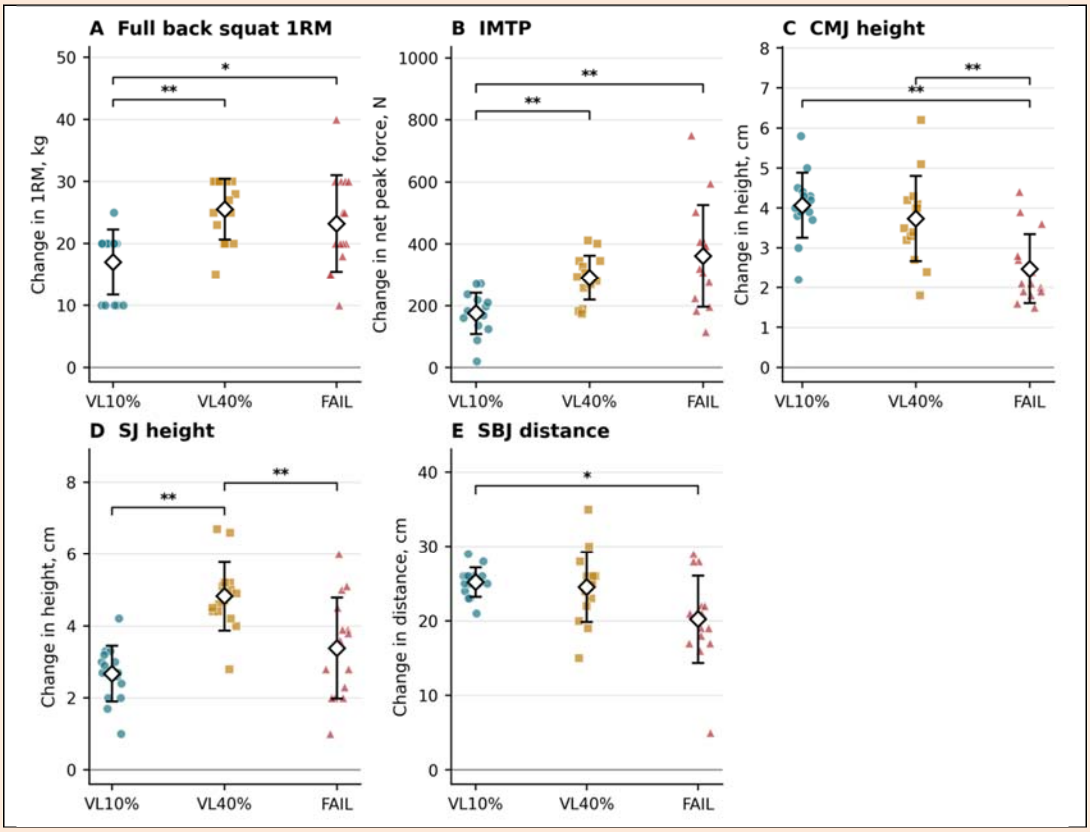

Figure 2. Individual pre-to-post change scores for full back squat one-repetition maximum (1RM), isometric mid-thigh pull (IMTP) net peak force, countermovement-jump (CMJ) height, squat-jump (SJ) height, and standing broad-jump (SBJ) distance. Points indicate individual participants; open diamonds and whiskers indicate mean ± SD. Brackets indicate statistically significant between-group contrasts (* adjusted p < 0.05; ** adjusted p < 0.01). VL10% = 10% session-reference peak-velocity-decline threshold; VL40% = 40% threshold; FAIL = volitional failure.

Table 4. **Working-set repetition-volume, peak-velocity, and perceived-exertion characteristics across all 16 supervised sessions.**

Variable	VL10% (n = 15)	VL40% (n = 15)	FAIL (n = 15)	F	p
Prescribed relative load, % current 1RM	30	30	30	-	-
Load updated after session 8	Yes	Yes	Yes	-	-
Prescribed session-reference peak-velocity decline, %	10	40	Not prescribed	-	-
Mean session-reference peak velocity, m/s	2.03 ± 0.08	2.02 ± 0.08	2.00 ± 0.08	0.545	0.584
Mean of the best working-set peak velocity, m/s	2.00 ± 0.08	1.99 ± 0.08	1.98 ± 0.08	0.234	0.792
Repetition-weighted mean working-repetition peak velocity, m/s	1.92 ± 0.08^{a}	1.58 ± 0.07^{b}	1.29 ± 0.08^{c}	257.536	< 0.001
Mean terminal peak velocity, m/s	1.81 ± 0.07^{a}	1.21 ± 0.06^{b}	0.80 ± 0.09^{c}	678.639	< 0.001
Mean best-to-terminal velocity decline, %	9.48 ± 0.84^{a}	39.25 ± 2.03^{b}	59.70 ± 4.03^{c}	2244.034†	< 0.001
Mean decline from session calibration reference, %	10.60 ± 0.80^{a}	40.00 ± 2.00^{b}	60.00 ± 4.00^{c}	2259.692†	< 0.001
Working-set repetitions per session	55.91 ± 0.61^{a}	74.26 ± 0.89^{b}	94.08 ± 0.93^{c}	8081.799	< 0.001
Total working-set repetitions over 16 sessions	894.6 ± 9.8	1188.2 ± 14.2	1505.3 ± 14.9	-	-
Session-averaged set RPE	12.44 ± 0.10^{a}	15.53 ± 0.31^{b}	16.74 ± 0.16^{c}	4042.795†	< 0.001

Values are mean ± SD unless otherwise stated and use participants as the unit of analysis. Different superscript letters within a row indicate a statistically significant between-group difference (adjusted p < 0.05). †Welch's ANOVA with Games-Howell post hoc comparisons; other tested continuous variables were analyzed using one-way ANOVA with Tukey HSD comparisons. Prescribed design variables were not tested. Velocity variables summarize 64 working sets per participant. Total working repetitions = mean repetitions per session × 16 and were not separately tested; the 5 calibration repetitions per session were excluded. RPE = rating of perceived exertion.

Working-set repetition volume, velocity, and perceived exertion

The termination strategies produced distinct working-set repetition volumes (Table 4). Working-set repetitions per session were 55.91 ± 0.61 in VL10%, 74.26 ± 0.89 in VL40%, and 94.08 ± 0.93 in FAIL ($F(2, 42) = 8081.80$, $p < 0.001$); all Tukey-adjusted pairwise comparisons were significant. Total working repetitions over 16 sessions were 894.6 ± 9.8, 1188.2 ± 14.2, and 1505.3 ± 14.9, respectively. Session-averaged set RPE also differed among all groups (Welch $F(2, 24.55) = 4042.79$, $p < 0.001$), with VL10% lowest and FAIL highest. Mean session-reference peak velocity and the mean of the best working-set peak velocity did not differ among groups ($p = 0.584$ and $p = 0.792$, respectively). In contrast, mean working-repetition and terminal peak velocity, best-to-terminal decline, and decline from the session reference differed among all groups (all adjusted pairwise $p < 0.001$).

Discussion

This study compared three set-termination strategies that produced clearly separated working-set repetition volumes during low-load BFR full back squat training. Three findings were central. First, VL10%, VL40%, and FAIL produced progressively greater repetition volume and perceived exertion, despite similar session-reference and best working-set peak velocities. Second, no statistically significant between-group difference was detected between VL40% and FAIL in the primary strength outcomes, although VL40% involved 21.1% fewer working-set repetitions per session. Third, VL10% produced the lowest repetition volume and favorable changes in selected jump outcomes but smaller primary strength improvements than VL40%. These findings indicate trade-offs among the repetition volumes and fatigue exposures produced by the termination strategies rather than a universally optimal velocity threshold.

The approximately 2.00 $m \cdot s^{-1}$ session-reference peak velocities were plausible for a low-load full back squat. Sánchez-Medina et al.,(2017) reported that peak velocity increased as relative load decreased and observed 1.87 ± 0.15 $m \cdot s^{-1}$ at 40% 1RM. Nevertheless, that study removed loads below 40% 1RM from its formal analysis, and peak velocity showed a weaker load-velocity association than mean and mean propulsive velocity. The present values therefore provide a protocol description, not a velocity-based confirmation that the external load equaled 30% 1RM; relative load was prescribed from measured 1RM.

VL40% involved 21.1% fewer working-set repetitions per session than FAIL and lower session-averaged set RPE, yet no statistically significant between-group difference was detected for 1RM or IMTP. This observation is consistent with evidence that nonfailure BFR can produce some similar chronic adaptations with less discomfort than failure protocols (Kataoka et al., 2026; Sieljacks et al., 2019). However, absence of a statistically significant difference does not establish equivalence or noninferiority. VL10% completed 75.3% as many repetitions as VL40%, showing that the nominal velocity-decline percentages did not translate proportionally into repetition volume under this low-load BFR protocol. The volume differences should also not be interpreted as an independently randomized dose-response experiment: repetition volume was produced by the assigned termination strategy and co-varied with terminal velocity, achieved velocity decline, and perceived exertion. Consequently, adaptation differences cannot be attributed to repetition volume alone.

The strength pattern differs from that reported by Sánchez-Valdepeñas et al.,(2026), who observed an inverted-U pattern in which low-to-moderate velocity-decline thresholds produced favorable strength and jump adaptations. Their intervention used 55%-70% 1RM, 3 sets, set-internal mean propulsive velocity measured with a linear transducer, session-by-session load adjustment, and 50% of directly measured arterial occlusion pressure. The present study used 30% of the current 1RM, 4 sets, accelerometer-derived peak velocity, a pre-session calibration reference, and a circumference-based pressure prescription. These factors likely altered both the repetition volume produced by a nominal threshold and its physiological meaning. Jump responses were also outcome specific:

VL10% favored CMJ height and SBJ distance relative to FAIL, whereas VL40% showed the largest SJ-height improvement. These secondary findings should be interpreted cautiously because multiple outcomes were tested and the study was not designed to establish a mechanism.

Limitations

Several limitations should be acknowledged. Repetition volume was an outcome of the randomized set-termination strategy rather than an independently randomized factor, and it co-varied with velocity decline and perceived exertion; causal effects of volume alone therefore cannot be isolated. The sample consisted of resistance-trained male university students performing a single low-load BFR full back squat model, which limits generalizability. Individual arterial occlusion pressure was not measured with Doppler ultrasound, so applied pressure could not be expressed as a confirmed percentage of arterial occlusion pressure. Thresholds based on peak velocity relative to a pre-session calibration are not directly interchangeable with conventional set-internal mean concentric or mean propulsive velocity thresholds. Finally, the 5 calibration repetitions were excluded from working-set totals despite contributing to total exposure, multiple secondary outcomes were examined, and no hypertrophy or mechanistic markers were measured.

Practical implications

For resistance-trained young men performing this low-load BFR full back squat protocol, velocity-regulated termination can be used to individualize working-set repetition volume. VL40% produced lower repetition volume and perceived exertion than failure while no between-group difference was detected in the primary strength outcomes. VL10% minimized repetition exposure further, although its smaller strength improvements relative to VL40% should be weighed against favorable changes in selected jump outcomes. These recommendations concern complete termination strategies and should not be interpreted as isolated volume-dose effects.

Conclusion

Under the same relative-load BFR prescription, VL10%, VL40%, and FAIL produced distinct working-set repetition volumes and perceived exertion. VL40% involved fewer repetitions than failure without a detected difference in the primary strength outcomes, whereas VL10% involved the lowest repetition volume but smaller strength improvements than VL40%. Because repetition volume resulted from the assigned set-termination strategy and co-varied with velocity and fatigue characteristics, the observed adaptations cannot be attributed to repetition volume alone.

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Key points

- The three set-termination strategies produced clearly separated working-set repetition volumes under the same 30%-of-current-1RM BFR prescription.
- VL40% involved lower repetition volume and perceived exertion than failure without a detected difference in the primary strength outcomes; VL10% reduced repetition exposure further but produced smaller strength gains than VL40%.
- Repetition volume was an outcome of the assigned set-termination strategy, so the observed adaptations cannot be attributed to volume independently of the velocity and fatigue conditions that produced it.
- The results apply most directly to resistance-trained young men using session-reference peak velocity to regulate repetition exposure during low-load BFR full back squat training.