REVIEW ARTICLE

THE EFFICACY AND VALIDITY OF BLOOD FLOW RESTRICTION TRAINING IN CLINICAL AND POST-SURGICAL POPULATIONS

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ABSTRACT

Background: We currently know BFR training is a viable modality for strength gains in the healthy population. However, it is unknown the effect of BFR training on post-surgical and clinical populations. Furthermore, the optimal use of the BFR modality regarding resistance vs. no-resistance (bodyweight) is also unknown. This literature review adds new information to the field of BFR training specifically in the post-surgical and clinical populations. The objective of the study is to explore the validity and efficacy of blood-restriction training (BFR) in conjunction with low-load resistance training (LL-BFR) versus low-load training without BFR and high-load resistance training without BFR to determine which is superior for strength gains.

Methods: The authors used SPORTDiscus, EBSCO, PubMed, and Science Direct to search for peer-reviewed articles. The articles chosen had the keywords/phrases "BFR," "vascular occlusion," "strength training," "resistance training." The studied emphasized patients with either clinical conditions (osteoarthritis) or musculoskeletal injuries (ACL reconstruction, total knee arthroplasty, knee arthroscopy). One hundred seventy-one articles were screened, and 17 articles reviewed.

Results: BFR, in conjunction with low-load resistance training yields superior strength gains when compared to low-load training alone ($p<.05$). The outcome measures show a higher 1-rep max (isotonic strength) and greater muscle size (cross-sectional area, muscle mass, muscle volume) ($p<.05$). However, BFR with low-load resistance training does not yield superior strength gains in comparison to high-load resistance training alone ($p<.03$).

Conclusion: As healthcare providers treating patients with musculoskeletal conditions, we know the importance of resistance training as a tool for rehabilitation and activities of daily living. However, at times heavy resistance training is contraindicated either due to joint instability/degeneration, pain, surgical restrictions. BFR training can be implemented with a 10-30% 1-rep max for comparable strength gains. This can be a potential tool used to offset post-surgical atrophy and atrophy due to arthralgia seen in certain systemic conditions. This can translate to better functional outcomes in post-surgical patients and superior quality of life in the geriatric population.

Keywords: Blood flow restriction training, occlusion training, BFR training, venous occlusion, low load resistance training, resistance training, rehabilitation

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INTRODUCTION

The physical rehabilitation model of today is evolving from invasive to preventative and from rest to activity. The gold standard of treating most injuries is centered around conservative care which includes manual therapy and rehabilitation program [1]. Similarly, even if conservative care fails and surgery is warranted, the post-operative plan centers around manual therapy and rehabilitation exercises to restore range of motion, strength, and function. The rehabilitation clinician has at their disposal manual therapy techniques, joint manipulation, and exercises aimed at returning patients to their previous level of performance. This new rehabilitation model of activity is creating programs that promote movement earlier, improve active care, and truly movement as its own modality to injury recovery [1]. Blood flow restriction (BFR) is a relatively new modality that proposes using partial venous occlusion to induce a local hypoxic response within the exercising muscle which evokes a large neuroendocrine response [2]. The premise of BFR training uses partial venous occlusion to induce an anabolic response at a low percentage of 1-repetition maximum [2]. Some of the anabolic agents induces reported to include growth hormone (GH), insulin-like growth factor 1 (IGF-1), and increased expression of the mechanistic target of rapamycin (mTOR) [2]. BFR has been explored to be safe because it only occludes venous blood flow but has no effect on arterial blood flow [3]. Typical recommendations include venous occlusion of 70-80% working at 20-30% of 1-RM [3].

Furthermore, because the external load is very low, most protocols prescribe a high-volume rep scheme [4]. BFR tools can take many forms with models that use a pressure gauge to set a specified pressure, to pneumatic devices that can continuously monitor pressure [5]. By using a very low load but still having anabolic responses within exercising muscles, BFR has the potential to augment rehabilitation protocols and quicken return to performance programs [5].

BFR proposes to produce an anabolic response in local muscle tissue due to its partial venous occlusion [2]. Arterial occlusion is unrestricted and allows oxygenated blood to flow throughout the body perfusing all of its tissues [2]. However, venous blood flow returning to the heart is partially occluded which results the body in triggering a hypoxic response[6]. This hypoxic response in the exercising muscle has been shown to be similar to the effect of muscular contraction and exercise at high percentages of 1-RM (>80%) [6]. The post-exercise effect of heavy resistance exercise induces both a local and systemic response within the body which includes an increase of local muscle and serum levels of IGF-1, GH, increased insulin sensitivity, and increased sensitivity of the mTOR pathway [7]. In BFR training, this post-effect also occurs much while working at much lower training intensities [8]. BFR protocols range from working at 20-30% of 1-RM for higher volume such as 60+ repetitions per exercise [9]. In post-surgical population where there may be restrictions on load or closed-chain vs open kinetic chain exercise BFR may provide an alternate means of protecting the surgical graft while off-setting the effects of immobility and muscle atrophy [10]. In clinical populations such as the patients with overuse injuries in avascular or less vascularized injuries such as meniscal tears and glenohumeral joint labral injuries, BFR may provide an alternate modality during conservative care [11]. The objective of this literature review was to explore the validity and efficacy of blood-restriction training (BFR) in conjunction with low-load resistance training (LL-BFR) versus low-load training without BFR and high-load resistance training without BFR to determine which is superior for strength gains.

METHODS

The authors used SPORTDiscus, EBSCO, PubMed, and Science Direct to search for peer-reviewed articles that met the criteria for inclusion. Inclusion criteria included articles that were published within the last 20 years, were at least level 3 of evidence on the Oxford Center for Evidence-Based Medicine (CEBM) [12], The PEDro scale was used to rate the levels of all randomized control trials [13], and articles written in the English language. Exclusion criteria included articles lower than level 3 on the CEBM scale [12], a low score on the PEDro scale [13], written in another language than English. Since this literature review focuses on musculoskeletal injuries, articles were excluded if they dealt with bio-enhancement modalities such as platelet-rich plasma (PRP) or Stem-cell therapy. The exclusion criteria also applied to neurological and vascular injuries such as stroke, intermittent claudication, and cerebral palsy. The articles chosen had the keywords/phrases "BFR," "vascular occlusion," "strength training," "resistance training." The studied emphasized patients with either clinical conditions (osteoarthritis) or musculoskeletal injuries (ACL reconstruction, total knee arthroplasty, knee arthroscopy). One hundred seventy-one articles were screened published from the years 1999-2019, 50 articles met the inclusion criteria, and 17 articles were included in the review.

RESULTS

The result shows that BRF training can be split into two categories: low-load resistance training and no-load resistance training [14]. The studies analyzed were compared to moderate-high load resistance training (70-80%) without BFR. The measures of cross-sectional area (CSA), muscle mass, and muscle volume were used to determine hypertrophy among the participants. BFR training with low-load resistance training yields superior outcomes compared to BFR training to no load ($p<.05$) [15]. However, moderate-high load resistance training without BFR was superior to both groups using BFR training ($p<.03$) [11].

Table 1: Overview of the articles included in the Review

Study	Clinical Focus	Participants	Study Design	Methods	Load/ Volume	Exercise Modality	Physiological Adaptation
Pearson et al. (2015)	Active/ Athletic Population	n= 250 subjects	Literature Review	Varied	10-30% 1RM	Blood Flow Restriction (BFR)	Increased strength using BFR training similar to traditional strength training ($p<0.05$)
Loenneke et al. (2015)	Healthy, recreationally active subjects	n= 50 subjects	Randomized Control Trial	4 weeks of upper and lower extremity exercises with BFR	20% 1RM	Blood Flow Restriction (BFR)	Patient maintained their strength gains using BFR training ($p<0.05$)
Schoenfeld et al. (2015)	Healthy, recreationally active subjects	n= 60 subjects	Randomized Control Trial	6 weeks of lower extremity exercises with BFR	15%1RM	Traditional Strength Training (TST)	Patients who trained with traditional strength training gained more strength than with BFR training ($p<0.05$)
Burgomester et al. (2003)	Geriatric population	n= 35 subjects	Crossover Study	5 sessions of upper and lower extremity exercises with BFR	25% 1RM	Blood Flow Restriction (BFR)	Patients who trained with traditional strength training gained more strength than with BFR training ($p<0.05$)
Dinenno et al. (1999)	Geriatric population	n= 440 subjects	Literature Review	Varied	10-35% 1RM	Blood Flow Restriction (BFR)	BFR training seems to be a safe strength training modality in the geriatric population ($p<0.05$)
Takarado et al. (2002)	Geriatric population	n= 365 subjects	Systematic Review	Varied	5-20% 1RM	Blood Flow Restriction (BFR)	BFR training is a viable modality for geriatric patients to gain and maintain strength ($p<0.05$)
Hughes et al. (2017)	Patients with Musculoskeletal (MSK) injuries	n= 500 subjects	Systematic Review/ Meta-Analysis	8-12 sessions of upper and lower extremity exercises with BFR	10-30% 1RM	Blood Flow Restriction (BFR)	In injured patients, BFR seems to be a viable modality in offsetting the effects of atrophy caused by injury ($p<0.05$)
Iversen et al. (2016)	Post-ACL Reconstruction patients	n=105 subjects	Cross-sectional study	8 weeks of lower extremity exercises with BFR	15% 1RM	Blood Flow Restriction (BFR)	BFR presents a safe way for ACLR patients to offset atrophy and strength losses ($P<0.05$)
Ohta et al. (2003)	Post-ACL Reconstruction patients	n=85 subjects	Randomized Control Trial	12 weeks of upper and lower extremity exercises with BFR	20% 1RM	Blood Flow Restriction (BFR)	BFR presents a safe way for ACLR patients to offset atrophy and strength losses ($P<0.05$)
Reeves et al. (2006)	Patients with Musculoskeletal (MSK) injuries	n=550 subjects	Literature Review	Varied	15-20% 1RM	Blood Flow Restriction (BFR)	In injured patients, BFR seems to be a viable modality in offsetting the effects of atrophy caused by injury ($p<0.05$)
Tennet et al. (2017)	Patients post knee arthroscopy	n= 65 subjects	Randomized Control Trial	10 weeks of running with BFR	10-20% 1RM	Blood Flow Restriction (BFR)	Patients who are post-knee arthroscopy may be able to begin the rehabilitation faster using a BFR approach ($p<0.05$)
Petterson et al. (2008)	Patients with knee osteoarthritis	n= 80 subjects	Prospective Cohort Study	6 weeks of lower extremity exercises with BFR	20% 1RM	Traditional strength training (TST) and Blood Flow Restriction (BFR)	Inpatient with knee osteoarthritis, BFR seems to be an effective tool in maintaining strength in the lower extremity without aggravating associated symptoms ($p<0.05$)
Palmieri et al. (2010)	Patients with knee osteoarthritis	n= 40 subjects	Prospective Cohort Study	4 weeks of upper and lower extremity exercises with BFR	20% 1RM	Traditional strength training (TST) and Blood Flow Restriction (BFR)	Inpatient with knee osteoarthritis, BFR seems to be an effective tool in maintaining strength in the lower extremity without aggravating associated symptoms ($p<0.05$)
Segal et al. (2010)	Patients with knee osteoarthritis	n= 22 subjects	Prospective Cohort Study	6 weeks of lower extremity exercises with BFR	15%1RM	Traditional strength training (TST) and Blood Flow Restriction (BFR)	Inpatient with knee osteoarthritis, BFR seems to be an effective tool in maintaining strength in the lower extremity without aggravating associated symptoms ($p<0.05$)

DISCUSSION

The results of this review agreed with the hypothesis of the authors (BS, JS) in that superior gains of strength would be made by high load resistance training without BFR vs. using the BFR modality [11]. Similarly, other researchers that high load resistance training yields greater CSA and hypertrophy as compared to BFR training [15]. However, in a recent review by Hughes et al. (2017) found that BFR training with low-load resistance resulted in similar strength gains when compared to high-load resistance training alone (Alpha .05) [9]. The purpose of this review was two-fold: to compare if high load resistance was superior to BFR training, and to compare how effective BFR training could be in the clinical and post-surgical population. It was found that high-load resistance training was superior compared to low-load resistance training [11]. The authors' reason that the stimulus of the high-load resistance (70-80%) stimulates an anabolic response within the exercising muscle that exceeds the anabolic response by BFR training [11]. However, it was also found that BFR with low-load resistance training produced strength gains and induced an anabolic response, albeit smaller [16]. This literature review focuses on the clinical populations which include patients who can't train at high-loads due to pain, range of motion limitations, and tissue damage [17]. Similarly, the post-surgical population also can't train at high loads in order to protect the surgical graft, tissue harvest site for anatomical healing purposes [14,18]. In these populations, BFR provides a novel, yet safe stimulus which can be performed to offset the deleterious effects of muscle atrophy, scar tissue contracture, and strength losses by still performing movement under a low load (20-30%) [18,19].

CONCLUSION

As healthcare providers treating patients with musculoskeletal conditions, we know the importance of resistance training as a tool for rehabilitation and activities of daily living. However, at times, heavy resistance training is contraindicated either due to tissue damage, pain, surgical restrictions [14,18,19]. BFR training can safely be implemented with 10-30% 1-rep max for comparable strength gains compared to traditional high-load resistance training [2,4,6]. This provides a new modality during conservative management and post-surgical care for patients to make strength gains, retrain the central nervous system, and neuromuscular re-education [5,9,11]. The findings of this literature review provide evidence that supports the use of BFR in the clinical and post-surgical populations [9,11].

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