The Effects of Supplementary Low-Load Blood Flow Restriction Training on Morphological and Performance-Based Adaptations in Team Sport Athletes

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Abstract

Scott, BR, Peiffer, JJ, and Goods, PSR. The effects of supplementary low-load blood flow restriction training on morphological and performance-based adaptations in team sport athletes. *J Strength Cond Res* 31(8): 2147–2154, 2017– Low-load resistance training with blood flow restriction (BFR) may be a method to enhance muscular development even in trained athletes. This study aimed to assess whether supplemental low-load BFR training can improve muscle size, strength, and physical performance characteristics in team sport athletes. Twenty-one semiprofessional Australian football athletes were assessed for 3-repetition maximum (3RM) and muscular endurance in the back squat, vastus lateralis muscle architecture, and performance in sprint and vertical jump tasks. Participants then undertook a 5-week training program, consisting of normal high-load resistance training supplemented by low-load squats with (LL_{BFR}) or without (LL) BFR. Participants also performed regular conditioning and football training during this period. After the training intervention, participants again completed the pretraining testing battery. Squat 3RM and endurance increased from pretraining levels in both LL (3RM = 12.5% increase; endurance = 24.1% increase; $p \leq 0.007$) and LL_{BFR} (3RM = 12.3% increase; endurance = 21.2% increase; $p = 0.007$) groups, though there were no between-group differences. No post-training changes were observed for muscle architecture, or performance in sprinting and jumping tasks. Although squat 3RM and endurance performance increased in both groups, adding BFR during supplemental exercise did not enhance these responses. Similarly, there were no large differences in the assessments of sprint, acceleration, and jumping performance between the groups after training. These findings suggest that although LL_{BFR} did not negatively affect adaptive responses to resistance training, this training strategy may not provide added benefit for healthy Australian football athletes already undertaking a rigorous training schedule.

Key Words muscle, strength, hypertrophy, resistance training

Introduction

Resistance exercise is an essential component of a team sport athlete's training plan, resulting in reduced injury risk, enhanced muscular strength and endurance, and improved speed and power (16). These qualities are particularly important for collision sports, where developing physically robust athletes is a priority. However, these athletes must concurrently develop other physiological qualities and sport-specific skills (24), which can significantly impact the time dedicated to resistance exercise. Additional factors including the total load associated with demanding periods of training, such as the preseason phase, can also impact on training prescription (4). Methods to facilitate muscular development while not adding substantially to the total training dose experienced are therefore of interest for team sport athletes. The use of blood flow restriction (BFR) during training can elicit muscle hypertrophy and strength responses similar to those observed after traditional high-load training (31), albeit using much lighter loads. Low-load BFR exercise has been shown to increase muscle size and strength for healthy (31), elderly (13) and injured (21) populations and presents a possible strategy for team sport athletes to increase muscular development without substantially higher training demands (22,24).

Despite the considerable literature describing the responses to BFR training for healthy and clinical cohorts, limited data are available regarding well-trained athletes (24). Furthermore, although the pressurized cuffs that are often employed in BFR research allow for strict manipulation of the restrictive stimulus, this approach may be impractical and expensive to implement for large squads of team

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sport athletes. Using elastic wraps for practical BFR was proposed by Loenneke and Pujol (15) and is a safe, effective, and ecologically valid method of applying BFR (29). Yamanaka et al. (30) and Luebbers et al. (16) have independently examined the practical implementation of BFR training in collegiate American football athletes, observing significant increases in squat strength postintervention when compared with a control group. These investigations corroborate previous research (31), suggesting that strength can be optimized by supplementing high-load training with low-load BFR exercise. However, these enhanced strength improvements were not consistent with increased hypertrophy as measured by leg circumference (16,30) and therefore contradict mechanistic explanations of how BFR training is thought to enhance muscular development (25). It is possible that the use of simple girth measurements to assess changes in muscle size were inadequate, and further research using more sensitive methods is required.

Aside from the benefits of increased muscular development after BFR training, research has demonstrated improved countermovement jump (CMJ) power (4), maximal and repeated sprint performance (1,4,17), change of direction speed (17), and aerobic shuttle run performance (17). These results are interesting given that improving sporting-related performance is the main aim of an athlete's strength program, rather than simply increasing muscle size and strength. However, these responses have not yet been investigated using practical BFR, or with this exercise applied as a supplementary stimulus after high-load training. Therefore, the primary aims of this study were to examine the affect of supplementary low-load BFR training on muscular strength, endurance, and architecture in trained athletes. Additionally, this investigation assessed whether these adaptive responses to BFR training could enhance results in physical tests related to team sport performance. It was hypothesized that adding BFR during supplementary low-load training would enhance these training responses.

Methods

Experimental Approach to the Problem

At the commencement of the study, subjects were tested for baseline muscle architecture via ultrasonography. Two days later, they completed 3-repetition maximum (3RM) and muscular endurance testing for the back squat. Two days later again, subjects were assessed for CMJ and sprinting performance. After baseline testing, subjects were assigned to either a low-load unrestricted training group (LL) or a low-load BFR training group (LL_{BFR}) after a matched pairs design for squat 3RM. Given that the participants were athletes who trained together as a squad, a blinded design was not appropriate for this study. Subjects then underwent a 5-week training block during which they performed their normal resistance training programs, as prescribed by the coaching staff (Table 1). Supplementary low-load squatting exercise was performed 3 times weekly either with or without BFR immediately after normal resistance training sessions, aside from week 5 (2 training sessions because of training scheduling), for a total of 14 sessions. Both groups also completed regular Australian football training together as part of the same squad. Football training was typified by tactical, technical, and match simulation drills involving running, sprinting, change of direction, jumping, collisions, and kicking. Within 4 days after the 5-week training period, subjects were again assessed using the pretraining battery to test the research hypothesis that LL_{BFR} would provide a more effective supplementary training stimulus than LL. This training period occurred during the preseason phase of the athletes' yearly schedule. Training periods of similar duration and session number have demonstrated enhanced muscular development resulting from BFR exercise in athletes (17,30).

Subjects

Twenty-one semiprofessional male Australian football players (age: 19.8 ± 1.5 years [age range: 18–23 years]; body mass: 80.8 ± 8.2 kg; height: 1.86 ± 0.08 m; pretraining squat

Table 1. Summary of the normal resistance training program undertaken by participants before supplemental low-load squat exercise.*†

Day 1		Day 2		Day 3	
Exercise	Sets × Reps	Exercise	Sets × Reps	Exercise	Sets × Reps
Jump shrug	4 × 6	Shoulder press	4 × 6	Back squat	4 × 10, 6, 6, 6
DB row	4 × 6	Chin-up	4 × max	Bench pull	4 × 6
Broad jump	3 × 6	DB chest press	3 × 8	Straight-leg deadlift	3 × 6
Bench press	3 × 5	Seated row	3 × 10	Bench press	3 × 8
DB front raise	3 × 10	Incline bench press	3 × 6	2-leg jump/1-leg land	3 × 5

*Reps = repetitions; DB = dumbbell; max = maximal repetitions.
†Participants in both groups completed this training program together using the heaviest loads possible while still completing the prescribed repetitions.

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3RM: 1.6 × body mass) were recruited from one club competing in the Western Australian Football League. All athletes trained together in the same squad. Subjects were instructed to abstain from strenuous activity outside of their team training for 24 hours before each testing and training session and were encouraged to maintain their normal dietary and fluid intake habits for the duration of the research. Before the commencement of the study, players were provided with information detailing the aims and requirements of the study and provided written informed consent. The Institutional Human Ethics Committee approved the research and experimental procedures before participant recruitment.

Procedures

Ultrasonography. Muscle structure was measured with real-time B-mode ultrasonography (M-Turbo; SonoSite Inc., Bothell, WA, USA) with a 15–6 MHz linear probe. A water-soluble gel was placed on the probe to allow for acoustic contact without depression the dermal layer. Participants lay for 10 minutes in a semirecumbent position with their knee slightly flexed over a foam roller to allow for fluid shifts to equilibrate. Measures of the vastus lateralis were then taken at 50% of the distance between the greater trochanter and the lateral epicondyle of the femur (7). The transducer was placed perpendicular to the skin with an orientation parallel to the fascicles based on each subjects' arrangement until the image was deemed adequate based on multiple viewable fascicles. Two sagittal plane images were recorded for each participant, which were stored for offline analysis.

Images were analyzed using free imaging software (ImageJ 1.40 g; National Institutes of Health, Bethesda, MD, USA). Muscle thickness (MT) was measured as the distance from the deep aponeurosis to the superficial aponeurosis. Pennation angle (θ_p) was defined as the angle between the echoes of the deep aponeurosis and the echoes from the interspaces among the fascicles measured. Each image was assessed 3 times and the average values for MT, θ_p and from these measures were used for analysis (20).

Muscle Strength and Endurance. Subjects were assessed for 3RM using the back squat after protocols described previously (2). During each attempt, subjects squatted down to a box that was customized for height to provide a guide for when appropriate depth had been reached. Squatting depth for each individual was determined by the team's coaching staff as the deepest range of motion at which each athlete could maintain neutral curvatures in the lumbar spine with their knees in line with the front of their foot. In this way, squatting performance was individualized to eliminate the effect of anatomical differences between athletes (e.g., femur length and ankle dorsiflexion range) on squatting performance. Subjects' 3RM was defined as their heaviest completed set of 3 repetitions and was determined within 3–6 sets. To prescribe loads for supplementary low-load training, 1RM was predicted from 3RM scores (2). After 10-minute rest, subjects underwent a test of muscular endurance for the squat exercise. This required them to perform as many repetitions as possible using 40% of predicted 1RM load to the same squatting depth used during 3RM assessment. Verbal encouragement was provided during this task to motivate each athlete to provide a maximal effort. The test ceased when subjects either reached volitional exhaustion or could not complete another repetition with correct technique.

Countermovement Jump Assessment. After a standardized warm-up, participants completed 2 trials of the CMJ. For each jump, participants were instructed to jump as high as possible (5). Starting from a standing position, participants were instructed to perform a downward countermovement to a self-selected depth followed immediately by a rapid jump in one continuous movement. During all jumps, jump height was assessed via a linear position transducer (GymAware; Kinetic Performance Technology, Canberra, Australia) attached to a wooden bar held across the upper back. Participants completed 2 trials separated by 1-minute recovery from which the highest jump height was recorded for analysis.

Table 2. Mean weekly training loads (sRPE × duration) for normal resistance, conditioning, and football training sessions during the intervention period.*†

	LL group			LL_{BFR} group		
	Resistance	Conditioning	Football	Resistance	Conditioning	Football
Week 1	900 ± 30	140 ± 7	1,213 ± 35	875 ± 32	140 ± 7	1,176 ± 38
Week 2	905 ± 21	No training	1,506 ± 36	896 ± 24	No training	1,514 ± 36
Week 3	925 ± 27	78 ± 7	724 ± 49	894 ± 20	81 ± 3	682 ± 38
Week 4	910 ± 25	59 ± 6	1,467 ± 43	856 ± 30	60 ± 4	1,515 ± 40
Week 5	905 ± 17	61 ± 3	1,670 ± 39	905 ± 24	60 ± 4	1,690 ± 48

*sRPE = session rating of perceived exertion.
†Data are mean ± *SD* in arbitrary units.

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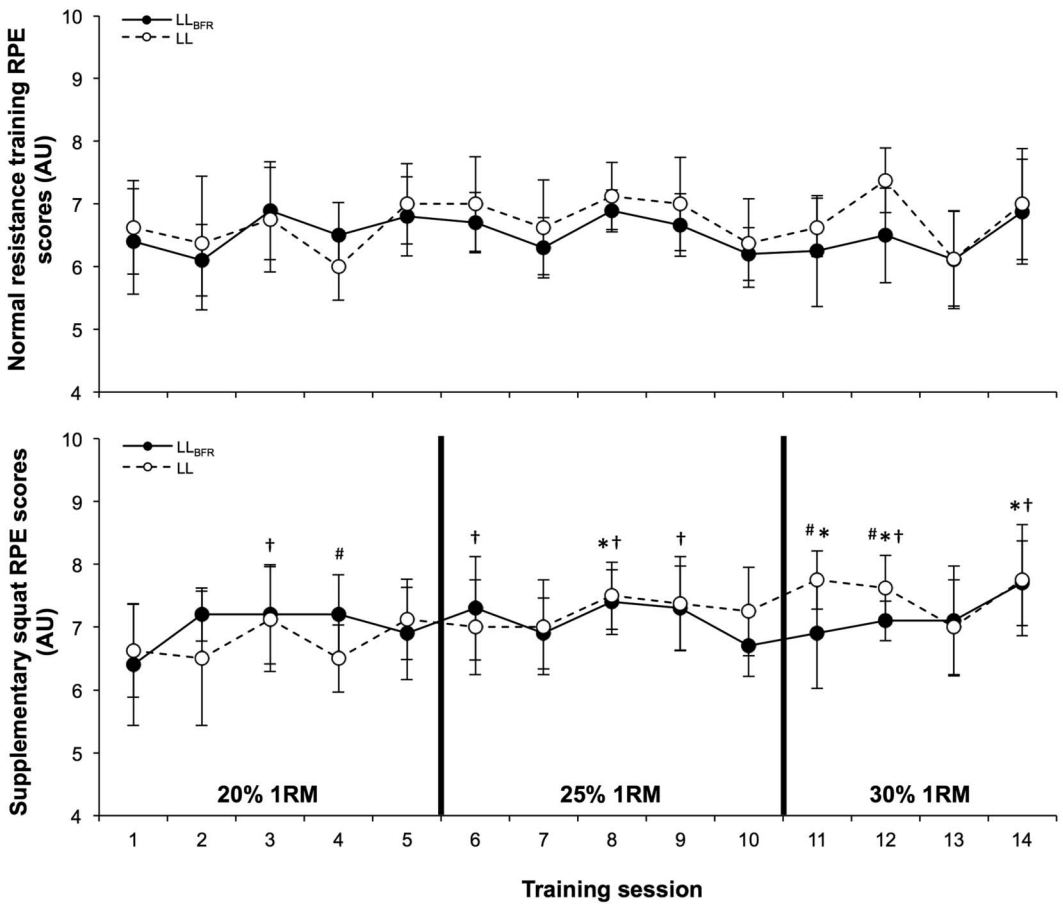


Figure 1. Session rating of perceived exertion (RPE) scores for training sessions excluding supplementary low-load squats (A) and for supplementary low-load squats only (B). RPE = rating of perceived exertion, 1RM = 1-repetition maximum. #Statistically different between conditions. *Statistically different from session 1 in LL. †Statistically different from session 1 in LL_{BFR}.

Acceleration and Sprinting Tests. To determine acceleration and maximal sprint speed qualities, subjects completed a 40-m sprint. Performance during sprints was assessed via a wireless electronic timing light system (SpeedLight; Swift Performance, Brisbane, Australia) with timing gates placed at 0, 10, 20, and 40 m. Participants were required to begin in a split stance with their nondominant foot placed 50 cm behind the start gate. To avoid any influence of reaction times on performance, participants were instructed to start sprinting once they were positioned on the starting line and ready. Participants were instructed to sprint for 5 m past the last gate to eliminate premature deceleration. All subjects correctly completed 2 sprints, which were separated by 2-minute recovery. The fastest 40-m sprint time was taken as each subject's best score, and this trial was used for further analysis. In addition, 0–10 and 20–40 m splits were calculated to assess acceleration ability and maximal sprinting speed, respectively, and a 0–20 m split was taken to reflect the standard test performed in Australian football.

Supplemental Low-Load Resistance Exercise. All participants completed the supplemental low-load exercise under the same conditions immediately after their normal resistance training sessions. Participants completed 4 sets of low-load squats following the standard 30-15-15-15 repetition scheme with 30-second interset recovery (23). To accomplish progressive overload across the training period, sessions 1–5 were completed using 20% predicted 1RM, sessions 6–10 using 25% 1RM, and sessions 11–14 using 30% 1RM for both groups.

Practical Blood Flow Restriction. Restriction of blood flow was achieved using elastic powerlifting knee wraps (7.5 × 250 cm, Standard knee wraps; Ironedge, Melbourne, Australia). Before beginning supplemental low-load squat exercise, the wraps were applied to the proximal thigh for subjects in the LL_{BFR} group. The wraps were initially applied without tension and just before the commencement of low-load exercise were tightened until participants reported a pressure rating

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of 7 out of 10 using methods established previously (29). The wraps remained in place for the entire duration of the low-load protocol and were removed immediately at the conclusion of the lifting session. All participants were familiarized with the application of practical BFR during their visit to the laboratory for muscle architecture assessment.

Session Rating of Perceived Exertion. After each resistance training session, participants provided a session rating of perceived exertion (sRPE) score pertaining to the overall intensity of only their normal high-load training and another relating to only the supplemental low-load exercise. They also provided these ratings for conditioning and football training sessions to ensure that both groups received similar overall training loads; this was calculated as sRPE multiplied by training duration in minutes (9). The sRPE scores were recorded using a category ratio-10 scale at least 15 minutes after training (26).

Statistical Analyses

All data approximated a normal distribution and are represented as mean ± *SD*. Data were analyzed using a 2-way ANOVA with repeated measures to determine whether differences existed between time points (pretraining vs. post-training; within-subject) and training groups (between-subject). More specifically, this analysis assessed whether BFR could enhance the training adaptations for measures of muscle architecture, squatting strength and endurance, and performance in sprinting, acceleration and jumping tasks. Where a significant main effect was observed, Fisher's least significant difference was calculated to assess where the differences existed. These analyses were completed using Statistical Package for the Social Sciences (version 22.0; IBM Corp., Somers, NY, USA). Cohen's effect size (d) was also calculated as the difference in group means divided by the standard deviation of the pooled data to quantify the magnitude of difference in measures between conditions (3). The level of statistical significance was set at $p \leq 0.05$.

Results

Of the 21 participants who commenced the training intervention, one withdrew because of an injury sustained during football training, and 2 did not attend more than 80% of training sessions and were excluded from further analysis. For the remaining participants (LL = 8 and LL_{BFR} = 10), mean training load scores are shown in Table 2. There were no differences between groups at any stage throughout the training intervention. RPE scores for each normal resistance training session and for the supplementary low-load portion of training are shown in Figure 1. For the normal resistance training portion of sessions, no differences were observed between groups. For the supplementary low-load training, sRPE scores were increased from session 1 for sessions 8, 11, 12, and 14 in the LL group ($p = 0.005$–0.022, ES = 0.54–1.24), and for sessions 3, 6, 8, 9, 12, and 14 for the LL_{BFR} group ($p = 0.002$–0.036, ES = 0.50–1.24). There were also significant differences between conditions for sessions 4, 11, and 12 ($p = 0.017$–0.025, ES = 1.03–1.08).

Muscle architecture data are shown in Table 3. No differences were observed between groups either before or after the training period for MT or θ_p. These variables also did not differ between pre- and post-training assessments within each training group.

Figure 2 illustrates changes in 3RM scores and the number of repetitions to fatigue using 40% of predicted 1RM. No differences were observed between training groups. A main effect of time was observed for 3RM score between

Table 3. Muscle architecture, countermovement jump, and sprinting assessment results before and after the training intervention.*†

	Control training		BFR training	
	Pretraining	Post-training	Pretraining	Post-training
Muscle architecture				
VL MT (cm)	3.19 ± 0.66	3.20 ± 0.73	2.88 ± 0.69	3.00 ± 0.77
VL θ_p (°)	17.26 ± 2.80	17.80 ± 2.43	17.27 ± 4.34	17.42 ± 2.94
CMJ performance				
Jump height (m)	0.51 ± 0.03	0.51 ± 0.03	0.51 ± 0.07	0.51 ± 0.09
Sprint performance m (s)				
0–10	1.73 ± 0.07	1.77 ± 0.07	1.74 ± 0.07	1.78 ± 0.04‡
0–20	3.00 ± 0.13	3.02 ± 0.11	3.01 ± 0.09	3.04 ± 0.07
0–40	5.38 ± 0.24	5.38 ± 0.19	5.37 ± 0.15	5.41 ± 0.12
20–40	2.37 ± 0.12	2.35 ± 0.10	2.37 ± 0.07	2.37 ± 0.06

*BFR = blood flow restriction; VL = vastus lateralis; MT = muscle thickness; θ_p = pennation angle.
†Data are mean ± *SD*.
‡Significantly different to pretraining.

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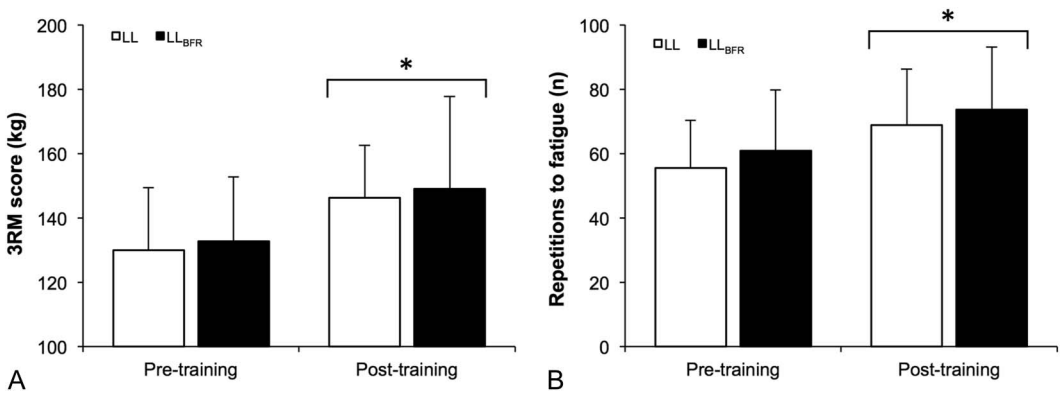


Figure 2. Squat 3-repetition maximum (3RM) scores (A) and the number of repetitions to fatigue using 40% of predicted 1RM (B) before and after 5 weeks of resistance training with or without blood flow restriction. *Statistically different to pretraining scores.

pretraining and post-training assessments ($F_{1,16} = 21.59$; $p < 0.001$; $\eta^2 = 0.57$) with an increase in 3RM from pretraining levels in both LL ($p = 0.007$, ES = 0.85) and LL_{BFR} ($p = 0.003$, ES = 0.64) groups. Similarly, repetitions to fatigue was different between pretraining and post-training time points ($F_{1,15} = 19.15$; $p = 0.001$; $\eta^2 = 0.56$), with more repetitions being performed after the training period for both LL ($p = 0.008$, ES = 0.78) and LL_{BFR} ($p = 0.007$, ES = 0.65) groups.

Pretraining and post-training CMJ and sprinting performance data are shown in Table 3. No differences were observed for CMJ height between training groups or between pretraining and post-training assessments within each group. A main effect for time was observed for 0–10 m sprint time between pretraining and post-training assessments ($F_{1,16} = 9.50$; $p = 0.007$; $\eta^2 = 0.37$). Post hoc analysis confirmed that 0–10 m sprint time increased from pretraining levels in the LL_{BFR} ($p = 0.036$, ES = 0.61) but not the LL ($p = 0.054$, ES = 0.53) group. There were no significant differences in sprinting performance for any other split between training groups or between pretraining and post-training assessments within each group.

Discussion

This study is the first to implement practical BFR exercise as a supplementary training stimulus for Australian football athletes. Although high-load training combined with low-load exercise increased muscular strength and endurance, adding BFR during supplemental exercise did not enhance these responses. Furthermore, resistance training did not alter muscle architecture or improve performance during sprinting and jumping tests. These findings may relate to inhibitory effects of concurrent endurance training on hypertrophic processes and suggest that the timing of BFR training may be an important factor to consider for team sport athletes.

Significant increases in squat strength were observed in both groups in this study in the absence of morphological changes in the vastus lateralis. These findings suggest that the strength increases occurred via neural, rather than hypertrophic processes (10). It is also possible that over the course of the training period, participants increased their technical proficiency in the squat movement pattern (8), though this is unlikely to have had a major influence on strength gains considering the training status of all participants. The absence of enhanced strength between the LL and LL_{BFR} groups in this study is inconsistent with previous BFR research using a range of athletic populations (24). Indeed, both Yamanaka et al. (30) and Luebbers et al. (16) have reported larger gains in squat strength for participants performing supplemental exercise with practical BFR when compared with those undertaking equivalent training without BFR. Nevertheless, Luebbers et al. (16) did not observe any effect of using BFR to increase bench press strength and suggested that the high-load training undertaken before supplemental bench press is likely to have already provided a maximum stimulus for increased strength, thus negating the additive stimulus from the BFR. Supporting this theory, Martín-Hernández et al. (18) have shown that doubling the volume of BFR training provides no additional improvements in muscle size and strength. Based on these findings, we believe that it is possible that the normal training program prescribed to athletes in this study was sufficient to elicit maximal strength development, and that the addition of low-load BFR exercise did not add any further beneficial stimuli. This would be an important distinction between well-trained athletes compared with recreationally active participants when assessing the usefulness of BFR training, but requires further investigation with little research to date comparing these 2 populations.

It is also possible that an interference effect on the hypertrophic processes normally associated with BFR

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training (25) influenced the strength outcomes within this study. As this study was conducted within normal preseason training sessions, the timing of training was prescribed by the club's coaching staff. Resistance training was scheduled before field-based conditioning and football skills sessions during which participants performed high-intensity running-based exercise. Importantly, this occurred within the acute recovery from resistance training, when muscle protein synthesis is known to be substantially increased (6). Endurance training is thought to compromise the acute molecular responses activated by resistance exercise, thus attenuating fiber hypertrophy (11). This could explain the absence of an increase in muscle thickness after the training period in either group. Given that the augmented levels of strength elicited by low-load BFR training are thought to arise predominantly via muscle growth (25), blunting of postexercise hypertrophic signaling would explain the lack of hypertrophy in the whole subject cohort and provide additional rationale for the lack of differences in strength gains between groups. Nevertheless, the interference effect of endurance exercise on resistance training adaptations remains somewhat controversial (19), and further research is required to understand whether or not this did affect the results of our study.

Despite significant increases in muscular endurance, we did not observe differences between training groups. These results contradict Manimmanakorn et al. (17), who reported that greater improvements in muscular endurance can be achieved during low-load training with BFR. Indeed, BFR training can improve muscle endurance capacity and enhanced oxygen delivery to working muscles (12), and the transcription of angiogenesis-related genes (14). The reasons why BFR did not augment muscular endurance in the current study are unclear. It is possible that the high training demands imposed on Australian football athletes during the preseason provide a sufficient stimulus for endurance-type adaptations, and that the addition of BFR did not add to this. Considering that the acute responses to BFR exercise are different between sprinting and endurance athletes (27), future research should examine the efficacy of BFR training to enhance muscular endurance in athletes who already exhibit high levels of endurance.

No improvements were observed for sprinting, acceleration, or jumping abilities after the training period in either group. These findings are dissimilar to Cook et al. (4) who reported significantly larger improvements in 40-m sprint time and CMJ maximal power for rugby union athletes after 3 weeks of moderate-load BFR training (70% 1RM) compared with the same training without BFR. Similarly, Abe et al. (1) and Manimmanakorn et al. (17) observed low-load BFR training interventions to improve sprinting performance, particularly for the first 5 m (17) and 10 m (1) acceleration phase. The results from the current study may be related to residual fatigue caused by participants' high overall training demands. Jumping and sprinting tasks are known to be sensitive neuromuscular and sport-specific fatigue in team sports (28). It is possible that by the end of the intervention period, participants in the current study were more fatigued from the accumulated demands of preseason training than at the beginning of the training block, which may have masked any improvements in jumping and sprinting/acceleration abilities. Nevertheless, there were no differences in mean weekly training loads between groups for resistance, conditioning and football training, and the addition of BFR to low-load squats did not cause consistent alterations to the perceived difficulty of exercise. As such, even if performance in jumping and sprinting tasks were influenced by residual fatigue, this was probably similar between the groups.

It is important to acknowledge that this study does have some limitations. By employing elastic straps for practical BFR, it was not possible to determine the restrictive pressure applied during training. Nevertheless, applying practical BFR using a similar methodology has been shown to maintain arterial inflow while occluding venous return and to enhance anabolic responses including metabolic stress, muscle swelling, and muscle activation (29). Participants were also familiarized with the application of practical BFR before beginning the study and were supervised during training by members of the research team to ensure that wraps were applied appropriately. This study took place in a typical semiprofessional team environment to enhance its ecological validity, and as such influence of residual fatigue was difficult to overcome. Nevertheless, because internal training loads were not different between groups, it appears that all participants were applied a similar overall training stimulus.

Practical Applications

Low-load BFR training has been repeatedly demonstrated to enhance muscular development even in well-trained athletes. However, the current study does not support using LL_{BFR} exercise as a supplementary stimulus to enhance muscular development or jumping and sprinting performance during the preseason phase for Australian football athletes. It should be highlighted though that BFR did not have detrimental impacts on muscular development in this study. Strength coaches looking to implement LL_{BFR} (e.g., for force-compromised athletes who cannot tolerate training with heavy loads) can be confident that this training strategy will not result in decreased strength levels. In addition, the current findings suggest that even with large increases in squatting strength, improvements in sprinting, acceleration, and jumping abilities may not occur. For the coach seeking to develop these attributes in their athletes, it is likely that more task-specific training is required.

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