IJARASEM

ISSN: 2395-7852

International Journal of Advanced Research in Arts, Science, Engineering & Management

Volume 10, Issue 4, July 2023

INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 6.551

+91 9940572462 +91 9940572462 ijarasem@gmail.com www.ijarasem.com

International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)

| ISSN: 2395-7852 | www.ijarasem.com | Impact Factor: 6.551 |Bimonthly, Peer Reviewed & Referred Journal|

IJARASEM

| Volume 10, Issue 4, July 2023 |

Brief Overview of BFRT in Exercise Physiology

Karan Pal Vishnoi[1], **Dr. Ram**[2]

Scholar, Department of Physical Education, Sunrise University, Alwar, Rajasthan, India[1]

Assistant Professor, Department of Physical Education, Sunrise University, Alwar, Rajasthan, India[2]

ABSTRACT: Occlusion training or Blood flow restriction training (BFRT) is being used more and more by physiotherapists, exercise physiologist or other trained allied health professionals to assist with improving muscle hypertrophy in a range of general and clinical populations.

It works by using compression at the proximal limb to limit blood flow out of the muscle.
Research has shown BFR training to increase muscular strength and hypertrophy using loads less than half of what is recommended by the ACSM for general hypertrophy training (60% of 1RM).

It is proposed that occlusion training works by altering the traditional ratio of mechanical loading and metabolic stress to give similar outcomes without high mechanical loads – perfect in a rehab setting.

KEYWORDS: BFRT, exercise, physiology, physiotherapy, stress, rehab

I. INTRODUCTION

The occlusion cuff compression limits venous return (blood flow out of the muscle) causing venous pooling. Be careful to not elicit full arterial restriction (don't wrap too tight).

This causes greater metabolic stress via elevated blood lactate levels which leads to increase growth hormone and IGF-1 (anabolic protein)

Studies have shown BFRT elicits increased fast-twitch fibre recruitment
BFRT has also shown to increase; cell swelling and protein synthesis
When to use BFRT:
More recent research suggests the use of BFRT to be useful to elicit improvements to quad/hamstring and lower limb strength, power and total workload in the rehabilitation of osteoarthritic knee pain, post-op ACL-reconstruction, osteochondral fractures and other lower limb pathologies in which heavy lifting (>60% 1RM) may be contraindicated.

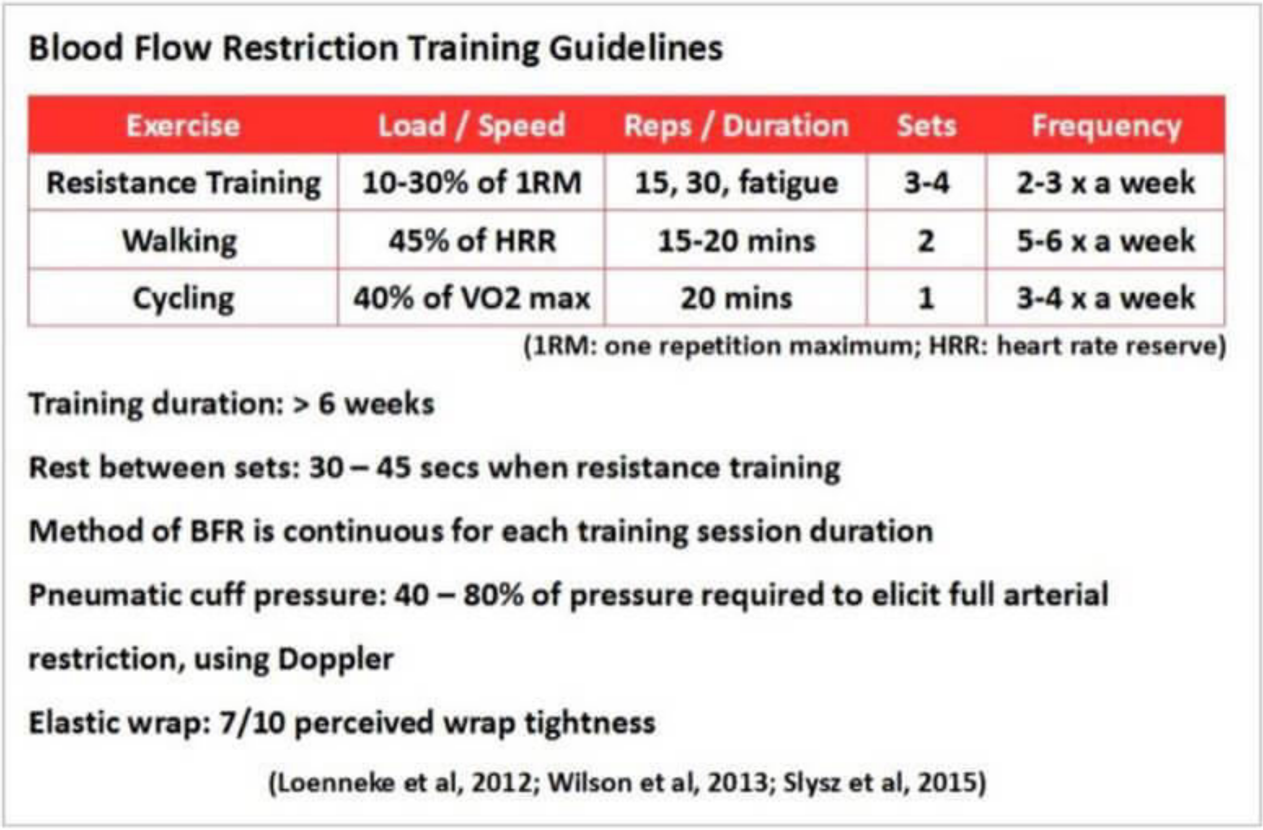
BFRT may be contra-indicated if you have deep vein thrombosis, varicose veins, high blood pressure, history of stroke or cardiac disease or during pregnancy.

Always consult your accredited Exercise Physiologist before starting BFRT to ensure this is appropriate for you.[1,2,3]

How to implement BFRT:
The use of a Sports Rehab tourniquet is best practice for Blood Restriction Training this is due to its ability to objectively measure the amount of pressure being applied.

As discussed above, the goal of occlusion training is to restrict venous return rather than occlude blood flow to the limb. For this reason, it is advised that pressure of 90-120mmHg is optimal. Once the compression has been applied the prescription of appropriate exercises at a specific rep & set range needs to be determined.

The following figure gives an outline as towards appropriate load, reps, sets and frequency.



Blood Flow Restriction Training Guidelines

Exercise	Load / Speed	Reps / Duration	Sets	Frequency
Resistance Training	10-30% of 1RM	15, 30, fatigue	3-4	2-3 x a week
Walking	45% of HRR	15-20 mins	2	5-6 x a week
Cycling	40% of VO2 max	20 mins	1	3-4 x a week

(1RM: one repetition maximum; HRR: heart rate reserve)

Training duration: > 6 weeks

Rest between sets: 30 – 45 secs when resistance training

Method of BFR is continuous for each training session duration

Pneumatic cuff pressure: 40 – 80% of pressure required to elicit full arterial restriction, using Doppler

Elastic wrap: 7/10 perceived wrap tightness

(Loenneke et al, 2012; Wilson et al, 2013; Slysz et al, 2015)

Clinical Case Review:
Mr John arrived at our clinic 9 months' post-op right knee injury (medial femoral condyle & trochlear lesion). He reported being unable to regain quadriceps and hamstring strength due to intense pain with squat, lunge or other lower limb activities.

Upon initial assessment Mr John was unable to stand from a sitting position without patellar femoral join pain >7/10 PVAS (front of knee pain), strength testing revealed his quadriceps strength was 45% compared to his left leg and hamstring strength 55% of his left side, he had noticeable quadriceps atrophy (muscle wasting) and was unable to walk, stand or drive his car for extended periods of time.

After 12 weeks of BFRT training (2 x sessions per week) Mr John can now complete repetitive lunges, squats too parallel and stairs with only very minimal discomfort.

He reports walking to be pain free and has even started to complete loaded step ups & squats with loads up to 15kg. His quadriceps and hamstring strength testing reveals significant improvements (Quadriceps 90% and Hamstring 85% of his left side respectively).

Due to Mr John being unable to handle high mechanical loads required to achieve hypertrophy gains BFRT allowed him to build the required lower limb strength to return to work and complete most of his activities of daily living without restrictions.

II. DISCUSSION

Blood Flow Restriction Training (BFRT), which is also commonly referred to as occlusion training or KAATSU (Japanese for "additional pressure") training, is a specific form of exercise therapy used by physiotherapists, doctors and other health professionals in both rehabilitation and for general health improvement.

BFRT was invented in Japan by Dr Yoshiaki Sato in the 1960's who called it KAATSU training. Since then there has been almost 50 years of academic research and development of BFRT, with over 400 peer reviewed articles showing its positive effects.

BFRT involves applying a medically approved pneumonic cuff, similar to the one used to take your blood pressure, to moderately but safely restrict the blood flow in and out of a limb and performing light exercise with that limb. This leads to blood and metabolites pooling in the limb, triggering a cascade of beneficial physiological effects.

The main aim of BFRT is to induce hypertrophy (hypertrophy = muscular growth), and it has shown to be very effective at achieving this [1]. Hypertrophy is important because a bigger muscle means a stronger muscle, and strength is vital for almost all parts of life, not just for injury rehabilitation or when recovering from injury.

Whilst hypertrophy is generally the main aim of BFRT, it has a wide variety of physiological benefits beyond this, these benefits will be discussed further below [2].

What conditions and other health benefits can BFRT be used for?
BFRT can be utilised by health and rehab professionals to directly treat and in the treatment of a range of conditions and to achieve better general health outcomes. Some of these are;

- Post-surgical rehabilitation
- Anterior Knee Pain (PFJP, Patella Tendinopathy)
- Sarcopenia (age related loss of muscle mass)
- Sports injury Rehabilitation
- Strengthening for the management of
- Arthritis
- Osteoporosis/Osteopenia
- Negate the negative effects of bed rest/immobilisation
- Bone Fracture and Stress Injury Rehabilitation
- Increased VO2 Max in elderly and athletic populations
- Improve vascular health/Circulation (Particularly in the elderly/aging population)
- Reduced risk of blood clots
- Cardiac Rehab
- Load management in athletes
- Recovery post sports
- Pre-Exercise Analgesia (pain reduction)
- Ischemic preconditioning (preparing for exercise)
- Muscular gain for general health
- Body Building
- Diabetes management*
- Falls Prevention**
- Prevention of scar tissue formation***

*Increased muscle mass leads to reduced insulin resistance
** BFRT has been show to improve 30 second sit-stand test which is positively associated with reduced falls risk
*** BFR leads to down regulation of Myostatin which is a key step in scar tissue formation
Blood Flow Restriction Training vs High Load Resistance Training – same outcomes without the weight
Traditionally, high load resistance training (HLRT) is used to improve muscular strength and hypertrophy. Ultimately, by lifting heavy things our muscles will get stronger[3,4,5].

Where BFRT has great advantage over HLRT, is that hypertrophy and other beneficial health effects are able to be achieved using very light loads and in a short amount of time [2].

Simply put, BFRT = quick strength gains with low loads
Why would we only want to use light loads? This is to protect healing, compromised or sensitive tissue from injury which can occur by using too heavy a load.

We refer to a person with tissues described above as being “load compromised”, meaning they can’t handle heavy loads. A few examples of this are after surgery (e.g. ACL reconstruction), when a tissue is healing (e.g. a broken leg) or if a joint is degenerated (e.g. an arthritic knee).

Why not just use light loads by themselves?
A fair question to ask is why not just use light loads to achieve hypertrophy? Unfortunately, use of light loads alone does not cause enough stress to stimulate muscular hypertrophy [89].

To understand this better, it is helpful to know the two ways our body makes our muscles grow. These are in response to mechanical stress and metabolic stress [89].

- Mechanical stress, caused by lifting heavy loads above 70%+ of 1RM (1 RM = the maximum weight you can lift once),
    - This leads to micro damage of muscle tissue. Micro damage is completely normal and when followed by natural healing, i.e. “Breaking down and building up”, leads to a bigger muscle.
    - Blood pooling insode the limb stimulates the mTOR pathway – which is a pathway that stimulates the brain to upregulate protein synthesis – i.e. start building muscle
- Metabolic Stress is caused by a build-up of metabolites, which are natural chemicals, that our cells release in response to high intensity exercise (i.e. lifting heavy). These chemicals then stimulate the body to grow muscle.

Use of light loads alone does not cause enough of either of these stresses to stimulate the body to grow muscle.
How does the addition of Blood Flow Restriction make light loads stimulate hypertrophy?
BFRT is able to achieve increases in strength, but without the need for heavy loads predominantly by stimulating hypertrophy through metabolic stress pathways, along with sell swelling caused by blood pooling activating the mTOR pathway [90].

By restricting blood flow and using light loads during BFRT (lifting light or, in the very early stages of rehab, this exercise may be as light as walking or riding a bike with BFR), we deprive the working muscles of oxygen which leads to a build-up of metabolites & cell swelling in the working limb.

The hypoxic (low oxygen) environment also causes the Type II muscle fibres (strength fibres) to contract instead of type I fibres (endurance fibres).

This mimics what would occur using traditional HLRT, without mechanical force on the working tissues, meaning it safe for the tissues when load compromised.

Basically – your body gets tricked into working hard using a light load, which makes BFRT a fantastic tool to build strength, particularly in a rehabilitation setting.

Why not use BFRT instead of high load resistance training all the time?
A question that is often asked is “why would we not use BFRT in preference to HLRT all the time?”, there are two main reasons for this.

Firstly, if we look beyond just muscular strength, other tissues in our body, namely tendon and bone, require mechanical loading to build up strength and stay healthy. Utilisation of HLRT induces beneficial changes in bone and tendon health that BFRT cannot [91, 92].

On top of the benefit to tendon and bone, most studies show that HLRT leads to strength gains of 1.3-1.6x greater than BFRT[6,7,8] so to reach maximum levels of strength, HLRT is advised.

This is a consideration when rehabbing or preparing athletes for high level performance, where max strength is an important attribute.

In most cases, but not always, the goal is to progress onto HLRT. BFRT plays a vital role in starting rehabilitation and more specifically, building strength, much earlier than what otherwise could have without BFRT.

This also makes the commencing HLRT easier to achieve and it can be started at a much higher level, reducing overall rehabilitation times and improving outcomes.

How long does BFR take to work?
Improvement in muscular hypertrophy and strength can generally be seen after 2 weeks using BFRT, this is in comparison to traditional HLRT that takes 8-12 weeks to see improvements.

The reason for this difference is that strength gains seen using BFRT are driven by changes in the muscle tissue itself (i.e. hypertrophy) [95] whereas strength gains seen with traditional HLRT are driven by the nervous system for the first 8 weeks then hypertrophy takes over after that [89].

This is often taken into consideration when rehabilitating an athlete that needs to get back to performing very quickly.
The many physiological benefits of BFRT (it's more than just hypertrophy)

Whilst hypertrophy has traditionally been the main aim of BFRT, a number of other physiological benefits have been discovered to be induced by BFRT

These are angiogenesis (growth of new blood vessels) [47], analgesia (pain reduction) [65, 66], reduced autophagy (tissue break down) [55, 80] and improvements in VO2 max (cardiovascular health) [9,10]

What does a session of Blood Flow Restriction Training involve? – the practical side
A session of BFRT will be different depending on a number of factors including what injury you have, what your goals are, your general health and how much training you have done in the past. This will be tailored to you by your physiotherapist to ensure it is effective and safe.

There are 3 ways we use BFRT, BFR + Resistance Training (BFR-RT), BFR + Aerobic Exercise (BFR-AE) and Passive BFR a thorough description of each and their applications can be found here.
In clinic BFR-RT and BFR-AE are the most common applications and a session will follow these steps;

1. Safety checks
    a. make sure it is safe to conduct the session
2. Find Arterial Occlusion Pressure (AOP)
    a. AOP = amount of pressure the cuff is inflated to that stops arterial blood flow into the limb
    b. This is the same as your systolic blood pressure (the higher number on a blood pressure reading)
    c. May not occur every session – commonly rechecked every 1-4 weeks
3. Determine what % of AOP training will occur at
    a. Up to 50% is used in the arm and 80% is used in the leg
    b. Early in training lower pressures are used and then advanced
    c. These pressures allow blood to flow into the limb, but not out, which leads to the all-important pooling.
4. Commence the exercise
    a. BFR-RT
        i. Lift a load 30% or less of 1RM
        ii. 75 reps in sets of 30/15/15/15 with 30 seconds rest between
        iii. Load will be advanced over time
    b. FR-AE
        i. Undertake aerobic exercise for a set amount of time
        ii. Commonly begins at 5 minutes and is progressed from there
5. Cuffs are deflated
    a. If a second round of BFR is to be conducted within the same session
        i. 5 minutes rest if exercising the same limb
        ii. Commence immediately if exercising a different limb

Is BFRT Safe?
As with any therapeutic or fitness intervention, safety must be the first consideration before undertaking BFRT. Overall, BFRT has been shown to be very safe, just as safe as regular strength training in fact [96, 97].

But there are some people that cannot use BFRT, here's a list of common conditions that may exclude someone from being able to use BFRT.

- Unstable Cardiac Disease
- Active or recent blood clots including Deep Vein Thrombosis (DVT)

- Severe varicose veins
- Pregnancy
- Active infection
- Wounds

The BIG question – does BFRT increase the risk or cause blood clots?
As BFRT causes blood to pool inside the limb, a common question is about the risk of thrombogenesis (blood clots) or DVT whist using BFRT.

Current evidence suggests that there is no increased risk of blood clots or DVT whilst using BFRT, in those that do not already show signs or risk factors of clotting or DVT [3].

Blood clots are caused by 3 factors, known as "Virchow's Triad". 1. Stasis (stagnant blood), usually through inactivity, such as bed rest or long-haul travel, 2. Hypercoagulation (excessively easy clotting of the blood) and 3. Endothelial (Blood Vessel) damage [98].

Whilst BFRT does lead to partial stasis in the limb, the lack of complete occlusion by only using a % of AOP and also the short time BFRT is used (usually 8 minutes) ensures stasis is not to a level to induce coagulation. Patients will be assessed for the two other factors. Further to this BFRT does not show an increase of markers of thrombogenesis in the blood [11,12]

In fact, there is emerging evidence that BFRT is protective against blood clots and DVT through the release of Tissue Plasminogen Activator (tPA) which is a protein involved in the break-down of blood clots [54] and also by improving vein health

All patients will be screened by a health care professional prior to any BFRT to assess if it is appropriate and safe for them to undertake.

How do I know if BFRT is right for me?
The best way to assess if BFRT is appropriate to be used in your rehabilitation or general health care is to contact a physiotherapist or health care provider qualified in Blood Flow Restriction Training.
Also, here are some further articles written by Compete Physio team members on BFRT

- Occlusion Training in Practice
- The Benefits of Blood Flow Restriction Training

III. RESULTS

Blood flow restriction training (BFRT) is a method of exercise training that involves execution of low-intensity resistance exercise combined with blood flow restriction (LI-BFR) provided by an inflatable cuff or a tourniquet placed proximal to the exercising muscle. In general, the external cuff pressure applied is set relative to the arterial occlusion pressure (AOP; i.e., the pressure required to cease blood flow to a limb), which is sufficient to produce partial restriction of arterial inflow and full occlusion of venous outflow (81, 116). This hypoxic and metabolic-demanding environment augments muscle motor unit recruitment and activates signaling pathways driving protein synthesis and stem cell activation, leading to muscle hypertrophy

BFRT has become increasingly popular in recent years due to its positive effects on muscle size and strength (80). Moreover, the capacity to generate neuromuscular improvements (e.g., muscle hypertrophy and physical function) comparable to more intense resistance training protocols, while employing low-intensity workloads, has generated considerable interest in utilizing BFRT as a potential therapeutic option for functionally impaired populations, which may be incapable of engaging in high-intensity resistance exercise regimens (e.g., older individuals, patients with knee osteoarthritis) (19, 35). Accordingly, several authors have suggested that BFRT could be used as an important therapeutic tool in clinical practice [13,14] constituting a promising and possibly suitable alternative to high-intensity resistance training for conditions such as postoperative rehabilitation, cardiac rehabilitation, and inflammatory diseases (118). However, for the appropriate implementation of this mode of training in the daily routine of clinical populations, the safety of routine BFRT use in clinical populations has yet to be fully determined.

Previous reviews reported potential negative side effects associated with BFRT, such as increased incidence of blood clots, vein congestion/distension, ischemia-reperfusion injury, muscle damage, and exertional rhabdomyolysis, but concluded that for most of these events BFRT is unlikely to present additional risks in comparison with traditional exercise. A large survey in Japan with BFRT instructors from 232 facilities did not verify any major event, such as cerebral hemorrhage, cerebral infarct, or thrombosis in >120,000 subjects with a large variability of demographical and clinical characteristics (e.g., older adults and people with obesity, diabetes, cerebrovascular and cardiovascular diseases). Reported side effects were generally minor, including transient numbness or dizziness, subcutaneous hemorrhage, and itchiness (98). However, care should be taken with general assumptions about BFRT safety given the paucity of long-term prospective trials with clinical populations, and the possibility of some remaining adverse effects that are still largely overlooked in the literature.

One area requiring further investigation regarding BFRT safety is its potential to promote exacerbated reflex-mediated cardiovascular responses via engagement of the muscle metaboreflex arm of the exercise pressor reflex (154). The metaboreflex is a sympathoexcitatory blood flow- and blood pressure (BP)-raising reflex originating in the contracting skeletal muscle which responds to the increase in muscle metabolites typically occurring during exercise. Upon activation, these afferents relay neural information to the central nervous system (63) which, in turn, produces increases in cardiac output (CO) and BP. While this reflex plays a pivotal role in controlling muscle blood flow during exercise, rapidly correcting any mismatch between oxygen demand and supply (39), an exacerbated activation of the metaboreflex has been shown to produce abnormal cardiovascular responses[15,16], which may be a matter of concern in specific groups of individuals.

Insufficient O_2 delivery to active muscle, and the resulting accumulation of metabolites within muscles fibers during the execution of BFRT, might promote augmented metaboreflex activation, producing increased BP and other abnormal cardiovascular responses, which may increase the risk of adverse cardiovascular events in individuals with cardiovascular risk factors or overt cardiovascular disease. This hypothesis is supported by several experimental and clinical studies demonstrating the role of metaboreflex activation on neural and hemodynamic responses to exercise in healthy and clinical populations Recent studies have assessed cardiovascular responses during typical BFRT sessions The equivocal results of these limited studies suggest that further investigation of the cardiovascular responses to BFRT are necessary and required to properly assess the cardiovascular safety of this method of exercise training. Importantly, some training variables of BFRT exercise might either increase or attenuate potential risks, which also deserve appropriate discussion. Therefore, the aim of this review is to provide experimental and clinical information about the role of the muscle metaboreflex on cardiovascular adjustments to exercise, to present the current evidences on the acute cardiovascular responses to BFRT, and to provide practical consideration regarding implementation of BFRT in clinical populations.

CARDIOVASCULAR ADJUSTMENTS TO EXERCISE: ROLE OF THE AUTONOMIC NERVOUS SYSTEM

During exercise, CO increases mainly due to elevations in heart rate (HR) and relatively smaller increases in stroke volume (SV), while systemic vascular resistance (SVR) may either fall (dynamic aerobic exercise) or increase (static/dynamic resistance exercise). This difference reflects whether skeletal muscle vasodilates substantially (as during dynamic aerobic exercise) or whether there is physical compression of blood vessels in the active muscle (as during strong static/dynamic resistance exercises). During aerobic exercise, the rise in CO is greater than the fall in resistance and, as a result, mean arterial pressure is increased, but the response is much larger during intense resistance exercise (39). Indeed, in experienced bodybuilders, intra-arterial measurements have shown increases in systolic blood pressure in excess of 300 mmHg during high-intensity dynamic contractions Studies with clinical populations and with submaximal resistance exercise intensities have shown more modest increases in BP In parallel to the rise in CO there is a shift in blood flow from inactive vascular beds (e.g., renal and splanchnic) to active (e.g., exercising muscle, heart, and skin). This coordinated hemodynamic response ensures adequate blood flow to all organs and tissues without compromising blood flow and oxygen supply to exercising muscle.

Exercise-induced hemodynamic responses are determined by alterations in the activity of the autonomic nervous system, with increases in sympathetic nerve activity to the heart and vasculature and decreases in cardiac parasympathetic nerve activity. These autonomic adjustments are tightly regulated by the synchronous action of multiple neural mechanisms, including central command (i.e., a feed-forward mechanism originating in higher brain areas involved in volition and effort sensation) the arterial baroreflex (i.e., a negative feedback reflex stimulated by stretch receptors within the carotid sinuses and aortic arch, sensitive to changes in pulsatile blood pressure) and the exercise pressor reflex The exercise pressor reflex (composed of the muscle metaboreflex and muscle mechanoreflex) originates in the contracting skeletal muscle and is triggered by the activation of thinly myelinated (group III) and unmyelinated (group IV) afferent nerve fibers. Group III afferents are mainly stimulated by mechanical stimuli (i.e., mechanoreceptors), whereas group IV afferents are mainly sensitive to changes in the chemical milieu in the interstitial space of skeletal muscle (i.e., metaboreceptors), secondary to the production of exercise metabolites. During exercise, descending signals from higher brain areas and afferent signals from baroreceptors and the exercise pressor reflex are integrated within specific areas of the brain stem and, as output, efferent signals carried by parasympathetic and sympathetic nerve fibers produce the abovementioned cardiovascular adjustments to exercise

Muscle Metaboreflex

As a component of the exercise pressor reflex, the muscle metaboreflex exerts an important role in regulating the cardiovascular response to exercise. Ischemia-induced metabolites produced during moderate- to high-intensity exercise (e.g., proton, lactate, ATP) stimulate metabolically sensitive afferent nerve receptors in the muscle interstitium [e.g., acid-sensing ion channels (ASIC), purinergic receptors (P2X), and transient receptor potential cation channels of the vanilloid type 1 (TRPV1)] [17,18], which relay information to the central nervous system to produce increases in blood flow to the working muscle (15). However, while optimal activation of the metaboreflex is paramount for regulating muscle blood flow during exercise, an augmented and sustained activation of this reflex might evoke abnormal cardiovascular responses, which could be a matter of concern in populations with increased cardiovascular risks.

IV. CONCLUSION

BFRT is a mode of resistance exercise training that has recently gained popularity due to its proved effectiveness in promoting increases in muscle strength, mass, and functionality. The capacity to generate clinically relevant neuromuscular gains with relatively reduced workloads has made BFRT a highly attractive mode of exercise to populations with functional incapacity and/or with certain chronic diseases. Indeed, recent guidelines have suggested that this mode of training might be a viable alternative to HI in patients with chronic diseases and/or during postsurgery rehabilitation. Despite the desirable effects promoted by this type of training on skeletal muscle function, the present review synthesizes evidence supporting the hypothesis that BFRT may evoke increased BP and other abnormal cardiovascular responses secondary to the augmented and sustained activation of the muscle metaboreflex. Based on the reviewed studies that provided peak BP values during the exercise protocols it is estimated that BFRT exercise might add 5–10 mmHg to the usual BP response during resistance exercise. These increased BP responses might trigger major cardiovascular events in populations with increased cardiovascular risks. These potential adverse outcomes do not support the general claims about safety of BFRT for populations with chronic diseases or under cardiac rehabilitation.[19]

It is important to underscore that the present review does not negate the hypothesis that in parallel to potentially increasing acute cardiovascular risks, BFRT might also promote subacute (i.e., reduction of BP hours after exercise) and chronic (i.e., reduction of BP weeks/months after exercise) benefits to the cardiovascular system [19]This acute-chronic paradox has been extensively discussed with other types of exercise (e.g., HI interval training (47)), and this discussion has only been recently initiated for the BFRT. More studies assessing the cardiovascular responses during BFRT in populations with increased cardiovascular risks are necessary to better elucidate the impact of this method of exercise training on the cardiovascular system. For instance, all BFRT studies with subjects with chronic diseases were conducted in women, whereas the studies in young subjects mainly involved men. Sex-based differences in cardiovascular responses have already been reported in metaboreflex studies (141), and this should be further investigated in BFRT studies. In addition, the effects of BFRT on intra- and extracranial circulation, coronary blood flow, and muscle sympathetic nerve activity remain to be characterized.

It is also likely that some aspects of BFRT prescription (e.g., using continuous vs. intermittent blood flow restriction protocols, types of exercise) might improve the benefits and reduce the risks of this mode of exercise. For instance, reduced BP responses during BFRT have been reported when lower AOPs (e.g., 40 vs. 80%) are employed (168). It is worth considering that, besides promoting lower circulatory arrest, the use of lower AOPs might also generate lower pain/discomfort levels (25), which per se might alleviate BP responses during BFRT (162). The metaboreflex literature also indicates lower cardiovascular responses when exercising with small vs. larger muscle masses (37, 39), and this may also occur in BFRT. Further investigation on the effects of different combinations of BFRT variables (e.g., cuff pressure and width, occlusion protocol, exercise intensity, and number of repetitions) on hemodynamic responses are necessary to better characterize the isolated effects of each of these variables on cardiovascular function during BFRT.

Even with further clarification, it should be emphasized that some training recommendations may not be practical in the real world. For instance, a recent review has recommended that cuff pressure should be established according to cuff width and based on previous measurements of AOP (i.e., from 40 to 80% of AOP) (118). However, despite our agreement with this recommendation, the use of tourniquets instead of BP cuffs, the occasional unavailability of Doppler ultrasound to personalize AOP, and absence of trained professionals may hamper this standardization. For instance, Patterson et al. (117) conducted a survey among BFRT practitioners and verified that only 11.5% of them based the cuff pressure according to the AOP, with the vast majority using previously defined cuff pressures. It should also be highlighted the challenges associated with accurately assessing BP responses during resistance exercise as the auscultatory method underestimate the peak BP during resistance exercise by 30–35% (168). More accurate methods require the use of expensive noninvasive devices (45) or arterial catheterization (50, 84, 168), making it impractical in the real world.

Finally, although some recent clinical trials with patients with heart (62) and kidney disease (10) or elderly subjects have not shown adverse cardiovascular effects during BFRT, long-term and powered prospective clinical trials in cardiovascular disease patients, directly targeting cardiovascular outcomes and including a detailed report of adverse effects, must also be conducted to identify potentially overlooked cardiovascular side effects associated with this type of exercise training. The safety profile of BFRT in a cardiovascular-related clinical setting can only come from a comprehensive investigation of the cardiovascular responses to BFRT in different disease populations (e.g., patients in cardiac rehabilitation, coronary artery disease patients, HF, HTN, PAD, inflammatory diseases, etc.). Inasmuch as these data are virtually nonexistent, it may be considered clinical malpractice to employ BFRT in a cardiovascular-related clinical setting without performing the appropriate risk assessment.[20]

REFERENCES

1. Lambert, B.S., et al., Blood Flow Restriction Therapy for Stimulating Skeletal Muscle Growth: Practical Considerations for Maximizing Recovery in Clinical Rehabilitation Settings. Techniques in Orthopaedics, 2018. 33(2): p. 89-97.
2. Jessee, M.B., et al., Mechanisms of blood flow restriction: the new testament. Techniques in Orthopaedics, 2018. 33(2): p. 72-79.
3. Bond, C.W., et al., Blood Flow Restriction Resistance Exercise as a Rehabilitation Modality Following Orthopaedic Surgery: A Review of Venous Thromboembolism Risk. journal of orthopaedic & sports physical therapy, 2019. 49(1): p. 17-27.
4. DePhillipo, N.N., et al., The role of blood flow restriction therapy following knee surgery: Expert opinion. Arthroscopy: The Journal of Arthroscopic & Related Surgery, 2018. 34(8): p. 2506-2510.
5. Hughes, L., et al., Comparison of the acute perceptual and blood pressure response to heavy load and light load blood flow restriction resistance exercise in anterior cruciate ligament reconstruction patients and non-injured populations. Physical Therapy in Sport, 2018. 33: p. 54-61.
6. Hughes, L., et al., Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis. Br J Sports Med, 2017. 51(13): p. 1003-1011.
7. Hughes, L., et al., Examination of the comfort and pain experienced with blood flow restriction training during post-surgery rehabilitation of anterior cruciate ligament reconstruction patients: A UK National Health Service trial. Physical Therapy in Sport, 2019. 39: p. 90-98.
8. Hughes, L., et al., Comparing the Effectiveness of Blood Flow Restriction and Traditional Heavy Load Resistance Training in the Post-Surgery Rehabilitation of Anterior Cruciate Ligament Reconstruction Patients: A UK National Health Service Randomised Controlled Trial. Sports Medicine, 2019. 49(11): p. 1787-1805.
9. Hughes, L., et al., Blood flow restriction training in rehabilitation following anterior cruciate ligament reconstructive surgery: A review. Techniques in Orthopaedics, 2018. 33(2): p. 106-113.
10. Ohta, H., et al., Low-load resistance muscular training with moderate restriction of blood flow after anterior cruciate ligament reconstruction. Acta Orthopaedica Scandinavica, 2003. 74(1): p. 62-68.
11. Patterson, S.D., L. Hughes, and J. Owens, Early Postoperative Role of Blood Flow Restriction Therapy to Avoid Muscle Atrophy, in Return to Sport after ACL Reconstruction and Other Knee Operations. 2019, Springer. p. 261-274.
12. Takarada, Y., H. Takazawa, and N. Ishii, Applications of vascular occlusion diminish disuse atrophy of knee extensor muscles. Medicine & Science in Sports & Exercise, 2000. 32(12): p. 2035-2039.
13. Tennent, D.J., et al., Blood flow restriction training after knee arthroscopy: a randomized controlled pilot study. Clinical Journal of Sport Medicine, 2017. 27(3): p. 245-252.
14. Yow, B.G., et al., Blood flow restriction training after Achilles tendon rupture. The Journal of Foot and Ankle Surgery, 2018. 57(3): p. 635-638.

15. Bryk, F.F., et al., Exercises with partial vascular occlusion in patients with knee osteoarthritis: a randomized clinical trial. Knee Surgery, Sports Traumatology, Arthroscopy, 2016. 24(5): p. 1580-1586.

16. Giles, L., et al., Quadriceps strengthening with and without blood flow restriction in the treatment of patellofemoral pain: a double-blind randomised trial. British journal of sports medicine, 2017. 51(23): p. 1688-1694.

17. Korakakis, V., R. Whiteley, and K. Epameinontidis, Blood Flow Restriction induces hypoalgesia in recreationally active adult male anterior knee pain patients allowing therapeutic exercise loading. Physical Therapy in Sport, 2018. 32: p. 235-243.

18. Korakakis, V., R. Whiteley, and G. Giakas, Low load resistance training with blood flow restriction decreases anterior knee pain more than resistance training alone. A pilot randomised controlled trial. Physical Therapy in Sport, 2018. 34: p. 121-128.

19. Hackney, K.J., et al., The role of blood flow restriction training to mitigate sarcopenia, dynapenia, and enhance clinical recovery. Techniques in Orthopaedics, 2018. 33(2): p. 98-105.

20. Abe, T., et al., Effects of low-intensity walk training with restricted leg blood flow on muscle strength and aerobic capacity in older adults. Journal of geriatric physical therapy, 2010. 33(1): p. 34-40.

IJARASEM

INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

निस्केयर
NISCAIR

International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)

| Mobile No: +91-9940572462 | Whatsapp: +91-9940572462 | ijarasem@gmail.com |

www.ijarasem.com