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SPORTS PERFORMANCE



Low-load blood flow restriction with elastic bands elicits superior gains in sprint and jump performance compared to heavy-load training in In-season collegiate basketball players

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ABSTRACT

This study compared low-load blood flow restriction with elastic bands (BFR-EBT) versus heavy-load training (HL-EBT) on performance in 18 Division I basketball players during a competitive season. Participants performed back squats twice weekly for 8 weeks at ~30% 1RM (BFR-EBT) or ~75% 1RM (HL-EBT). Significant Group $\times$ Time interactions were observed for CMJ height ($p=0.031$) and 30-m sprint time ($p=0.014$). BFR-EBT significantly optimized CMJ height (+3.4%; Hedges' $g = 1.50$) and sprint time (-0.8%; Hedges' $g = -3.80$). HL-EBT showed non-significant changes in CMJ (+1.8%) and sprint speed (+0.2%). Both groups achieved similar 1RM strength gains ($p>0.05$). Notably, BFR-EBT adaptations occurred with a 3.6-fold lower mechanical training load ($p<0.001$). Covariate analysis confirmed results were independent of playing time. Low-load BFR-EBT appears more effective than HL-EBT for optimizing power and speed in elite players while sparing mechanical load during a congested season. BFR-EBT represents a viable tool for in-season fatigue management.

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KEYWORDS

Blood flow restriction;
resistance training; team
sport; athletic performance;
strength; power

Introduction

Basketball is a high-intensity, intermittent team sport where on-court success is fundamentally determined by explosive actions such as sprinting, jumping, and changing direction (Ben Abdelkrim et al., 2007; García et al., 2021). The ability to repeatedly produce high levels of power is therefore a critical physical attribute. Consequently, for athletes managing the dual stressors of a competitive season, maintaining a high-quality training stimulus that enhances these qualities without compromising recovery is paramount.

For decades, heavy-load resistance training (HLT; $>70\%$ 1RM) has been the cornerstone for developing the foundational strength that underpins explosive power (Association, 2021). However, the high mechanical stress associated with HLT presents a significant challenge, particularly during the demanding in-season period. For athletes managing the dual stressors of competition and practice, accumulating excessive training-induced fatigue not only elevates injury risk but can directly impair sport-specific performance (Carroll et al., 2017; Scanlan et al., 2018). This necessitates the

exploration of alternative paradigms that can elicit potent adaptations while mitigating mechanical load.

Blood flow restriction (BFR) training has emerged as a promising modality in this context. It utilises a pneumatic cuff to create a significant local metabolic stress, hypothesised to enhance the recruitment of high-threshold motor units and emulate the neuromuscular adaptations of HLT (Loenneke et al., 2011; Patterson et al., 2019; Schoenfeld, 2013). This potential to uncouple physiological stimulus from high mechanical load is particularly appealing for practitioners seeking complementary tools with a favourable stimulus-to-fatigue ratio. Indeed, while acute BFR application shows nuanced effects – sometimes mitigating power decline (Trybulski et al., 2022) but not always enhancing bar velocity (Gawel et al., 2025) – its chronic application as a load-sparing tool is supported by meta-analytic evidence confirming its effectiveness for enhancing strength in athletes (Li et al., 2025; Lixandrão et al., 2018).

This study explores this question by investigating the interaction between BFR and elastic band training (EBT). EBT provides a form of variable resistance that may offer

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a unique stimulus profile (Lopes et al., 2019). However, each modality has its own limitations; BFR's stimulus is primarily metabolic, while EBT can have lower precision in load quantification. The novel combination investigated herein aims to synergistically harness the metabolic stress of BFR with the accommodating mechanical tension of EBT, a concept not previously explored. While prior work has explored BFR's role in short-term contexts like tapering (Smith et al., 2025), its long-term efficacy as an alternative to a heavy-load variable resistance programme throughout a competitive season constitutes an important and practical knowledge gap.

Therefore, the purpose of this study was to investigate the effectiveness of a novel, low-load BFR-EBT protocol versus a heavy-load HL-EBT protocol for enhancing lower-body strength and explosive power in collegiate basketball players during an 8-week in-season training block. We hypothesised that the BFR-EBT group would demonstrate greater improvements in explosive performance (jump height and sprint speed), and that these enhancements would be achieved with a significantly lower mechanical training load.

Methods

Study design

This investigation employed a single-blind, randomised controlled trial (RCT) design, conducted in-season with highly-trained collegiate basketball players. The study was approved by the local Institutional Review Board (Approval No. 2023LCLL-76) and adhered to the principles of the Declaration of Helsinki. All participants provided written informed consent after being fully informed of the procedures, potential benefits, and associated risks. Following a one-week familiarisation period to standardise exercise technique, participants completed baseline testing. Subsequently, they were randomly allocated following baseline testing. The allocation sequence was generated by an independent researcher using a computerised random-number generator. To ensure allocation concealment, assignments were placed in sequentially numbered, opaque, sealed envelopes, which were opened by the supervising coach only after a participant had irrevocably been entered into the trial. The intervention lasted 8 weeks, with all training and testing sessions supervised and conducted at the same time of day (15:00–17:00 h) to control for circadian variations. The performance assessor (a research assistant from the Sports Training Institute, Guangzhou Sport University) remained blinded to group allocation throughout the study. While participants and coaches could not be blinded to the training

loads, all individuals were naive to the specific study hypotheses to minimise motivational bias. To maintain consistency, both groups received identical encouragement and were told both protocols were considered potentially effective training strategies. A schematic overview of the study design is provided in Supplemental Figure S1.

Participants

Eighteen highly-trained collegiate male basketball players (Mean $\pm$ SD; Age: 21.5 ± 0.6 years; Height: 180.5 ± 2.6 cm; Body mass: 83.7 ± 2.5 kg; Back squat 1RM: 135.1 ± 5.8 kg) from the same university team competing in an NCAA Division I league participated. The cohort consisted of players with varied on-court roles (starters and rotational players). Inclusion criteria were: a minimum of three years of continuous, supervised resistance training experience; proficiency in the back squat; and no lower-limb musculoskeletal injuries within the last six months. Participants were excluded if they had prior experience with BFR training or reported any contraindications (e.g., history of DVT, uncontrolled hypertension) on a pre-screening health questionnaire (Supplemental Material S1). Participant well-being was systematically monitored at each session using a standardised adverse event questionnaire (Supplemental Material S2). Mean thigh circumference of the participants was 58.4 ± 4.2 cm.

Sample size estimation and justification

Due to the fixed roster size of the elite collegiate team, the total sample size was fixed at $N = 18$. A sensitivity analysis was conducted using G*Power (v. 3.1.9.7) to determine the minimum effect size our study was adequately powered to detect. For a 2 (Group: BFR-EBT, HL-EBT) $\times$ 2 (Time: Pre, Post) repeated measures ANOVA (within-between interaction), specifying $\alpha = 0.05$, Power $(1 - \beta) = 0.80$, and assuming a conservative correlation of 0.5 among repeated measures, the study was powered to detect a Group $\times$ Time interaction with an effect size of $f = 0.35$ or greater. This corresponds to a standardised difference (Hedges' g) of approximately 0.70.

Testing procedures

Before each testing session, participants performed a standardised 10-minute warm-up including light aerobic activity, dynamic stretching, and submaximal trials of the scheduled tests (Supplemental Material S4). To minimise fatigue-related confounding, the order of tests was

standardised: on Day 1, (1) Anthropometry, (2) Jump Performance (CMJ, SJ, RSI), (3) Standing Long Jump, (4) Change-of-Direction Ability (T-test), and (5) 30-m Sprint. Participants performed three maximal efforts for each jump and sprint test, with the highest value (best performance) used for analysis. Vertical jump and reactive strength index (RSI) were quantified using a 1000-Hz contact mat system (SMARTSPEED PT, Fusion Sport, Australia). Linear sprint speed was recorded to 0.01-s precision using wireless dual-photocell photoelectric timing gates (Brower Timing Systems, USA). The 1RM back squat test was conducted on Day 2, separated by 48 hours to prevent residual fatigue. All tests were conducted by a blinded assessor from the Sport Training Institute at Guangzhou Sport University. Test-retest reliability was established during familiarisation (Table 1). The Smallest Worthwhile Change ($SWC = 0.2 \times \text{baseline SD}$) and Minimal Detectable Change (MDC with 95% confidence) were calculated to interpret the practical significance of changes.

Training intervention

Both groups trained twice-weekly for 8 weeks, integrated into their auxiliary in-season programming. All sessions were supervised by a certified strength and conditioning specialist (CSCS) to ensure proper technique and 100% adherence (>95% of scheduled sessions completed). Each session began with a standardised 10-min dynamic warm-up (Supplemental Material S4). The primary exercise was the back squat augmented with elastic bands. All repetitions were performed with maximal concentric velocity and a controlled 2-s eccentric phase. Training was not performed to muscular failure; a target of approximately 2–3 repetitions in reserve (RIR) was maintained for work sets in the HL-EBT group. Session-RPE (CR-10 scale) was collected 20 minutes post-session.

- **BFR-EBT Group:** Trained at a total intensity of ~30% 1RM (1 set of 30, followed by 3 sets of 15 repetitions; 60s rest). A non-elastic, 5-cm wide nylon cuff containing a 3-cm wide internal pneumatic bladder (KAATSU Air Bands, KAATSU Global, Inc., Japan) was applied proximally to both thighs and inflated to a fixed pressure of 180 mmHg during work sets.

Based on cohort thigh circumferences, this corresponds to approximately 60–80% of arterial occlusion pressure (Patterson et al., 2019).

- **HL-EBT Group:** Trained at a total intensity of ~75% 1RM (4 sets of 8–10 repetitions; 3 min rest).
- **Load Progression:** For both groups, variable resistance from elastic bands contributed ~20% of the total load at the top of the movement. Variable resistance was provided by two identical commercial-grade elastic bands (Rogue Monster Bands, Blue; Rogue Fitness, USA), which were doubled and looped over each end of the barbell and anchored to the base of the power rack. Band resistance was individually quantified using a digital tension gauge (Mark-10 Series 5, USA), calibrated to provide ~10 kg at the bottom and ~25 kg at the top of each participant's individual range of motion (Figure 1). Barbell loads were adjusted after a mid-point 1RM test at week 4.

Training load quantification

To compare the mechanical stimulus, total volume load for the back squat over 8 weeks was calculated as: $\text{Sets} \times \text{Repetitions} \times (\text{Barbell Load [kg]} + \text{Average Band Resistance [kg]})$.

Statistical analysis

All statistical analyses were performed using R (Version 4.4.3). Descriptive statistics are presented as Mean $\pm$ SD. The alpha level was set a priori at $p \leq 0.05$. Assumptions of normality and homogeneity of variances were verified via Shapiro-Wilk and Levene's tests.

Performance outcomes were analysed using Mixed-design Repeated Measures ANOVA (Group $\times$ Time) via the afex package. Standardised effect sizes were calculated as Hedges' g to account for the small sample size ($N = 18$). To ensure robust inference, 95% confidence intervals (CI) for all mean changes and effect sizes were derived from 1000 non-parametric bootstrap resamples using the bias-corrected and accelerated (BCa) method. Secondary

Table 1. Test-retest reliability and interpretable change thresholds.

Variable	ICC (3,1)	CV (%)	SEM	SWC ($0.2 \times \text{SD}$)	MDC (95% CI)	Interpretation
CMJ Height (cm)	0.95	2.1	0.80	0.46	2.22	Excellent
30-m Sprint (s)	0.92	1.2	0.02	0.02	0.05	Excellent
Squat 1RM (kg)	0.98	2.5	2.50	1.20	6.93	Excellent

Notes: ICC = Intraclass Correlation Coefficient; CV = Coefficient of Variation; SEM = Standard Error of Measurement; SWC = Smallest Worthwhile Change (the minimum improvement with practical relevance for elite athletes); MDC = Minimal Detectable Change (reflecting the 95% confidence threshold for physiological change).

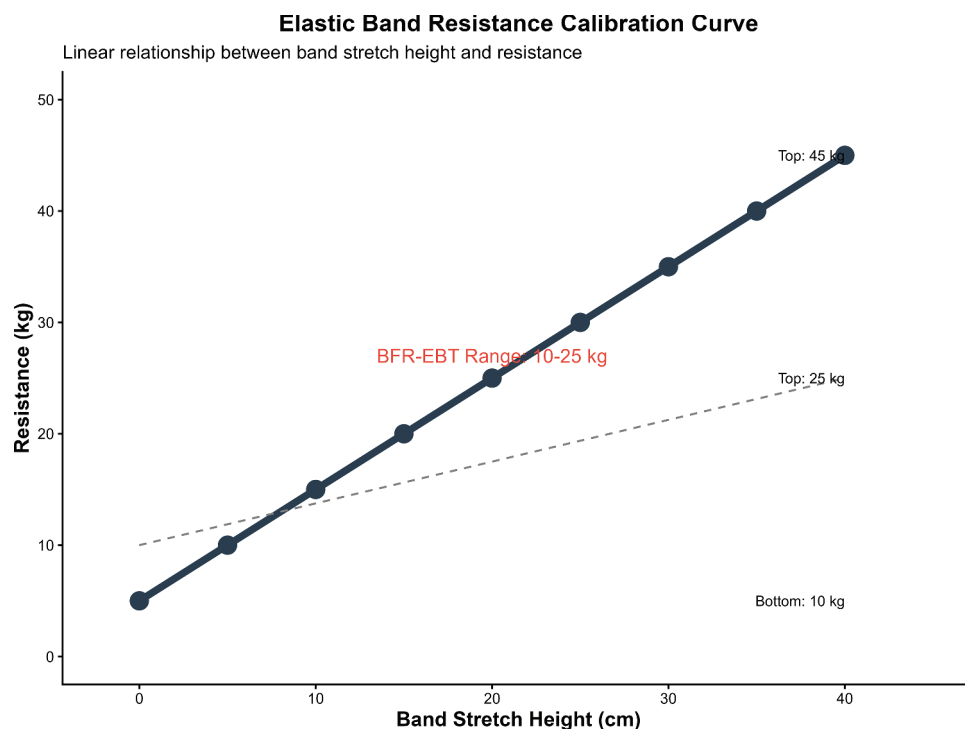


Figure 1. Elastic band resistance calibration curve. The linear relationship between band stretch distance (height) and measured resistance (kg).

analyses included ANCOVA with seasonal playing time and baseline performance values as covariates. Baseline characteristics were compared via independent samples t-tests. Post-hoc pairwise comparisons utilised Bonferroni corrections. Longitudinal Session-RPE trends were analysed using a linear mixed-effects model (LMEM).

Results

The flow of participants through the study is illustrated in the CONSORT diagram (Figure 2). All 18 randomised Division I collegiate basketball players successfully completed the 8-week intervention with an adherence rate of >95%. All participants were included in the final analysis. As presented in Table 2, the groups were well-matched at baseline for all anthropometric and performance characteristics, as well as for seasonal competitive playing time (BFR-EBT: 35.3 ± 23.0 min/week; HL-EBT: 34.7 ± 22.1 min/week; $t(16) = 0.06$, $p = 0.952$).

Intervention fidelity and training load

The training intervention was implemented as intended. The total 8-week mechanical volume load for the back squat was significantly lower in the BFR-EBT group ($\sim 12,500$ kg) compared to the HL-EBT group ($\sim 44,500$ kg;

$p < 0.001$), representing a 3.6-fold disparity in total mechanical load (Figure 3). Despite this disparity, the subjective experience of effort was matched between groups; the average weekly Session-RPE did not significantly differ between the BFR-EBT (7.4 ± 0.8) and HL-EBT (7.1 ± 1.0) groups ($t(16) = 0.71$, $p = 0.49$) (Figure 4). No training-related injuries or adverse events were reported.

Training-induced performance changes

The primary findings from the mixed-design RM-ANOVA are presented in Table 3. A significant main effect for time was observed for maximal strength (squat 1RM; $F(1,16) = 152.9$, $p < 0.001$) and horizontal power (SLJ; $p < 0.05$), indicating that both protocols were effective at improving these qualities. However, no significant Group $\times$ Time interactions were found for squat 1RM ($F(1,16) = 0.27$, $p = 0.612$), squat jump (SJ), or reactive strength index (RSI) (all $p > 0.05$), suggesting both groups improved to a similar extent. Exploratory ANCOVA confirmed that individual variations in seasonal playing time did not significantly influence these primary outcomes ($p > 0.05$; see Table 4) (Figure 5). Conversely, significant Group $\times$ Time interactions were detected for the primary outcomes of vertical jump and sprint speed. For countermovement jump height (CMJ), a significant interaction was detected ($F(1,16)$

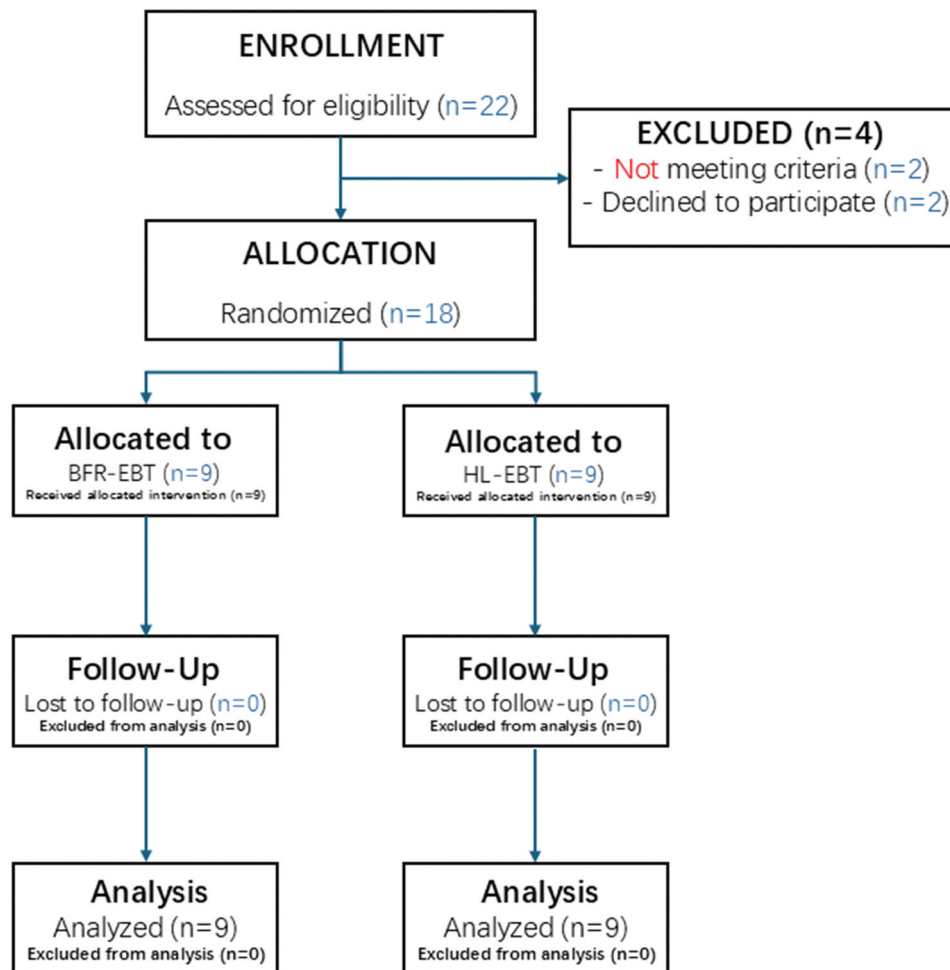


Figure 2. CONSORT (Consolidated standards of reporting trials) flow diagram detailing the recruitment, enrollment, random allocation, and final analysis of the study participants.

Table 2. Baseline anthropometric and performance characteristics (mean $\pm$ SD).

Variable	BFR-EBT (n = 9)	HL-EBT (n = 9)	p-value
Age (years)	21.5 $\pm$ 0.7	21.6 $\pm$ 0.5	0.735
Height (cm)	180.4 $\pm$ 3.0	180.6 $\pm$ 2.4	0.829
Body Mass (kg)	83.5 $\pm$ 2.8	83.9 $\pm$ 2.4	0.735
Squat 1RM (kg)	136 $\pm$ 7	134 $\pm$ 5	0.511
CMJ Height (cm)	47.8 $\pm$ 2.3	49.0 $\pm$ 2.1	0.252
30-m Sprint (s)	4.49 $\pm$ 0.10	4.51 $\pm$ 0.08	0.605
Weekly Playing Time (min)	35.3 $\pm$ 24.0	34.7 $\pm$ 22.1	0.952

Note: No statistically significant differences ($p > 0.05$) were found between groups at baseline, indicating successful randomization and balanced competition exposure.

$=5.63, p = 0.031$). Analysis of mean changes and Bootstrap inference revealed that the BFR-EBT group achieved a significant modest improvement ($+3.4\%$; mean change = 1.64 cm, Bootstrap 95% BCa CI: 1.17 to 1.95 cm; $p < 0.001$). The HL-EBT group showed a smaller, non-significant increase ($+1.8\%$; mean change = 0.88 cm, $p > 0.05$). The magnitude of the between-group difference was large (Hedges' $g = 1.50$). While the group mean improvement did not exceed the conservative MDC

(2.22 cm), it far exceeded the SWC (0.45 cm), signifying meaningful athletic enhancement within this elite cohort. Individual percent changes and trajectories are illustrated in Figure 6A and Figure 7A. A significant interaction was also observed for 30-m sprint time ($F(1,16) = 7.61, p = 0.014$). The BFR-EBT group achieved a small but consistent reduction in sprint time (-0.8% ; mean change = -0.037 s, Bootstrap 95% BCa CI: -0.050 to -0.031 s; $p < 0.001$), while the HL-EBT group exhibited

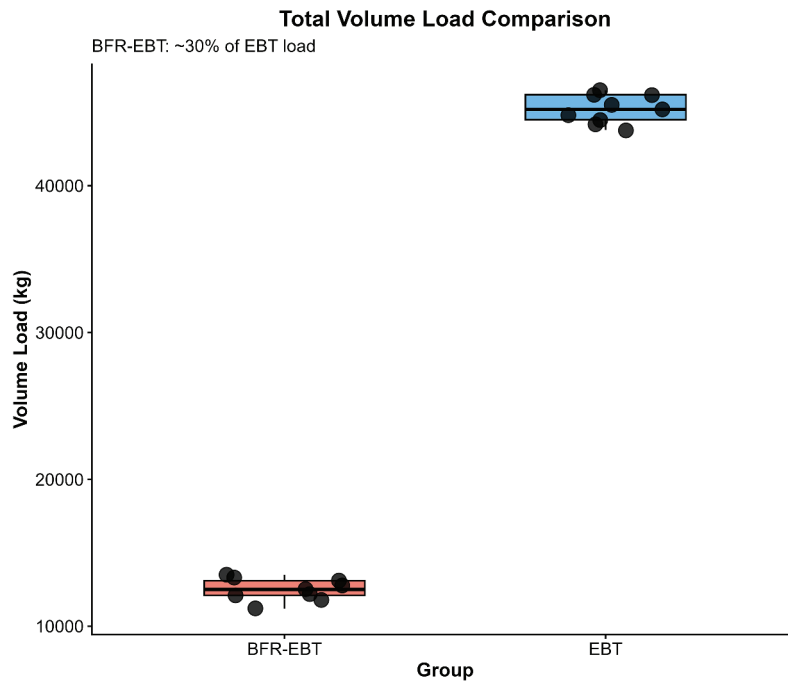


Figure 3. Comparison of total 8-week mechanical volume load (kg) for the back squat exercise between BFR-EBT and HL-EBT groups. Data are presented as boxplots with individual data points overlaid. *** $p < 0.001$ indicates a significant 3.6-fold disparity in mechanical loading.

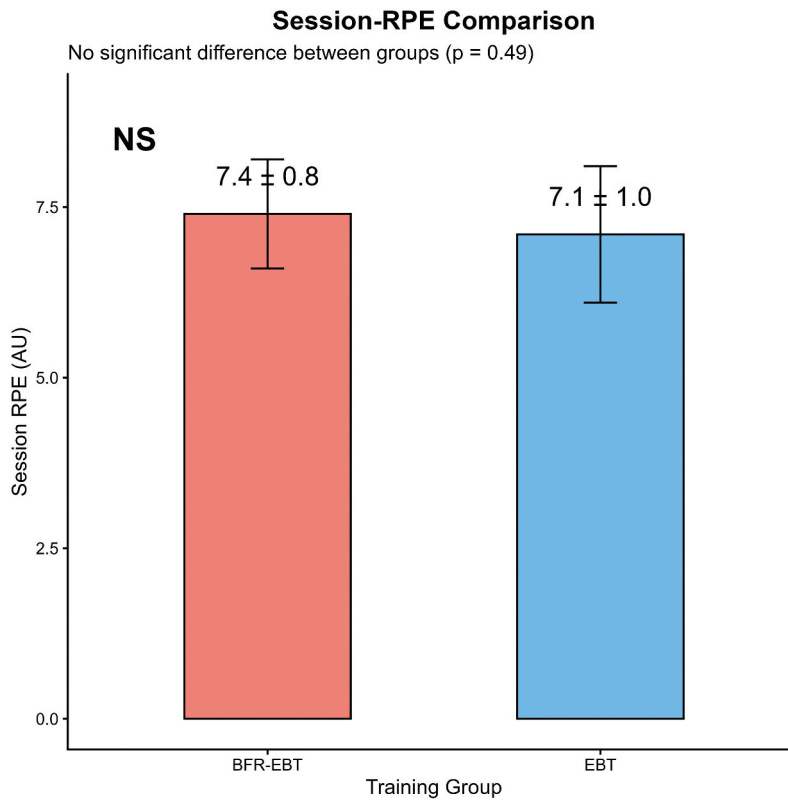


Figure 4. Session-RPE comparison. Mean $\pm$ SD values for the BFR-EBT and HL-EBT groups recorded 20 minutes post-training. No significant difference was observed ($p = 0.49$).

Table 3. Performance outcomes before (Pre) and after (post) the 8-week intervention.

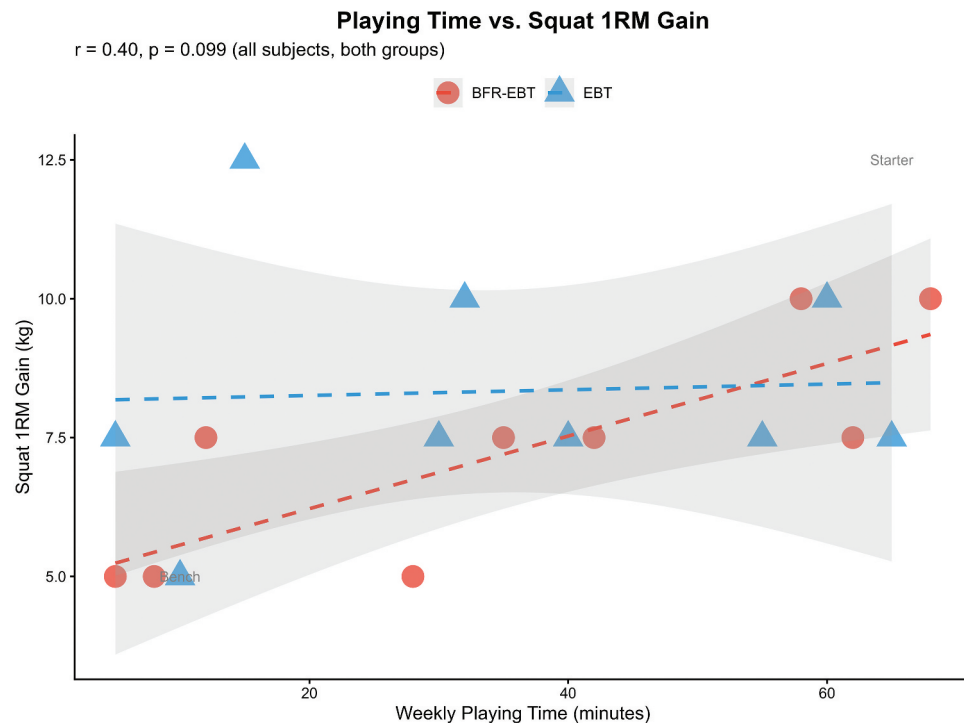
Performance Variable	Group	Pre (Mean±SD)	Post (Mean±SD)	Mean Change (3.4%/-0.8%)	Bootstrap 95% BCa CI	p (Interaction)	Hedges' g
CMJ (cm)	BFR-EBT	47.8 ± 2.3	49.4 ± 2.7	+1.64*	[1.17, 1.95]	0.031	1.50
	HL-EBT	49.0 ± 2.1	49.9 ± 2.1	+0.88*	[0.73, 1.03]		
30-m Sprint (s)	BFR-EBT	4.49 ± 0.10	4.45 ± 0.10	-0.037*	[-0.050, -0.031]	0.014	-3.80
	HL-EBT	4.51 ± 0.08	4.52 ± 0.08	+0.009	[0.003, 0.015]		
Squat 1RM (kg)	BFR-EBT	136 ± 7	143 ± 9	+7.2*	[5.8, 8.1]	0.612	-0.54
	HL-EBT	134 ± 5	142 ± 5	+8.3*	[6.7, 10.0]		

Notes: CI = Confidence Interval; BCa = Bias-Corrected and Accelerated; * denotes a significant within-group change ($p < 0.05$). Hedges' g reflects the standardized between-group difference in mean change.

Table 4. Summary of covariate analysis (ANCOVA) for competitive load.

Outcome Measure	Weekly Playing Time (β)	Playing Time (p-value)	Group $\times$ Time Interaction (Adjusted p)
CMJ Height	0.0374	0.0468	0.505
30-m Sprint	0.0008	0.2316	0.290
Squat 1RM	0.2500	<0.001	0.612

Notes: Playing time (min/week) was included as a covariate to control for seasonal competition load. Although playing time significantly correlated with 1RM strength profiles, it did not confound the training-induced adaptations in primary power metrics ($p_{adj} > 0.05$).

**Figure 5.** Relationship between weekly competitive playing time and Squat 1-repetition maximum (1RM) strength gains. Data points represent individual athletes (Red Circle: BFR-EBT; Blue Triangle: EBT) with regression lines illustrating the non-significant correlation ($r=0.40$, $p=0.099$).

a non-significant increase (+0.2%; 0.009 s, $p > 0.05$). The standardised between-group difference was exceptionally large (Hedges' $g = -3.80$), reflecting the high directional consistency of the response in the BFR-EBT group. As depicted in the individual trajectories (Figure 7B), the BFR-EBT intervention effectively maintained or slightly optimised sprint speed during the competitive season. These findings were further confirmed by exploratory linear mixed-effects model (LMEM) analysis ($p = 0.012$).

Discussion

The results of this investigation suggest that for in-season collegiate basketball players, a low-load blood flow restriction protocol combined with elastic bands (BFR-EBT) may elicit more favourable optimisations in key measures of explosive performance compared to traditional heavy-load elastic band training (HL-EBT). Specifically, BFR-EBT appeared to be associated with optimisations in vertical jump height (+3.4%) and 30-m sprint

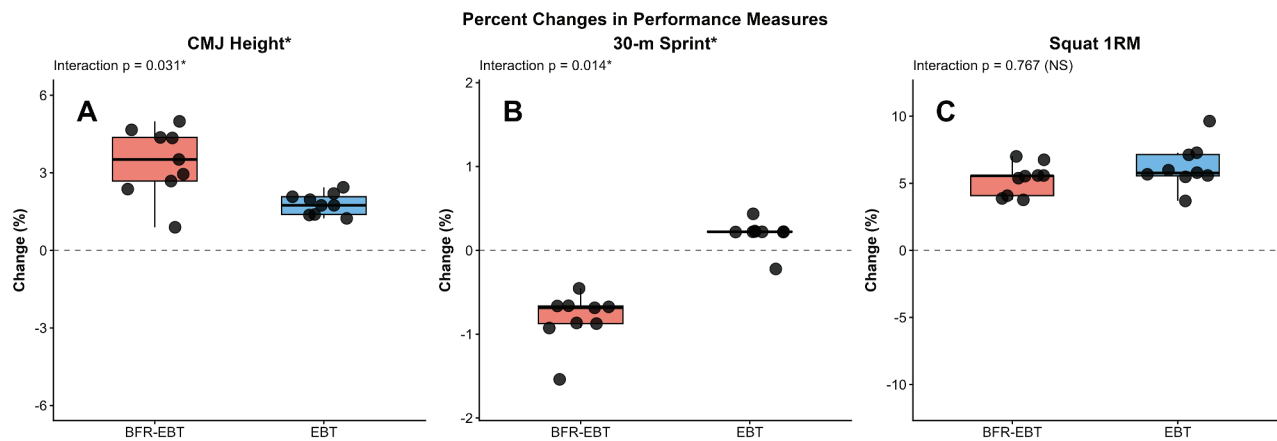


Figure 6. Percent changes in performance measures across all outcome variables. Panel A: Countermovement Jump (CMJ) height; Panel B: 30-m Sprint time; Panel C: Squat 1-repetition maximum (1RM). Boxplots represent group medians and quartiles, while individual dots represent each subject's specific adaptive response. * indicates a significant Group $\times$ Time interaction ($p < 0.05$).

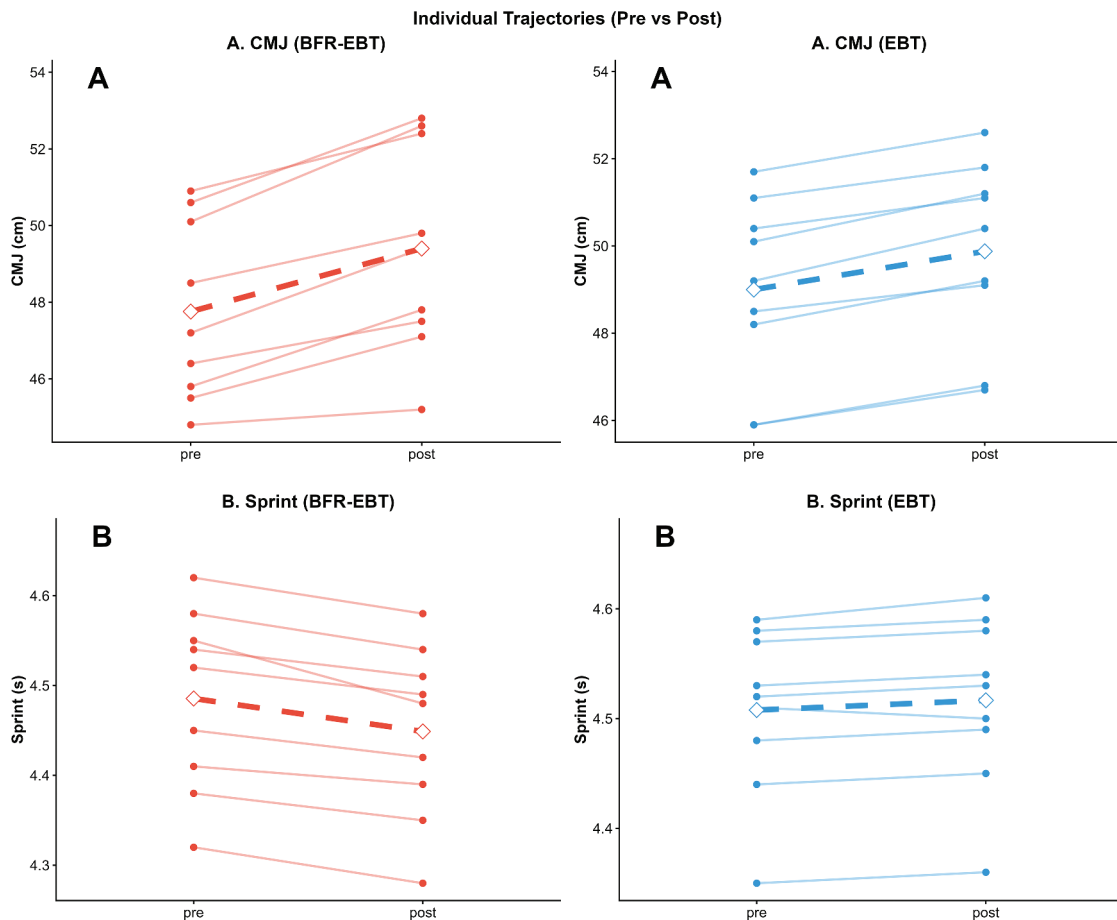


Figure 7. Individual and group-mean performance trajectories for countermovement jump (CMJ) height (Panel A) and 30-m sprint time (Panel B). Solid lines represent individual subject responses (red = BFR-EBT; blue = EBT), while dashed lines represent group averages. These plots illustrate the directional consistency and raw distribution of performance changes.

speed (-0.8%). Critically, these adaptations in power were observed despite a significantly lower mechanical training load (~ 3.6 -fold lower), while still promoting comparable gains in maximal strength. The magnitude of these

differences was supported by robust statistical inference, including Hedges' g effect sizes and bootstrap confidence intervals. Taken together, these preliminary findings suggest that BFR-EBT may serve as a viable, mechanical load-

sparing training strategy to support athletic performance during the demanding competitive season.

The improvements in the BFR-EBT group for CMJ performance (+3.4%) warrant interpretation, especially when compared to the existing literature. These results appear consistent with the work of Shi et al. (2022), who demonstrated that integrating variable resistance (elastic bands) into collegiate basketball programmes effectively supports neuromuscular adaptations and selective power performance. Furthermore, our findings remain more pronounced than the modest improvements reported by Cook et al. (2014) and stand in contrast to the null findings of Scott et al. (2017). These discrepancies could likely be attributed to crucial methodological differences. For instance, our study integrated BFR-EBT as the primary lower-body training stimulus. This distinction is critical, as a standalone protocol likely provides a more robust and direct signal for adaptation compared to a supplementary one, which may compete with or be diluted by the signals from primary training.

Furthermore, a plausible explanation for this enhancement may lie in a unique interaction between the physiological environment induced by BFR and the mechanical properties of EBT. We postulate that the profound metabolic stress and hypoxia from BFR may have compelled the recruitment of a larger pool of high-threshold motor units, a phenomenon supported by surface EMG studies showing increased muscle activation under BFR conditions (Takarada et al., 2000; Yasuda et al., 2014). The variable resistance of the elastic bands could then have applied maximal mechanical tension specifically to these newly-recruited fibres during the final phases of hip and knee extension – a biomechanically critical window for vertical jump performance. This potential ‘recruitment-tension’ coupling may offer a more potent stimulus for velocity-specific power development than BFR with traditional isotonic loading alone.

A similar narrative may explain the consistent reduction in 30-m sprint performance (−0.8%). Perhaps more telling is the lack of improvement in our HL-EBT group (+0.2%), despite significant gains in 1RM strength. This finding highlights a classic dissociation between maximal force production and its application at high velocities. This aligns with the principles of the force-velocity curve, where training exclusively at the high-force, low-velocity end of the spectrum (as with HL-EBT) may not effectively improve performance at the low-force, high-velocity end required for sprinting (Cormie et al., 2011). We speculate two potential reasons. Firstly, the high neuromuscular demand and residual fatigue from the

heavy-load protocol may have masked the expression of high-velocity power, a common challenge in in-season training (Enoka & Duchateau, 2016). Secondly, one plausible explanation is that the chosen load for the HL-EBT group (~75% 1RM), while effective for strength, represented more of a hypertrophic stimulus. It is possible that a higher-intensity protocol (e.g., >85% 1RM for fewer repetitions) may have elicited different results. In contrast, the BFR-EBT group, potentially benefiting from the acute potentiation effects of external compression as noted by Gepfert et al. (2020), may have experienced a more specific stimulus for the rate of force development (RFD), which is critical for acceleration.

A cornerstone finding of this study was the dissociation between mechanical load and perceived exertion. The BFR-EBT group trained with a significantly lower mechanical load (~12,500 kg vs. ~44,500 kg), yet reported a Session-RPE (7.4 ± 0.8) statistically similar to the HL-EBT group (7.1 ± 1.0). This ‘perceptual matching’ (Hughes & Patterson, 2020) suggests that the metabolic stress and ischaemic pain associated with BFR can create a perception of effort that mirrors high-load training. This is a profound practical advantage: it potentially allows athletes to achieve a high-intensity training stimulus while sparing their joints and connective tissues from high mechanical strain. Both groups achieved significant gains in 1RM strength, a finding that aligns with the meta-analysis by Li et al. (2025), confirming that BFR training is an effective modality for enhancing lower-extremity maximum dynamic strength in athletes. However, it is crucial to acknowledge a potential trade-off. Traditional HLT provides a superior stimulus for adaptations in bone mineral density and tendon stiffness due to high mechanical loading (Bohm et al., 2015). Therefore, BFR-EBT should be considered a strategic complement rather than a wholesale replacement for heavy-load training.

The specificity of the observed adaptations provides a remarkably clear picture of the intervention’s effects. The improvements in CMJ (a slower SSC task) coupled with a lack of change in the RSI (a faster SSC task) is not a contradictory finding, but rather a precise indicator of the adaptive window. Slow SSC movements are primarily dependent on neuromuscular force generation, whereas fast SSC movements are more influenced by the stiffness and elastic energy return of the musculotendinous unit (Turner & Jeffreys, 2010). It suggests that the primary adaptations were likely driven by

neuromuscular mechanisms rather than an increase in tendon stiffness, which typically requires high-impact plyometric exercises for adaptation (Bohm et al., 2015). The non-significant change in the T-test further underscores this specificity, indicating that linear power gains might not automatically transfer to multi-directional agility without the inclusion of specific change-of-direction drills.

This investigation has several limitations that must be acknowledged. First, the study's sample size ($N = 18$) is limited, which warrants caution when generalising the findings. To formally address this, we conducted a sensitivity analysis which determined our study was powered to detect large between-group effect sizes, and we further employed Hedges' g to correct for small-sample bias along with 1000-resample bootstrapping to derive robust confidence intervals. Despite the sample size, this cohort represents the entire available roster of a highly-trained Division I team, providing high ecological validity for this specific population. Second, while we strictly monitored weekly competitive playing time and included it as a covariate in our analysis – confirming it did not significantly influence the primary outcomes ($p > 0.05$) – other uncontrolled variables such as individual variations in basketball practice intensity, sleep hygiene, and daily nutritional intake were not quantified. These factors may have influenced individual adaptive responses and represent an area for more comprehensive monitoring in future research. Third, our study design did not include a traditional low-load training group (i.e., without BFR). The inclusion of such a group would have allowed us to definitively partition the effects attributable specifically to the metabolic BFR stimulus versus the low-load, high-velocity nature of the exercise itself. Fourth, the omission of direct measures of muscle hypertrophy, biochemical markers of muscle damage, or longitudinal neuromuscular fatigue limits our ability to draw firm mechanistic conclusions regarding the intracellular signalling or structural changes driving the observed adaptations. Finally, the generalisability of these results is restricted to young, well-trained, male collegiate basketball players. Given the physiological differences in hormone profiles and muscle architecture across different demographics, these findings should be interpreted with caution when considering other populations, such as female athletes or recreational trainees. Confirmation of these preliminary findings in larger-scale, multi-centre trials is warranted to further validate the long-term efficacy of BFR-EBT across diverse athletic contexts.

Practical applications

Based on our preliminary findings, strength and conditioning coaches may consider integrating BFR-EBT as a strategic lower-body stimulus during periods when managing cumulative mechanical load is prioritised (e.g., within 48–72 hours post-competition or during tactical deload microcycles). A twice-weekly protocol appears viable for supporting explosive performance optimisations in highly trained athletes. This strategy might be particularly advantageous for 'high-minute' players who are already exposed to substantial on-court mechanical stress, or for athletes with a history of joint issues who may have a limited tolerance for high-volume heavy resistance training. The protocol's observed efficacy in maintaining or slightly improving linear speed suggests it could be a valuable tool during training blocks focused on enhancing transition offence and defence efficiency. Future research should aim to validate these findings in larger, more diverse cohorts and explore the direct effects of BFR-EBT on longitudinal markers of muscle damage, systemic inflammation, and acute neuromuscular fatigue compared to traditional constant-resistance training.

Conclusion

In conclusion, for this specific cohort of in-season competitive basketball players, low-load BFR-EBT appeared to be a more effective strategy than traditional heavy-load EBT for optimising vertical jump height and maintaining sprint speed. These findings suggest that BFR-EBT can effectively uncouple explosive power gains from high mechanical loading, providing a comparable strength stimulus at a fraction of the mechanical cost. While these preliminary results are promising, they represent adaptations achieved within a narrowly defined, elite population and should be integrated into comprehensive training programmes with careful consideration for individual player fatigue profiles and long-term athletic development goals.

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Author contributions

CRedit: **Tianyuan He:** Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; **Ruli Zhang:** Visualization, Writing – original draft, Writing – review & editing; **Zhiwei Chen:** Visualization, Writing – original draft, Writing – review & editing; **Jingyi Bei:** Visualization, Writing – original draft, Writing – review & editing; **Duanying Li:** Project administration, Resources, Validation, Writing – review & editing; **Jian Sun:** Investigation, Project administration; **Guoxing Li:** Conceptualization, Funding acquisition, Project administration, Resources, Supervision, Validation, Writing – review & editing.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions involving participant information.

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