EFFECTS OF LOW-INTENSITY RESISTANCE TRAINING WITH BLOOD-FLOW RESTRICTION ON MUSCLE

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**ABSTRACT**

Due to its potential for increasing muscular strength and hypertrophy, the use of blood flow restriction (BFR) during low-intensity resistance training has attracted a lot of attention recently. The objective of this comprehensive review is to examine the available scientific data about the impact using blood flow restriction along with low-intensity resistance training on muscle physiology and performance. An explanation of the basic processes governing the BFR training approach, as well as its effects on muscle oxygenation, cellular metabolism, and hormone release, is given in the review's opening paragraph. In-depth analysis of the complex interactions between BFR and conventional resistance training is provided, emphasising how low-intensity loads combined with limited blood flow cause muscle stress and set off adaptive responses. In conclusion the present research shows that blood flow restriction combined with low-intensity resistance training can be a successful and secure method for enhancing muscle adaptations. However, further investigation is required to clarify the ideal procedures, long-term effects, and potential drawbacks of this training approach. Athletes, fitness enthusiasts, and rehabilitation specialists may eventually find it helpful to understand the underlying mechanics and practical applications of BFR training in order to improve training methods and achieve desired results.

**Keywords:** blood flow restriction training; low intensity resistant training with BFRT; rehabilitation

**INTRODUCTION**

Blood-Flow Restriction has gained a lot of attention in recent years as a substitute for high intensity resistance training in rehabilitation facilities, gyms, etc. It also aids in increasing muscular mass, strength, and endurance during workouts. The purpose of blood-flow restriction, or BFR training, is to totally obstruct venous return while partially lowering arterial inflow. This is done by applying pressure cuffs to the proximal region of the leg or arm.

The minimal pressure necessary to completely block arterial inflow and venous return is called limb occlusion pressure (LOP), and it is advised that BFR be given to the individual using this proportion of personalised pressure. The pressure cuffs should target a tightness of 6-7 on a scale of 10. Increases in occlusion pressure may improve the training-related response to BFRT, according to recent studies.

The degree of exercise (low, moderate, or high), the volume of exercise with BFR, the pressure of occlusion (partial or complete), the type of occlusion (continuous or intermittent), and all of these factors affect the adaptations to exercise with BFR. [1].

To induce muscular hypertrophy, the American College of Sports Medicine (ACSM) advises lifting weights that are at least 70% of one's concentric one repetition maximum (1-RM), as it anything less than this intensity does not result in appreciable muscle growth [2].

This idea has recently been refuted by the use of Low-Intensity Resistance Exercise with Blood-Flow Restriction (BFR), which consistently demonstrates that hypertrophic adaptations may be elicited with significantly lower exercise intensities (50% 1-RM)[3]. Skeletal muscle growth, enhanced strength, and improved endurance have been seen when low intensity training (20-30% concentric 1-RM) and venous blood-flow restriction (VBFR) are coupled [2]. The patient engages in resistance training with modest intensity—20–30% of 1 repetition maximum (1RM)—high repetitions (15–30 repetitions) each set, and brief rest periods (30 seconds) between sets.

**CONTRAINDICATIONS OF BFRT**

Table 1. Contraindications of BFRT [4]

|  |  |  |
| --- | --- | --- |
| Active cancer/tumorsa | History of thrombosis | Renal compromisea |
| Arterial calcificationa | Lymphectomies | Respiratory disease |
| Cardiovascular disease | Medications that increase clotting risk | Severe uncontrolled hypertensiona |
| Crush injuriesa | Obesitya | Sickle cell anemia traita |
| Extremity infection | Open fracturesa | Smoker |
| Family history of clotting disorders | Peripheral vascular compromisea | Uncontrolled diabetes mellitus |
| Hemophilia | Poor circulatory system | VTE |

aAlso might be associated with Risk Factors for VTE. This list (while listed in alphabetic order) is not comprehensive and might be precautions based on clinical judgement.

**RISK FACTORS OF BFRT**

Table 2. Risk Factors of BFRT [4]

|  |  |  |  |
| --- | --- | --- | --- |
| Age>/ =40 yr | Dialysis | Lymphectomies | Physical inactivity |
| Arterial calcification | Fractures of pelvis, hip or long bones | Major general/ orthopaedic surgery | Pregnancy (perinatal, postnatal) |
| Atherosclerotic vessels | Grafts (skin, vascular) | Multiple traumas | Prior history or family history of VTE |
| Blood clotting disorders | Hypertension | Nonhealing soft tissue injuries | Renal compromise |
| Cancer/tumor | Immobility | Obesity | Sickle cell anemia |
| Central catheter | Implanted medical device | Open fractures | Spinal cord injuries |
| Crush injuries | Increased intracranial pressure | Oral contraceptives | Stroke |
| Diabetes | Infection (general or local) | Peripheral vascular disease | Varicose veins |

This list (while listed in alphabetic order) is not comprehensive and might be precautions based on clinical judgement.

**PHYSIOLOGY**

When used properly, the Blood-Flow Restriction training approach allows blood to enter the musculature via arterial inflow, but the veins are constrained to prevent blood from leaving the working muscle during exercise. Compared to an unoccluded limb at rest, the muscles of the affected limb continue to receive more blood. The subsequent venous pooling and hypoxia from a relative drop in blood flow set off a chain of events that result in local and systemic endocrine and metabolic responses in the muscles. The hypoxic environment is hypothesised to support muscle growth by enhancing muscle protein synthesis, changing muscle satellite cell gene regulation, boosting muscle fibre recruitment, and enhancing muscular endurance. Through the creation of reactive oxygen species (ROS), which cause changes in cellular protein metabolism and promote satellite cell development, the buildup of metabolites causes muscle hypertrophy. The exercise pressor response, a sequence of cardiovascular adjustments brought on by muscular contraction that raises systemic vascular resistance and heart rate during exercise, is likewise started by this metabolic cascade.

Based on the length, pressure, and intensity of training during BFR, studies have demonstrated an increase in muscle strength, bulk (hypertrophy), endurance, and some alterations in aerobic and anaerobic capacity. [4]

**METHODOLOGY**

Three electronic databases, PubMed, Scopus, and Google Scholar, were searched. Studies that have been published since January 2015 were included in the search method. However, some of the included review articles incorporated data from excellent research that, in some cases, were conducted before 2005. The pre-established search terms were: “blood flow restriction training” and “low intensity resistant training with BFRT” and “rehabilitation”.

To lessen variability, all published studies retrieved from the literature databases were gathered, arranged by date and type of intervention, and then double entries were eliminated. This review covered randomised, double-blind studies (randomised controlled trials, RCTs) as well as observational cohort, case-control, cross-sectional, systematic reviews, and meta-analyses.

Studies using experimental models and animals were not included in the study. Studies with insufficient sample sizes, inadequately defined selection criteria, or that included participants receiving medication for a different condition that affected bone or muscle metabolism were also disregarded. Finally, the review did not include case reports, editorials, letters to the editor, or conference proceedings.

**DISCUSSION**

There are various impacts of blood flow restriction &low intensity resistance Exercise (BFR + LIRE) on hormonal factors, transcriptional factors associated with muscle hypertrophy, changes in hemodynamic,endothelial function and autonomic function, which are discussed below.

IMPACT OF BFR+LIRE ON HORMONAL FACTORS ASSOCIATED WITH MUSCLE HYPERTROPHY

Following single high-intensity resistance exercise bouts, muscle growth and enhanced strength are typically believed to be related to the recruitment of high threshold motor units [5]. Increased mechanical stress, endocrine responses, and metabolite buildup are all brought on by the recruitment of these motor units. According to earlier research, BFR+LIRE produces similar endocrine effects and muscle adaptations, such as an increase in muscular mass and hypertrophy, as compared to high intensity resistance training [6].

In addition to these chronic positive effects, Pierce and colleagues reported an acute 9-fold increase in serum GH from baseline to the cessation of knee extension exercise at 20% maximum voluntary contraction (MVC) with BFR. Others have reported GH increases of up to 290 times baseline values, with the GH responses following BFR+LIRE being similar to, or even higher than those reported during high intensity resistance exercise of intensities at about 70% 1RM [7].

IMPACT OF BFR+LIRE ON TRANSCRIPTIONAL FACTOR IN MUSCLE HYPERTROPHY

Skeletal muscle hypertrophy is mostly controlled by transcriptional mechanisms, such as the up-regulation of mRNA in mTOR (mammalian target of rapamycin) pathways[8].

Muscle protein synthesis and ribosomal S6 kinase 1 (S6K1) phosphorylation are both increased following a single bout of BFR+LIRE, according to a recent study by Fujita and Yasuda. The up-regulation of hypertrophy-associated genes including phosphoinositide 3- kinase (PI3K), protein kinase B (AKT), and mTOR after BFR+LIRE may be the cause of these abrupt alterations in transcriptional factors linked to muscle hypertrophy.

By activating the mTOR pathway, Drummond et al. showed that the brief periods of hypoxia and reperfusion brought on by BFR improve cell survival and growth adaptations within skeletal muscle. Additionally, hypertrophy depends on the up-regulation of vascular endothelial growth factor (VEGF), which is thought to be a crucial regulator in vasculogenesis and angiogenesis and can be triggered by hypoxia and lactate buildup [8].

IMPACT OF BFR+LIRE ON CHANGES IN HEMODYNAMICS

It is widely known how BFR with RT affects hemodynamic parameters. Prior research suggested that as both systolic and diastolic pressure increase during moderate to intense resistance training with blood flow restriction on cardiovascular and skeletal muscle function 193 large muscle groups, especially during isometric contractions, there is a significant rise in mean arterial pressure [9].

Although resistance training is thought to naturally trigger the exercise-induced pressor response, it's vital to remember that BFR can cause blood pressure to vary substantially more than typical exercise does [10].

IMPACT OF BFR+LIRE ON ENDOTHELIAL FUNCTION

BFR+LIRE does not appear to adversely influence blood vessel function as measured by the arterial compliance of major and small arteries, despite the fact that the effect of BFR+LIRE on vascular function has not been thoroughly reporte. Additionally, it has been demonstrated that walking while using BFR promotes carotid arterial compliance and muscle hypertrophy simultaneously [11].

Additionally, Credeur et al. hypothesised that endothelial function in brachial arteries was compromised after 12 weeks of BFR+handgrip exercise training. The stimulation of endothelin I caused by BFR, which increased retrograde flow in working muscle, was cited by the authors as the explanation for the functional impairment [12].

Although endothelial function in the vasculature is crucial for comprehending the mechanisms underlying changes in function following BFR+LIRE but researcheson this are lacking and yields mixed results.

IMPACT OF BFR+LIRE ON AUTONOMIC FUNCTION

LIRE's effects on autonomic function in sick populations, including patients with hypertension and heart failure, have shown improved parasympathetic nerve activity. In healthy young and old people, however, LIRE does not enhance parasympathetic nerve activity to the same extent. By using experimental occlusion, it has been found that blood flow restriction can boost the autonomic nervous system's (ANS) reaction [13].

Researchers hypothesised that the high pressures on the limbs caused by the BFR cuff increases baroreflex, resulting in vasoconstriction and an enhanced blood pressure response. Baroreflex sensitivity and autonomic function are critical aspects of vasomotor regulation. Due to the pooling of venous blood and the decreased femoral arterial blood inflow, Iida and colleagues found that applying BFR alone to the legs dramatically lowered blood flow, including cardiac output [13].

This BFR causes blood flow to be retained in the lower extremities, which then results in hemodynamic alterations that affect the autonomic nervous system. Orthostatic intolerance following bed rest has been proven to be prevented with the ensuing adaptation for lower body negative pressure. As a result, BFR might be a valuable technique to encourage appropriate autonomic function, which could ultimately aid elderly people in reducing their risk of fainting and falling.

Different protocols choices are discussed below.

PROTOCOL CHOICE

1. increasing BFR pressure with constant exercise intensity (IP-CE),
2. constant partial BFR pressure with increasing exercise intensity (CPP-IE),
3. constant complete BFR pressure with increasing exercise intensity (CPC-IE), and
4. increasing BFR pressure with increasing exercise intensity (IP-IE).

12 training sessions comprised of repeated bouts of 2 min running on a treadmill with BFR interspersed by 1-min recovery without BFR. Series of tests to assess muscle strength, aerobic, and anaerobic performances. Muscle strength, anaerobic power, and aerobic parameters including maximum oxygen consumption (VO2 max), time to fatigue (TTF), velocity at VO2 max (vVO2max), and running economy (RE) can be assessed to evaluate the effect of BFRT [2].

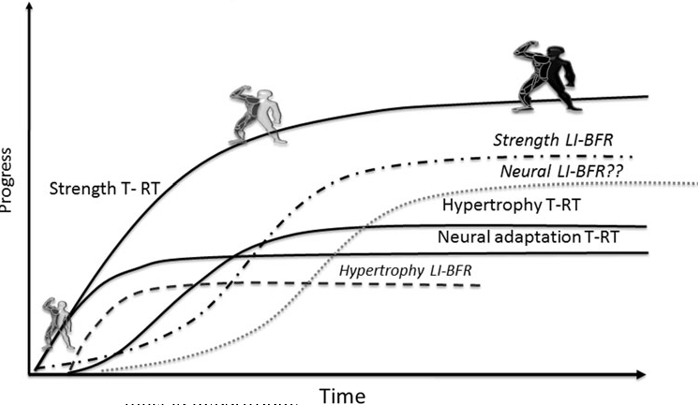


Figure: - 1 Theoretical reverse pattern of adaptations in Traditional Vs. Low-Intensity Blood-Flow Restriction Exercises. This figure is a graphical representation of the possible interaction between the strength, hypertrophy and neural adaptations during both low intensity Blood-Flow Restriction exercise (LI-BFR) and Traditional Resistance Training (T-RT) [2]. The progress-time graph for T-RT, there is an increase in strength initially& is due to change in muscle hypertrophy, which is then followed by neural adaptations. Whereas in the LI-BFR progress-time graph depicts that the pattern followed by LI-BFR might occur the other way around, concluding that combining Blood-Flow Restriction with low intensity exercise training marks to be beneficial than Blood-Flow Restriction with walking.

In a study in 2019 to understand the proximal, distal and contralateral effects of Blood-Flow Restriction training on lower extremities [14]. Healthy patients were randomized to unilateral low-load BFR training or to a non-BFR control group. The results of the study showed a statistically greater escalation in strength was seen proximal and distal to the BFR tourniquet when compared with both the non-tourniquet extremity and the control group (*P* < 0.05).The improvement in the BFR group compared with controls were found out to be an approximate twice. A significant amount of growth occurred in thigh girth (0.8% vs 2.3%) and knee extension strength (3% vs 8%) in the non-tourniquet BFR extremity compared with the control group (*P* < 0.05).

Low-load Blood-Flow Restriction (LL-BFR) training induces similar morphological and mechanical Achilles Tendon adaptations compared to High-load resistance training [13]. The study provided first evidence that LL-BFR can increase similar Achilles Tendon morphological and mechanical properties as conventional High-load Resistance training. The study included fifty-five male volunteers (27.9 ± 5.1 years) who were randomly divided into the following three groups:

1. LL-BFR (20-35% of one-repetition maximum, 1RM),
2. High Load (70-85% 1RM) or
3. a non-exercising control group (CON).

Furthermore, the Cross-Sectional Area of the gastrocnemius medialis muscle and the strength of plantar flexors significantly increased in both training groups (*p* < 0.05), while the CON group did not show any such significant changes in the evaluated parameters. To conclude the study.

3 ACL repair cases, 3 knee osteoarthritis cases, 13 older persons at risk of sarcopenia and 1 patient with sporadic inclusion body myositis were taken into consideration in a small number of research on the effects of blood-flow restriction in clinical musculoskeletal rehabilitation. Low-load Blood Flow Restriction training had a moderate effect on boosting strength, according to the analysis of data gathered from multiple sources (Hedges' g=0.523, 95% CI 0.263 to 0.784, p0.001). In conclusion, low-load BFR training is found to be more beneficial and tolerated than low-load training, making it a promising clinical rehabilitation intervention. [15].

**CONCLUSION**

This research was conducted to understand the effects of Blood-Flow Restriction training along with Low-Intensity Resistance training on the physiology of muscle. This research supports the evidence that using Low-Intensity Resistance training along with Blood-Flow Restriction is able to generate muscle hypertrophy, increase in muscular strength, endurance, aerobic capacity, anaerobic capacity and an overall fitness. This data can be used further in rehabilitation purposes and general fitness purposes.

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