To Review Blood Flow Restriction Training on Muscle Strength and Hypertrophy in Powerlifters

Adhithya Dinesh[1], Preethu Mohanan K K[2], Manjunatha H[3], Belle Sharvani[4],

[1]BPT, Department of Physiotherapy, Akash Institute of Physiotherapy, Bengaluru.
[2]Lecturer, Department of Physiotherapy, Akash Institute of Physiotherapy, Bengaluru.
[3]Principal & HOD, Department of Physiotherapy, Akash Institute of Physiotherapy, Bengaluru.
4Associate Professor, Department of Physiotherapy, Akash Institute of Physiotherapy, Bengaluru.

ABSTRACT

Background: Blood Flow Restriction Training (BFRT) has gained considerable attention in both clinical and athletic settings for its ability to promote muscle hypertrophy and strength gains using low-load resistance. This is particularly relevant in powerlifting, where athletes are prone to overuse injuries due to high mechanical loading.

Objective: This review aims to evaluate the effectiveness of BFRT in enhancing muscle strength and hypertrophy among powerlifters.

Methodology: A narrative literature search was conducted using databases including PubMed, Google Scholar, and Cochrane Library from 2015 to 2024. Ten peer-reviewed studies were selected based on inclusion criteria focusing on trained individuals, particularly powerlifters, and outcomes related to muscle strength and hypertrophy.

Results: The review found that BFR training, when performed with low to moderate loads, can produce strength and hypertrophy gains similar to those achieved with traditional heavy-load training. Notable benefits included improved muscle activation, increased hormonal response, and reduced mechanical stress on joints. These effects were especially evident when individualized protocols were applied, such as adjusting cuff pressure and training volume.

Conclusion: BFR training presents a safe and effective alternative or complement to conventional high-load resistance exercises in powerlifters. It allows for continued muscle development while minimizing the physical strain associated with heavy lifting. Future research should focus on optimizing BFR protocols and exploring its long-term effects in strength athletes.

Keywords: Blood Flow Restriction training, Hypertrophy, Low load training, Muscle Strength, Powerlifting, Resistance Training.

INTRODUCTION

Blood Flow Restriction Training (BFRT) is an emerging technique in the field of resistance training that has gained attention due to its ability to help muscle growth and strength gains using relatively low external load [1]. The technique involves applying pressure - via cuffs or elastic bands - to the proximal portion of a limb, thereby partially restricting arterial flow and considerably limiting venous return [2]. This creates a localized hypoxic state in the working muscles, which leads to metabolic stress and activates physiological pathways normally associated with high-load resistance training [3].

Initially developed in Japan (KAATSU training), BFRT has changed from a limited rehabilitation training into mainstream strength and conditioning programs [4]. The method is particularly beneficial for individuals who are unable to lift heavy loads due to injury, surgery, or medical conditions, and is increasingly being examined for its usage in athletic populations seeking performance enhancement without excessive joint stress [5].

Several key studies have demonstrated that BFRT performed at loads as low as 20–30% of one-repetition maximum (1RM) can produce muscle hypertrophy and strength gains comparable to traditional high-load training (>65% 1RM) [6, 7]. Therefore, this effect is thought to arise from increased recruitment of fast-twitch muscle fibers, elevation in anabolic hormone levels (such as growth hormone and IGF-1), and enhanced muscle protein synthesis [8]. These changes happen party by the accumulation of metabolites like lactate and the elevated neural drive required under conditions of limited oxygen [9].

The practical application of BFRT, however, is complex. Recent literature shows the importance of individualizing variables such as cuff pressure (often expressed as a percentage of arterial occlusion pressure or AOP), cuff width, duration of restriction (continuous vs. intermittent), and training volume [10]. Inconsistent protocols across studies have made it difficult to draw conclusions, and improper application may raise safety concerns, particularly with excessively high pressures or prolonged restriction [11].

Moreover, as interest in BFRT extends into high-performance sports like powerlifting, new questions are emerging. Can BFRT be effectively integrated alongside traditional heavy-load training? Does it provide additional benefits or simply serve as a substitute when full loading is not possible? And importantly, how does BFRT shows neuromuscular performance, rate of force development, and long-term adaptation in strength athletes? [12].

Articles from The Journal of Strength and Conditioning Research, The Journal of Applied Physiology, and others have explored these themes, with some studies showing improvements in muscle activation, strength endurance, and recovery, while others report minimal benefit or variation based on protocol specifics [13]. Additionally, recent reviews such as the one from UC Davis emphasize the lack of standardized guidelines and the need for greater methodological rigor [14].

One of the key reasons power-lifters integrate BFR into their routine is to maintain or even increase muscle size without placing undue stress on joints and tendons [15]. The heavy, repetitive nature of powerlifting can often lead to overuse injuries or gradual exhaustion, especially in areas like the knees, elbows, or lower back. BFR enables lifters to continue training the muscles particularly smaller or accessory muscles without the wear and tear associated with high-load training [16]. Since the technique works by restricting venous blood flow while allowing arterial inflow, it creates a hypoxic state in the muscle that leads to increased metabolic stress, lactate build up, and subsequent muscle fiber recruitment. These physiological conditions mimic the effects of high-intensity training, stimulating growth hormone release and muscle protein synthesis [17].

For injured power-lifters or those undergoing rehabilitation, BFR is especially beneficial. During injury or beginning of the recovery phase traditional lifting is not possible due to pain or structural limitations, BFR allows athletes to retain muscle mass and strength by performing low-load exercises [18]. This has been shown to significantly reduce the rate of atrophy and assist in maintaining neural activation of the muscle [19]. Furthermore, because BFR training is less stress on the central nervous system, it can be used more frequently or in conjunction with high-load training to add volume without increasing overall fatigue [20].

This literature review aims to combine current findings on BFRT by examining its physiological mechanisms, effectiveness in both clinical and athletic populations, methodological considerations, and its potential role in strength-based sports such as powerlifting. By evaluating the existing body of evidence, this review will also identify gaps in the literature and propose future directions for research and application.

OBJECTIVES OF THE STUDY

- To review Blood Flow Restriction training on muscle strength in power lifters.
- To review Blood Flow Restriction training on muscle hypertrophy in power lifters.

METHODOLOGY

Study design: A comprehensive narrative literature review was conducted, focusing on peer-reviewed studies including Systematic reviews, meta-analyses, randomized controlled trials (RCTs), and narrative reviews published from 2015 onward to assess the effectiveness of Blood Flow Restriction (BFR) training on muscle strength and hypertrophy in powerlifters.

Databases Searched: PubMed, Cochrane, Google Scholar, Journal of Strength and Conditioning Research

Search Keywords: Blood Flow Restriction training, Hypertrophy, Low load training, Muscle Strength, Powerlifting, Resistance Training, One Repetition Maximum

Inclusion Criteria:

- Articles in English
- Published after 2014
- Studies involving athletes or strength-trained individuals
- Research focusing on muscle hypertrophy or strength

Exclusion Criteria:

- Non-English studies
- Studies published before 2015
- Articles lacking valid strength or hypertrophy outcomes

RESULT

A comprehensive review of ten relevant studies on Blood Flow Restriction (BFR) training revealed consistent improvements in muscle strength and hypertrophy, even when low training loads were used. Most studies included trained individuals or athletes, with some specifically involving strength-based populations. The following key outcomes emerged:

- **Strength Gains:** Several studies demonstrated statistically significant increases in 1-repetition maximum (1RM), peak torque, and muscle power in participants undergoing BFR training (Gepfert et al., 2024; Bowman et al., 2019). These strength improvements were evident in both upper and lower limbs.

- **Muscle Hypertrophy:** Low-load BFR training led to notable increases in muscle cross-sectional area (CSA), particularly in type I fibers, alongside greater myonuclei count and capillary density (Pignanelli et al., 2021; Muller et al., 2024). Compared to traditional high-load resistance training, BFR often yielded comparable or greater hypertrophic adaptations with lower joint stress.
- **Functional and Sport-Specific Performance:** Studies assessing explosive strength and endurance parameters (e.g., jump height, rowing performance) reported enhancements with BFR training (Bradley et al., 2023; Bahamondes-Avila et al., 2024). Such improvements are beneficial in performance optimization without high-intensity mechanical loading.
- **Physiological Responses:** Elevated occlusion pressures (e.g., 150% AOP) and longer time under tension (TUT) protocols amplified metabolic stress, lactate accumulation, and hormonal responses associated with muscle growth (Gepfert et al., 2024; Patterson et al., 2019).
- **Safety and Feasibility:** Across all studies, BFR training was deemed safe when performed under controlled conditions. No severe adverse effects were reported when individualized occlusion pressures were applied and training volumes were appropriately monitored (Wortman et al., 2021; Yang et al., 2024).

Table 1: Different studies identified for reviewing effectiveness of Blood Flow Restriction Training on Muscle Strength and Hypertrophy in Powerlifters.

Author & Year	Aim	Methodology	Result	Conclusion
Gepfert et al. (2024)	Effect of BFR pressure on powerlifting outcomes	7-week program with 150% AOP; measured 1RM, PV, TUT, MR	Significant improvement in all strength metrics with high-pressure BFR	High AOP enhances muscle fatigue and metabolic stress, boosting hypertrophy and strength
Korkmaz et al. (2022)	BFR vs. traditional resistance training	23 trained soccer players; 2 groups (BFR @ 30% 1RM vs. RES @ 80%)	BFR group showed greater strength gains and RF thickness	BFR more effective than traditional high-load training for hypertrophy
Pignanelli et al. (2021)	BFR for high-performance athletes	6.5-week training; low-load BFR vs. high-load conventional	BFR increased CSA, myonuclei, and capillaries in type-I fibers	BFR leads to structural and performance gains even in elite athletes
Wortman et al. (2021)	Systematic review on BFR in athletes	10 studies reviewed	78% showed strength gains, 50% hypertrophy, 75% performance enhancement	BFR training beneficial for strength and performance in athletes
Bowman et al. (2019)	Effects on proximal/distal limbs with BFR	26 patients (16 BFR, 10 control)	Greater strength and muscle size gains in BFR limbs	BFR effective for local and systemic muscle strengthening

Bradley et al. (2023)	BFR effects on size, power, and VO_2max	20 adults, 4-week program (BFR vs. control)	BFR improved power output more than control group	BFR feasible for low-intensity rehab and performance improvement
Yang et al. (2024)	Meta-analysis on BFR and athletic fitness	28 studies, 542 athletes	BFR improved strength, speed, power, and body composition	BFR broadly improves physical fitness; outcomes vary by protocol
Muller et al. (2024)	BFR with aerobic training	7 eligible studies from 4,462 records	Greater strength and hypertrophy with AT + BFR than aerobic training alone	BFR enhances the effects of aerobic exercise on muscle growth
Jing et al. (2024)	Upper limb BFR meta-analysis	11 studies, 220 participants	LL-BFRT and HLRT had similar strength and hypertrophy outcomes	LL-BFRT outperforms low-load training alone for upper limb strength
Bahamondes-Avila et al. (2024)	BFR and Smith machine jump training	Recreational individuals, 4-week program	Improved jump height and lower effort in BFR group	BFR enhances explosive strength and reduces fatigue perception

DISCUSSION

The findings of this literature review reinforce the value of BFR training as a viable and effective alternative or complement to traditional resistance training, particularly in powerlifters and strength athletes. The physiological mechanisms underlying BFR include localized hypoxia, increased metabolite accumulation, and greater recruitment of fast-twitch muscle fibers—factors that are key contributors to muscle hypertrophy and strength development (Scott et al., 2015; Patterson et al., 2019).

A key advantage of BFR training lies in its ability to stimulate muscle adaptation at intensities as low as 20–30% 1RM, which reduces the mechanical stress typically associated with heavy lifting. This has important implications for powerlifters in phases of injury rehabilitation, deloading, or recovery, where high-load training may not be feasible (Korkmaz et al., 2022).

Gepfert et al. (2024) showed that even with extremely high arterial occlusion pressures (150% AOP), participants experienced marked increases in strength metrics, highlighting the dose-dependent effects of BFR intensity. In another study, Pignanelli et al. (2021) reported enhanced hypertrophy markers such as increased muscle fiber CSA and myonuclei count in elite athletes using BFR. These findings suggest that BFR training can produce beneficial adaptations even in highly trained populations with limited capacity for further gains.

Interestingly, Bowman et al. (2019) demonstrated strength improvements not only in the limb under occlusion but also in proximal and contralateral limbs, indicating possible systemic neuromuscular adaptations. This could be especially useful in unilateral injury scenarios where training of the affected limb is restricted.

Moreover, meta-analyses by Yang et al. (2024) and Muller et al. (2024) highlight that training variables such as cuff pressure, session frequency, and load percentage significantly influence the outcomes. Hence, individualized protocols based on arterial occlusion pressure (AOP) and training goals are critical for maximizing benefits while minimizing risk.

Although promising, the current body of literature shows heterogeneity in protocols, cuff types, and measurement outcomes, making it challenging to establish a standardized framework. There is also limited long-term data on the safety and sustainability of BFR training in high-level strength athletes.

CONCLUSION

This evidence-based review confirms that BFR training is a safe and effective method to enhance muscle strength and hypertrophy in powerlifters. By using low loads under vascular occlusion, BFR enables muscle growth and neuromuscular adaptations similar to those achieved through traditional high-intensity resistance training, with the added benefit of reduced joint stress. BFR training proves particularly valuable in periods of injury recovery, reduced training availability, or when minimizing mechanical load is necessary.

While BFR training has been validated across both clinical and athletic populations, its successful integration into powerlifting programs requires individualized protocols, careful monitoring of cuff pressure, and proper guidance by trained professionals. Future research should focus on long-term outcomes, optimal training frequencies, and comparative studies between different occlusion methods to further refine its application in strength sports.

When appropriately applied, BFR can be a powerful adjunct to enhance strength performance, accelerate recovery, and extend athletic longevity in powerlifting and related sports.

REFERENCES

1. Scott BR, Loenneke JP, Slattery KM, Dascombe BJ. Exercise with blood flow restriction: an updated evidence-based approach for enhanced muscular development. *Sports Med*. 2015; 45(3):313–25.
2. Pearson SJ, Hussain SR. A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. *Sports Med*. 2015; 45(2):187–200.
3. Patterson SD, Hughes L, Warmington S, et al. Blood flow restriction exercise: considerations of methodology, application, and safety. *Front Physiol*. 2019; 10:533.
4. Nakajima T, Takano H, Morita T, et al. Use and safety of KAATSU training: Results of a national survey. *Int J KAATSU Train Res*. 2016; 12(1):1–10.
5. Centner C, Lauber B, Seynnes OR, Jerger S, König D. Low-load blood flow restriction training induces similar morphological and strength adaptations compared to high-load resistance training. *Front Physiol*. 2019; 10:407.
6. Lixandrão ME, Ugrinowitsch C, Laurentino GC, et al. Effects of exercise intensity and occlusion pressure after 12 weeks of resistance training with blood-flow restriction. *Eur J Appl Physiol*. 2018; 118(4):905–14.
7. Slysz JT, Stultz JS, Burr JF. The efficacy of blood flow restricted exercise: A systematic review & meta-analysis. *J Sci Med Sport*. 2016; 19(8):669–75.
8. Laurentino GC, Ugrinowitsch C, Roschel H, et al. Strength training with blood flow restriction diminishes myostatin gene expression. *Med Sci Sports Exerc*. 2012; 44(3):406–12.

9. Loenneke JP, Wilson JM, Marín PJ, Zourdos MC, Bemben MG. Low intensity blood flow restriction training: A meta-analysis. *Eur J Appl Physiol*. 2012; 112(5):1849–59.
10. Jessee MB, Buckner SL, Mouser JG, et al. Muscle adaptations to high-load training and low-load training with blood flow restriction. *Front Physiol*. 2018; 9: 1448.
11. Hughes L, Paton B, Rosenblatt B, et al. Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis. *Br J Sports Med*. 2017; 51(13):1003–11.
12. Wilk M, Krzysztofik M, Filip A, et al. The effects of blood flow restriction on strength, power and muscle endurance in healthy individuals: A systematic review. *J Sci Med Sport*. 2020; 23(5):463–70.
13. Abe T, Loenneke JP, Fahs CA, Rossow LM, Thiebaud RS, Bemben MG. Exercise intensity and muscle hypertrophy in blood flow–restricted limbs and non-restricted muscles: a brief review. *Clin Physiol Funct Imaging*. 2016; 36(6):385–90.
14. University of California, Davis. How hard should you squeeze? A review of blood flow restriction training in powerlifting. *The Aggie Transcript*. 2019.
15. Brandner CR, Warmington SA. Delayed onset muscle soreness and perceived exertion after blood flow restriction exercise. *J Strength Cond Res*. 2017; 31(11):3101–8.
16. Cook SB, LaRoche DP. Effect of blood flow restriction on muscle fatigue during dynamic contractions in the forearm. *J Appl Physiol*. 2014; 116(11):1235–40.
17. Manini TM, Clark BC. Blood flow restricted exercise and skeletal muscle health. *Exerc Sport Sci Rev*. 2019; 47(2):90–5.
18. Ladlow P, Coppack RJ, Dharm-Datta S, et al. Low-load resistance training with blood flow restriction improves clinical outcomes in musculoskeletal rehabilitation. *Front Physiol*. 2018; 9:1269.
19. Neto GR, Novaes JS, Salerno VP, et al. Effects of resistance training with blood flow restriction on muscle strength and damage. *J Strength Cond Res*. 2015; 29(9):2466–70.
20. Counts BR, Dankel SJ, Barnett BE, et al. Influence of relative blood flow restriction pressure on muscle activation and muscle adaptation. *Muscle Nerve*. 2016; 53(3):438–45.
21. Hoang D. How hard should you “squeeze”?: A review into blood flow restriction training on powerlifting. The Aggie Transcript [Internet]. 2024 Aug 11 [cited 2025 Jun 26].
22. Korkmaz E, Dönmez G, Uzuner K, Babayeva N, Torgutalp ŞŞ, Özçakar L, et al. Effects of blood flow restriction training on muscle strength and architecture. J Strength Cond Res. 2022 May 1;36(5):1396–1403. doi: 10.1519/JSC.0000000000003612
23. Pignanelli C, Christiansen D, Burr JF. Blood flow restriction training and the high-performance athlete: science to application. J Appl Physiol (1985). 2021 Apr 1;130(4):1163–1170. doi:10.1152/japplphysiol.00982.2020
24. Wortman RJ, Brown SM, Savage-Elliott I, Finley ZJ, Mulcahey MK. Blood flow restriction training for athletes: a systematic review. Am J Sports Med. 2021 Jun;49(7):1938–1944. doi:10.1177/0363546520964454. PMID: 33196300
25. Bowman EN, Elshaar R, Milligan H, Jue G, Mohr K, Brown P, Watanabe DM, Limpisvasti O. Proximal, distal, and contralateral effects of blood flow restriction training on the lower extremities: a randomized controlled trial. Sports Health. 2019 Mar/Apr;11(2):149–156. doi:10.1177/1941738118821929. PMID: 30638439.
26. Bradley KM, Bunn JA, Feito Y, Myers BJ. Effects of blood flow restriction training on muscle size, power, and $\dot{V}O_2$max in active adults. Transl J ACSM [Internet]. Winter 2023;8(1):e000219. doi:10.1249/TJX.0000000000000219

27. Yang K, Chee CS, Abdul Kahar J, Tengku Fadilah Tengku Kamalden, Li R, Qian S, et al. Effects of blood flow restriction training on physical fitness among athletes: a systematic review and meta-analysis. Sci Rep. 2024 Jul 18;14:16615. doi:10.1038/s41598-024-67181-9
28. Muller CHL, Farinha JB, Leal-Menezes R, Ramis TR. Aerobic training with blood flow restriction on muscle hypertrophy and strength: systematic review and meta-analysis. J Strength Cond Res. 2024 Jul 1;38(7):1341–1349. doi:10.1519/JSC.0000000000004800. PMID: 38900180
29. Jing J, Zheng Q, Dong H, Wang Y, Wang P, Fan D, Xu Z. Effects of upper extremity blood flow restriction training on muscle strength and hypertrophy: a systematic review and meta-analysis. Front Physiol. 2025 Jan 6;15:1488305. doi:10.3389/fphys.2024.1488305. PMID: 39835205.
30. Bahamondes-Avila C, Lagos Gutiérrez JD, Bustos-Medina L, Curilem Gatica C, Hernández-Mosqueira C, Berral de la Rosa FJ, Salazar Navarrete LA. Effects of strength training in Smith press with partial blood flow restriction on jump performance. J Phys Educ Sport. 2024 May; 24(5):1048–1058. doi:10.7752/jpes.2024.05120.