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# Blood Flow Restriction Training

**Daniel S. Lorenz, DPT, PT, ATC, CSCS*; Lane Bailey, PhD†;
Kevin E. Wilk, DPT, PT‡; Robert E. Mangine, MEd, PT, ATC§;
Paul Head, MSc, MCSP, HCPC||; Terry L. Grindstaff, PhD, PT, ATC, SCS¶;
Scot Morrison, DPT#**

*Lawrence Memorial Hospital–OrthoKansas; †Memorial Hermann Health System, Houston, TX; ‡Champion Sports Medicine, Birmingham, AL; §University of Cincinnati; OH; ||St Mary's University, Twickenham, London, UK; ¶Creighton University, Omaha, NE; #Physio Praxis, Vancouver, WA

Muscle weakness and atrophy are common impairments after musculoskeletal injury. Blood flow restriction (BFR) training offers the ability to mitigate weakness and atrophy without overloading healing tissues. It appears to be a safe and effective approach to therapeutic exercise in sports medicine environments. This approach requires consideration of a wide range of factors, and the purpose of our article is to provide insights into proposed mechanisms of effectiveness, safety considerations, application guidelines, and clinical recommendations for BFR training after musculoskeletal injury. Whereas training with higher loads produces the most substantial increases in strength and hypertrophy, BFR training appears to be a reasonable option for bridging earlier phases of rehabilitation when higher loads may not be tolerated by the patient and later stages that are consistent with return to sport.

***Key Words:*** clinical rehabilitation, hypertrophy, occlusion training, resistance training

**Key Points**

- Blood flow restriction training can be used to augment strength and hypertrophy gains during the early phases of rehabilitation, when higher loads may not be tolerated by the patient.
- The risk for injury or an adverse event from this training is thought to be consistent with traditional exercise models, provided that clinicians use appropriate training specifications.
- Evidence suggests that blood flow restriction training can improve function and pain outcomes beyond traditional resistance training in individuals with joint injuries.

Muscle weakness and atrophy are common impairments addressed in sports medicine after musculoskeletal injury and surgery. A common example occurs after anterior cruciate ligament reconstruction as deficits in quadriceps strength can persist for years despite rehabilitation.[1] Efforts to mitigate weakness should start early in the rehabilitation process. The development of both strength and hypertrophy depends on progressive tensile loading of the muscle, typically modified in the clinic via the amount of weight lifted (ie, external load) and the number of sets and repetitions performed.[2] Resistance training guidelines for enhancing strength advise the use of higher loads (>60% 1-repetition maximum [1-RM]; 8–12 repetitions).[2] However, training at this intensity immediately after injury or surgery may adversely stress damaged and healing tissues (eg, cartilage, ligament, tendon, muscle). The use of lower loads, with repetitions to failure, can minimize excessive stress on healing tissues but has less ability to increase strength than training with heavier loads does.[3] It is critical to use clinical strategies that better transition from lower-load exercises performed in the early stages of injury rehabilitation to higher-load exercises consistent with training for athletic performance.

Given the substantial evidence for persistent strength deficits, clinicians should consider all available methods to address weakness. The use of blood flow restriction (BFR) training to enhance strength gains in healthy individuals, as well as those with injuries, has garnered considerable interest in the past 15 years.[4,5] This method is synonymous with terms such as *Kaatsu* (Kaatsu Global, Inc), *occlusion training*, and *hypoxic training*. It uses a strap or pneumatic cuff to partially restrict arterial blood inflow while occluding venous outflow until the cuff pressure is released. Training loads are usually lower (20%–30% of 1-RM; 15–30 repetitions per set), which offers the sports medicine professional a method of mitigating weakness and atrophy after musculoskeletal injury or surgery without overloading healing tissues.

The authors[4,5] of previous systematic reviews demonstrated mixed efficacy for BFR in clinical populations. The use of low-load BFR training typically results in more positive adaptations (eg, increased strength or muscle cross-sectional area) than work-matched low-load resistance training does,[4,5] but the outcomes were mixed when compared with higher-load resistance training.[6,7] These results are generally consistent in healthy populations.[3,8] When using BFR in a clinical environment, the provider must consider a wide range of factors. These include the injury, the patient's medical history, the time since injury or surgery, cuff selection, arterial occlusion pressure (ie, limb occlusion pressure), exercise specifications (sets, repetitions, load), and the length of time BFR is applied. Because of mixed outcomes in clinical populations[4,5] and little consensus regarding treatment protocols,[9,10] clinicians may not be confident using this treatment approach. Therefore, the purpose of our article is to provide the sports medicine practitioner with information regarding the practical application of BFR in clinical settings after musculoskeletal injury. Specifically, we will discuss proposed mechanisms of effectiveness, safety considerations, application guidelines, and clinical recommendations. The strength of evidence supporting each clinical recommendation was graded using the Strength of Recommendation (SOR) Taxonomy.[11]

## PROPOSED MECHANISMS OF EFFECTIVENESS

Muscular adaptations from exercise are due to the combined effect of mechanical tension, muscle damage, and metabolic stress.[12] A variety of physiological mechanisms are thought to cause the increased muscular size and strength seen with BFR training, although the exact mechanisms remain unknown. The general consensus suggests that muscular changes occur through the indirect effect of metabolite accumulation and the hypoxic environment, which result from greater muscular activation, fatigue, and anabolic signaling than the same intensity of exercise done without BFR.[13–15] Muscle hypertrophy occurs when a positive protein balance is achieved in the intracellular environment from increased muscle protein synthesis or decreased muscle protein breakdown.[12] The opposite is seen with muscle atrophy, which reflects an increased rate of muscle protein breakdown.[16] When not combined with exercise, BFR produces some acute increases in muscle thickness, along with a comparable reduction in plasma volume, but pairing BFR with exercise appears to be necessary for muscle protein synthesis rates to increase at a more rapid pace than in load-matched control individuals without restriction.[13]

The role played by metabolites pooling within the working muscle is not well understood. Some researchers have attributed the muscular adaptations observed with BFR to pooled metabolites, but this claim has been strongly debated.[13] Other suggestions were that the increased accumulation of metabolites (lactate and hydrogen ions) and decreased intramuscular pH seen during BFR training stimulates group III and IV afferent fibers, thereby causing earlier neuromuscular fatigue than seen in non-BFR exercise at the same load. [13–15] Taken together, group III and IV muscle afferents play a substantial role in exercise capacity and susceptibility to fatigue.[17] Impairment of the force-generating capacity of a muscle after activity is defined as *muscle fatigue*.[15] It may be that this increase in fatigue causes higher-threshold motor units to be recruited earlier in the exercise set to maintain the required muscle force output in order to complete the prescribed number of repetitions. This would result in a hypertrophic stimulus for a greater proportion of muscle fibers during BFR training than during an equivalent exercise done without BFR.[5]

The hypoxic environment associated with BFR may also induce fatigue and promote anabolic signaling within the muscle.[13–15] Oxygen availability to the muscle is severely reduced during BFR training,[18] contributing to increased fatigue and decreased force production, which may be compensated for by the progressive recruitment of additional motor units.[9] Furthermore, increased production of reactive oxygen species such as nitric oxide results from fluctuations in oxygen availability which, in turn, can stimulate muscle growth by activating muscle satellite cells.[14] The increase in metabolites also contributes to an increase in growth hormone and promotes an inflammatory response, which increases production of myokines (such as interleukin 6), thus activating muscle satellite cells.[13–15] This hypoxic environment is purported to stimulate angiogenesis through the proliferation of vascular endothelial growth factor in a manner similar to that seen with conventional resistance training.[13,15]

Overall, limited data support the various proposed mechanisms of BFR training, but strong evidence indicates that it produces clinically significant changes in strength, hypertrophy, and angiogenesis. Although the mechanisms are still being identified, BFR training appears to increase the ability to load high-threshold motor units and elicit relevant adaptations. *SOR: C*

## SAFETY CONSIDERATIONS

The safety of BFR training, especially in a clinical setting, raises concern for side effects and serious complications. Common side effects seen with BFR training include pain or discomfort during exercise, delayed-onset muscle soreness, and cardiac stress (increased heart rate, increased blood pressure, decreased stroke volume), whereas more serious, less common side effects include numbness or nerve injury, bruising or ischemic injury, dizziness or fainting, thrombus formation, muscle damage, and rhabdomyolysis.[9,19] Contraindications for use include a history of or the potential for deep vein thrombosis, blood clotting disorder, poor circulation, hypertension, inadequate lymphatic system, history of endothelial dysfunction, varicose veins, peripheral vascular disease, diabetes, easy bruising, active infection, cancer, renal compromise, pregnancy, and intervention intolerance.[20] No definitive postsurgery timeline has been identified regarding when it is safe to begin BFR training, but BFR training has been used as early as 2 to 3 weeks postsurgery.[6,20,21] It should be noted that investigators have not specifically compared adverse event rates between BFR training and traditional resistance training. The risk for injury or an adverse event is thought to be consistent with traditional exercise models, provided that clinicians use appropriate BFR training specifications,[22] training volume progressions (ie, rhabdomyolysis), and cuff or device selection and screen patients for contraindications. *SOR: C*

### Risk of Blood Clot

Whereas the formation of a blood clot is possible due to external pressure and vascular occlusion, a study[22] of blood markers associated with coagulation (eg, D-dimer, C-reactive protein, prothrombin fragment) did not demonstrate changes in these values beyond those equivalent to exercise and indicated that BFR therapy may actually help to reduce the risk of deep vein thrombosis. Blood flow restriction therapy has been used for a variety of musculoskeletal injuries, including postoperative patients (as early as 2–3 weeks after surgery), and no serious adverse events were reported in participants who met the study inclusion criteria (ie, no contraindications for resistance training exercise or BFR training).[6,20,21,23] *SOR: B*

### Certifications and Use of Food and Drug Administration–Approved Devices

Clinicians should be familiar with the safety and effectiveness of any intervention, and this knowledge may come from entry-level training or continuing education. Unfortunately, continuing education courses and marketing can be substantially influenced by financial conflicts of interest, creating greater confusion regarding device selection, training, and safety. Although some entities offer opportunities for BFR certification, it is not specifically required. Medical device manufactures must provide directions for safe and effective use and ensure that the end user is adequately trained, but leeway exists regarding appropriate training (ranging from an instruction manual to intensive in-person training). It is also the responsibility of the clinician to be familiar with the mechanisms, precautions and contraindications, target populations, and associated risks. Regarding the use of US Food and Drug Administration (FDA)–approved devices, a pneumatic tourniquet is considered a class I device (low risk) and intended to reduce or totally occlude circulation during surgery (https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=878.5910). The FDA has exempted almost all class I devices (510K exemption), indicating that the devices only need to be listed with the FDA because they have already been approved. At this time, no BFR device is FDA approved for use in an exercise or rehabilitation setting, but clinicians should strongly consider using BFR training devices that are listed with the FDA. Decisions regarding certification or device selection should be discussed by clinical and administrative stakeholders and informed by administrative policies, malpractice insurance carriers, or specific state practice acts.

## APPLICATION GUIDELINES

Safe and effective BFR application requires the provider to assess various elements of the treatment process and device, including but not limited to cuff width and placement, cuff pressure, and device selection.

### Cuff Design and Implications

The BFR training devices represent an evolution of surgical tourniquets, but the latter are applied at much higher pressures and for longer periods of time with continuous monitoring of the patient. Research[24] on surgical tourniquets has shown that a narrower cuff requires a higher level of pressure to achieve arterial occlusion and that neurologic injury most often occurs at the edge of the tourniquet, where the pressure gradient is highest. Two groups[25,26] have examined the effect of a wide versus a narrow cuff for BFR training. When the same arterial occlusion pressure was used, the percentage of blood flow occluded did not change on the basis of cuff width (5 versus 10 versus 12 cm)[26] and resulted in similar increases in strength and muscle size.[25] These findings suggested that a wider cuff could achieve arterial occlusion for BFR training at a lower pressure than a narrower cuff and was preferred for patient safety. As BFR training has evolved, manufacturers have added contoured cuff designs and automated versus manual control of pressure. Although anecdotal evidence may indicate increased comfort and support manufacturer suggestions regarding the superiority of automated systems, studies have not demonstrated differences in safety, efficacy, effectiveness, or comfort. *SOR: C*

### Cuff Placement

The standard recommendation for cuff placement is the most proximal location of the exercising limb, regardless of the targeted muscle group (Figure 1).[9] This location allows occlusion to occur in the majority of the muscle belly being worked (eg, quadriceps) without affecting normal joint excursions. The more proximal cuff placement also minimizes the potential for damage to the superficial nerves, which are more common in the distal extremities (eg, superficial fibular nerve). A barrier, such as a limb protection sleeve, should be placed on the limb before cuff application to minimize the risk of pinching, friction burns, or blisters. *SOR: C*

### Cuff Pressure

To partially restrict arterial blood inflow while occluding venous outflow, BFR therapy uses a strap or pneumatic cuff. *Arterial occlusion pressure* (ie, limb occlusion pressure) is the pressure needed to completely occlude arterial blood flow and serves as an upper limit reference point for training and patient safety. The 5 most common methods for determining cuff pressure are arbitrary pressure selection (eg, 150–200 mm Hg), a percentage of systolic blood pressure (eg, 130% systolic), limb circumference, an intensity scale of tightness, or a percentage of arterial occlusion pressure.[19,26–28] It is not clear whether one approach lends itself to outcomes superior to the others or enhances safety.[29,30] Reproducibility and safety are the 2 main concerns when selecting pressure, in particular with respect to whether arterial flow is completely occluded. To understand how to safely apply BFR, it is important to consider the various factors that affect arterial occlusion pressure. Fixed factors such as systolic blood pressure, diastolic blood pressure, limb circumference, sex, and race have all been shown to affect arterial occlusion pressure.[31] Modifiable factors such as body position and cuff width also affect occlusion pressure.[32,33] We recommend basing the pressure selection on a percentage of arterial occlusion pressure to best standardize the pressure used for each patient, regardless of limb or cuff size. In addition, we advise clinicians to determine arterial occlusion pressure in the same position in which the exercise is performed because body position can affect occlusion pressure.[32,33] Whereas this approach may provide a more precise dosage pressure, it remains to be seen whether this approach improves outcomes or better addresses safety concerns[32,33] or whether personalized pressures fall within arbitrary ranges (eg, 150–200 mm Hg). Arterial occlusion pressure

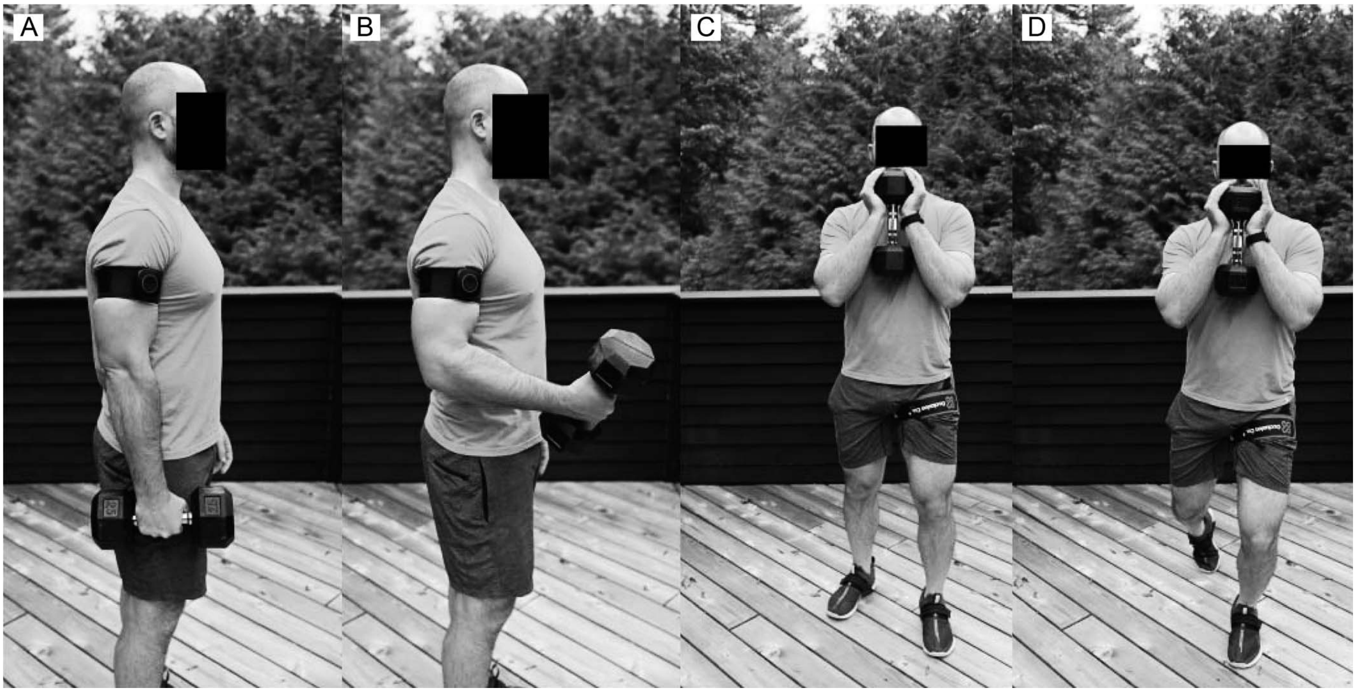

**Figure 1. Cuff placement: A and B, upper extremity. C and D, lower extremity. The cuff should be placed proximally on the limb, which allows occlusion to occur in the majority of the muscle without interfering with movement.**

can be identified in a variety of ways, including an automated, higher cost, personalized tourniquet system or a manual method using a handheld Doppler ultrasound unit (Figure 2) or pulse oximeter, both of which are lower-cost methods with acceptable reliability.[34–36] Whether automated personalized tourniquet systems increase safety or effectiveness more than Doppler ultrasound or a pulse oximeter is unclear.

In general, 40%–80% of arterial occlusion pressure is suggested as the range with the greatest likelihood of achieving training goals while minimizing the risk for potential complications.[9,29] The pressure used also depends

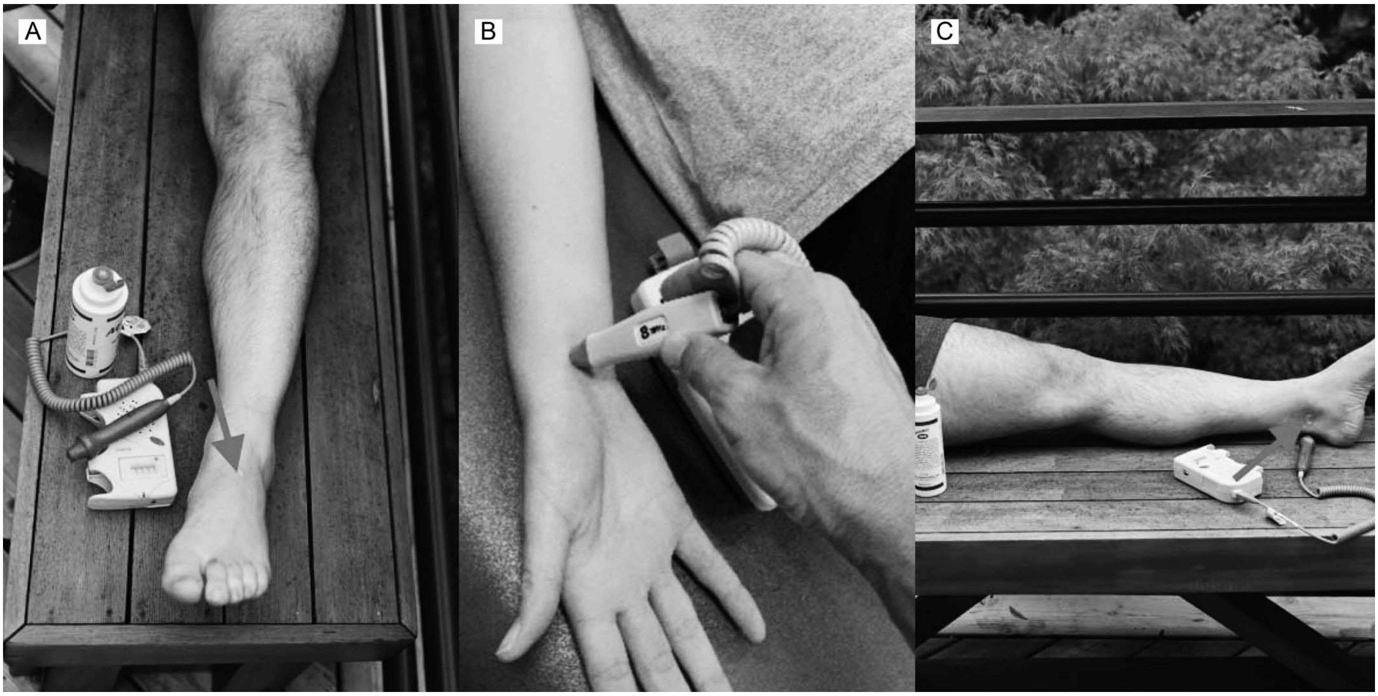

**Figure 2. Determining arterial occlusion pressure using a pulse oximeter or A, a handheld Doppler ultrasound. A pulse oximeter can be placed on a finger. The Doppler ultrasound is placed on a distal artery: B, upper extremity, radial artery; C, lower extremity, dorsalis pedis. Once the pulse has been identified, the cuff is slowly inflated (eg, start at 50 mm Hg and increase by 10-mm Hg increments every 10 seconds) to the point at which full occlusion occurs (ie, pulse is absent).**

on limb size, with larger limbs usually being trained at a higher relative pressure (closer to 80%) than smaller limbs (closer to 40%–50%). Higher pressures are usually associated with greater levels of discomfort and perceived exertion,[37,38] but lower pressures may require a higher relative load to achieve the desired results at the same volume.[39–41] Thus, clinicians should use a pressure that minimizes discomfort but allows training at a lower load to minimize stress on healing tissues.[38]

Although selecting pressure based on arterial occlusion pressure is suggested, not all clinical settings may have this capacity and patients may perform training outside of clinical settings with personal devices. When arterial occlusion pressure cannot be established, the rehabilitation professional should, at a minimum, ensure that arterial occlusion has not occurred by manually palpating the pulse (eg, posterior tibial artery, dorsalis pedis artery, or radial artery). Pressure ranges used in the clinic (eg, 40%–80% of arterial occlusion pressure), benchmarked against known arterial occlusion pressures, can be recommended when performing BFR training as part of a home exercise program. When pressure is not specifically regulated by the device (ie, weight-lifting knee wraps), a rating of perceived pressure of 7 out of 10 or less (on a numeric pain rating scale) can be used.[28] Regardless of the approach, distal pulses should be palpated to ensure that wrap pressure or an individual's perception of perceived tightness does not exceed arterial occlusion pressure. This method provided equivalent training results[29] but should be approached with a level of caution because actual arterial occlusion pressure will not be established. Whether patient outcomes vary based on arbitrary pressure selection or individualized cuff pressure[29,30] when using established methods is unknown.[19,26–28] *SOR: C*

### Device Selection

A wide variety of cuffs or devices are available in the market and have either static or dynamic pressure controls. Clinicians can make a decision on the basis of the preceding advice regarding cuff width and the ability to measure arterial occlusion pressure and automatically adjust cuff pressure. Broadly, BFR cuff systems fall into 2 categories: static cuff (standard sphygmomanometer) or dynamic cuff (pneumatically regulated system). Although each approach has proposed advantages and disadvantages for the implementation of pressure control during exercise, current evidence suggests their clinical outcomes are not different.[5] Whereas pressure in a static cuff is initially set to a specific amount, the actual pressure may vary during exercise due to limb movement and muscle contraction under the cuff. A dynamic cuff can maintain a specified pressure through a sensor and pneumatic pump but regulates pressure on the basis of fluctuations in cuff pressure, which may differ from changes in arterial pressure or the percentage of occlusion, especially during dynamic movement. It should be noted that authors have not specifically investigated arterial pressures (in vivo) during exercise, so the validity of this suggestion is unknown. Other factors such as cost, quality, ease of use, and ability to clean should also be considered. Whether the rate of adverse events or patient outcomes varies on the basis of cuff or device selection is uncertain. *SOR: C*

## CLINICAL GUIDELINES

### Strength and Hypertrophy

The sports medicine professional prescribes exercise to those who are injured or postsurgery while taking into account tissue healing processes, recognizing that in the early rehabilitation phases, it may not be possible to use the higher loads (>60% of 1-RM) typically applied to elicit changes in strength and hypertrophy.[2,4] This is why options such as BFR, which may offer an alternative to traditional approaches, have generated so much interest and are finding a place in the practice of sports medicine.[5–7] It is important to note that the effects of BFR training on adaptations vary. For instance, hypertrophy will likely be similar to that seen with traditional progressive resistance exercise, yet changes in strength may be less than those achievable with traditional progressive resistance exercise.[40] Current evidence[3] suggested that when effort was matched, changes in hypertrophy seemed to be equivalent across loads, regardless of the methods used. A recent meta-analysis[40] demonstrated no comparable difference in muscle mass (ie, hypertrophy) between high-load resistance training (>65% of 1-RM) and low-load BFR training (20%–50% of 1-RM). Hypertrophic changes may occur at a more rapid rate during BFR training than traditional training, but these effects could be due in part to local cell swelling as well as the ability to train at a higher frequency.[9]

In contrast to hypertrophy, these same researchers[40] found that strength adaptations seemed to favor high-load resistance training, regardless of the cuff size, absolute occlusion pressure, or method of measuring this pressure. Although this result has been questioned by a follow-up review[42] that involved different inclusion criteria, the overall body of evidence still seems to support the use of high-load resistance training when strength is the primary goal. As such, when absolute strength is desired, heavier loads are ideal; however, when these loads are contraindicated, BFR can be used instead to improve strength with lower loads. For hypertrophy, however, BFR will yield results equivalent to any other approach, which offers the clinician a way to strategically achieve these results with a reduced volume load and less stress on healing tissues.[15,29,40,43,44] *SOR: C*

When applying low-load BFR training in the clinic, it may be possible to address both strength and hypertrophy with the same treatment protocol (Table). The number of sets and repetitions differed across studies; the most common prescription was either 3–5 sets to failure or 30 initial repetitions followed by 3 sets of 15 repetitions with approximately 30 seconds of rest between sets.[9,29,40] Because the results do not vary much between these approaches, we suggest a clinical approach of 2–3 sets to failure, with an additional 1–2 sets if more volume is desired. This approach is suggested due to its ease of implementation and clinical applicability. A minimum intensity has been proposed as necessary to stimulate hypertrophy with traditional resistance training models, but precise values have yet to be determined.[44,45] In general, loads lower than 40% of 1-RM are used for BFR exercises.[9,40] However, because some mechanical tension is required to elicit an adaption, these loads should not drop below a threshold of 20% of 1-RM.[41,44] In a practical sense,

**Table. Strength and Hypertrophy Blood Flow Restriction Training Prescription Guidelines**[4,5,9,55]

| Cuff Placement | Applied Proximally on Working Limb(s) |
|---|---|
| Occlusion pressure | 40%–80% arterial occlusion pressure using lower pressures with smaller limbs or for comfort<br>Arterial occlusion pressure identified via Doppler ultrasound (eg, dorsalis pedis, tibial, or radial) or pulse oximetry |
| Total occlusion time | <10 min total between periods of reperfusion |
| Load (as % of RM) | 20%–40% of 1-repetition maximum |
| Sets | Minimum of 2–3 sets and ≤5 sets total per exercise |
| Repetitions | 45–75 repetitions per exercise (1–2-s concentric:eccentric movements per repetition), with the lower end assuming 1–2 sets are completed to failure; more than 75 repetitions per exercise appears to be unnecessary and fewer may be sufficient, especially if sets are taken to failure |
| Effort level | Either concentric failure or approaching fatigue as determined by a significant drop in execution velocity or use of compensatory strategies |
| Rest period | 30–60 s between sets |
| Frequency | 2–3 times weekly for approximately 4–6 wk<br>Can also be done 1–2 times daily for brief (<3-wk) periods |
| Exercise selection | To ensure stress is applied to specific muscles and maximize motor-unit recruitment, use isolated, single-limb approaches when possible<br>Bilateral, multijoint exercises can be used to maximize training program efficiency given that more muscles will be used in the same amount of time but may reduce efficacy and stress shield the target tissue. |

these percentages are not easily calculated because a maximum strength test may be contraindicated or not performed immediately after injury or surgery to minimize the potential for tissue damage. The 1-RM can be estimated by obtaining a 1-RM on the uninvolved limb or selecting a load that allows at least 20 repetitions but no more than 40 to 50 repetitions to be performed during the first set.[43,46] Subsequent sets can approach or be to failure, with a total of 75 repetitions per exercise likely being sufficient.[9,43,46] This also ensures that the lower-volume benefits that BFR offers in comparison with low-load training to failure are realized. Short rest intervals allow for metabolite accumulation and contribute to the hypoxia that is achieved during exercise, and BFR training increases metabolic stress more than low-intensity exercise does.[47] Maintaining pressure during the rest period enhances metabolic stresses and inflating the cuff 5 minutes before exercise can further increase metabolic stress.[48] *SOR: C*

## Pain and Function

Whereas strength and hypertrophy are often clinical goals to address impairments and improve function, these outcomes often do not reflect patient-oriented evidence. The use of BFR training (6–12 weeks) resulted in greater improvements in function (eg, Short Form–36 scores, International Knee Documentation Committee subjective scores, timed-up-and-go test) and dynamic balance and decreased pain than traditional high-load resistance training alone in individuals with arthritic conditions or anterior cruciate ligament reconstruction.[6,7,20] Decreased pain also occurred in individuals with patellofemoral or anterior knee pain[49,50] as well as patellar tendinopathy.[51] Most studies focused on physiological outcomes such as hypertrophy, strength, and reduced atrophy,[52] yet emerging evidence indicates that BFR can improve outcomes related to function and pain. *SOR: B*

## Aerobic Conditioning and Exercise

Blood flow restriction training is a viable option for eliciting improvements in both aerobic conditioning and hypertrophy when used with walking or cycling.[8,53,54] Much like BFR when used for strength and hypertrophy, expected gains can be realized in as little as 2 to 3 weeks.[53,54] For aerobic exercise, BFR can be implemented in the sports medicine setting in a number of ways. It can be used to enhance a warmup and cooldown session, increase the intensity of aerobic exercise, or simply introduce variability into an otherwise mundane workout session. In lieu of resistance training, BFR can be used during walking or cycling to help mitigate any strength and hypertrophy losses, but this has not been specifically investigated in injured individuals. With some minor differences, cuff pressures and widths as well as restriction time are relatively the same for both strength and hypertrophy objectives. The restriction time for resistance training exercise is typically 5 to 10 minutes per exercise with reperfusion between exercises, whereas with aerobic conditioning, it varies between 5 and 20 minutes.[9] Differences in restriction time may be due to the relative intensity of exercise. For resistance exercise, intensity is typically 20% to 40% of 1-RM, whereas intensity for aerobic conditioning is less than 50% of $\dot{V}O_2$max or the heart rate reserve.[9] Frequency is 2 to 3 times per week or 1 to 2 times per day for 1 to 3 weeks.[9] *SOR: C*

## CONCLUSIONS

In summary, BFR training provides the sports medicine professional an alternative method of achieving exercise intensity. Current research strongly supports its inclusion in situations without contraindications, in which the goal is strength and hypertrophy but exercise volume or load is constrained. By judiciously applying BFR training, the clinician can implement a minimum effective dosage at a volume and load that would otherwise be insufficient. In populations in whom occlusion is not contradicted and traditional progressive resistance training is appropriate, BFR training appears to be a safe and effective adjunctive approach to therapeutic exercise in sports medicine environments.

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*Address correspondence to Daniel S. Lorenz, DPT, PT, ATC, CSCS, Lawrence Memorial Hospital–OrthoKansas, 6265 Rock Chalk Drive, Suite 1700, Lawrence, KS 66049. Address email to danielslorenz@gmail.com.*