Blood Flow Restriction Therapy Impact on Musculoskeletal Strength and Mass

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Background: Blood flow restriction (BFR) training restricts arterial inflow and venous outflow from the extremity and can produce gains in muscle strength at low loads. Low-load training reduces joint stress and decreases cardiovascular risk when compared with high-load training, thus making BFR an excellent option for many patients requiring rehabilitation.

Indications: Blood flow restriction has shown clinical benefit in a variety of patient populations including healthy patients as well as those with osteoarthritis, anterior cruciate ligament reconstruction, polymyositis/dermatomyositis, and Achilles tendon rupture.

Technique Description: This video demonstrates BFR training in 3 clinical areas: upper extremity resistance training, lower extremity resistance training, and low-intensity cycling. All applications of BFR first require determination of total occlusion pressure. Upper extremity training requires inflating the tourniquet to 50% of total occlusion pressure, while lower extremity exercises use 80% of total occlusion pressure. Low-load resistance training exercises follow a specific repetition scheme: 30 reps followed by a 30-second rest and then 3 sets of 15 reps with 30-seconds rest between each. During cycle training, 80% total occlusion pressure is used as the patient cycles for 15 minutes without rest.

Results: Augmenting low-load resistance training with BFR increases muscle strength when compared with low-load resistance alone. In addition, low-load BFR has demonstrated an increase in muscle mass greater than low-load training alone and equivalent to high-load training absent BFR. A systematic review determined the safety of low-load training with BFR is comparable to traditional high-intensity resistance training. The most common adverse effects include exercise intolerance, discomfort, and dull pain which are also frequent in patients undergoing traditional resistance training. Severe adverse effects including deep vein thrombosis, pulmonary embolism, and rhabdomyolysis are exceedingly rare, less than 0.006% according to a national survey. Patients undergoing BFR rehabilitation experience less perceived exertion and demonstrate decreased pain scores compared with high-load resistance training.

Conclusion: Blood flow restriction training is an effective alternative to high-load resistance training for patients requiring musculoskeletal rehabilitation for multiple disease processes as well as in the perioperative setting. Blood flow restriction has been shown to be a safe training modality when managed by properly trained physical therapists and athletic trainers.

Keywords: blood flow restriction; rehabilitation; resistance training; physical therapy

VIDEO TRANSCRIPT

In this video, we will be reviewing blood flow restriction (BFR) training used for musculoskeletal rehabilitation. We will walkthrough the current use of BFR, discuss the rationale and indications, and perform demonstrations of 3 techniques: upper extremity resistance training, lower extremity resistance training, and low-intensity cycle training.

There are no relevant disclosures.

Blood flow restriction training is an increasingly popular intervention to facilitate musculoskeletal rehabilitation in a variety of patient populations.[1,2,7]

During this technique, a blood pressure cuff is inflated to reduce arterial and venous blood flow to the injured extremity while the patient performs low-load resistance exercises.[1,2]

Systematic reviews and randomized controlled trials have shown significant increase in muscle strength and size when low-load resistance training is augmented with BFR.[2,6,10]

Although the specific mechanism is incompletely understood, BFR training establishes both metabolic stress and mechanical tension—the 2 primary hypertrophy factors required to induce muscle growth.

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BFR training allows patients to gain muscle mass and strength at low loads, thus reducing joint stress and cardiovascular risk, making it an excellent option for many patients requiring rehabilitation.[1,2]

BFR has been effective in a variety of patient populations, including healthy individuals and those with osteoarthritis, anterior cruciate ligament reconstruction, polymyositis or dermatomyositis, and Achilles tendon rupture.[1,2,7] Within the field of sports medicine, BFR is indicated for any athlete who is unable to perform high-load resistance training, such as those with acute injury and postoperative patients.

There are multiple BFR systems and training regimens which have shown safety and efficacy in musculoskeletal rehabilitation. To date, no studies have been conducted comparing the various devices or training protocols. We will demonstrate the Owens Recovery Science method using the Delfi Personal Tourniquet System which is used by Northwestern University athletic trainers with our student athletes.[9] The following are the steps taken before undertaking BFR training of any extremity. The cuff is placed proximal to the area requiring rehabilitation.[9] It is then inflated to determine the total occlusion pressure for the individual patient.[9] If performing rehabilitation of the upper extremity, the cuff will be set to 50% of total occlusion pressure during exercise.[9] For the lower extremity, 80% of total occlusion pressure is used.[9]

To begin upper extremity BFR, the cuff should be placed proximally to the humeral head without impeding range of motion. Be sure to provide the patient with a sleeve to avoid skin irritation from the tourniquet. Ensure the patient is supine and remains still and quiet during the calibration measurement.

When performing upper extremity BFR, it is ideal to achieve 50% blood flow occlusion. This unit will calibrate by measuring the pressure at which 100% blood flow occlusion is achieved and will use that number to calculate 50% occlusion.

Once the calibration process is complete, the 50% occlusion pressure will appear on the top of the screen, with 100% occlusion pressure underneath. The unit will be set to 50% blood flow occlusion.

Once the unit is set, the patient can be positioned to begin exercising. The patient can be given weight or resistance that is appropriate for their stage of rehabilitation.

Once in position, the unit can be inflated and the patient can begin exercise.

The sets and repetitions prescription will always follow a 1 set of 30 repetitions followed by 3 sets of 15 repetitions for each individual exercise. Between each set, there will be 30 seconds of rest with the cuff still inflated. Following the last exercise set, a minimum rest time of 1 minute should be taken with the cuff deflated before beginning another exercise.

It is important to note that distal vein engorgement, limb swelling, and cyanosis can be expected when using BFR.

Continue to cue patient on proper form and technique throughout all exercises as they will become fatigued quickly.

A similar setup will be followed for lower extremity BFR as was shown for upper extremity, *with the cuff placed proximally to the hip*. Be careful not to place the cuff too high as this may irritate the groin and/or reduce hip range of motion.

For lower extremity, blood flow occlusion will be set to 80% based on patient calibration. Once set to 80% occlusion, the cuff will be inflated and the patient will begin exercise following the same prescription of 1 set of 30 repetitions and 3 sets of 15 repetitions with 30 seconds of rest between each set. Again a minimum of 1-minute rest should be taken between each exercise with the cuff deflated.

As with upper extremity, expect to see limb engorgement, swelling, and cyanosis.

Continue to coach patient on good form and technique as they will become fatigued quickly.

BFR can also be used with low-intensity cardio exercises such as biking. The same setup is followed for calibration to find 80% of blood flow occlusion relative to the patient. Once calibrated, the patient may be seated on the bike. Once the cuff is inflated, the patient may begin cycling.

With cardio activity, the patient may complete 15 minutes of activity without rest or cuff deflation. The patient should again rest for 1 minute between any additional activities following biking.

As with the previous 2 examples, expect to see limb engorgement, swelling, and cyanosis.

BFR training is a generally safe intervention for patients requiring musculoskeletal rehabilitation.

The most common adverse effects include exercise intolerance, discomfort, and dull pain at the site of injury, all of which are also common during traditional resistance training.[7] Pain scores have actually been shown to be lower with low-load BFR compared with high-intensity resistance training.[3,5]

Severe adverse effects have been described in case reports including deep vein thrombosis (DVT), pulmonary embolism (PE), and rhabdomyolysis.[4,8] A national survey of Japanese providers issuing BFR determined risk of these events to be exceedingly rare, each less than 6 hundredths of a percent (0.055% for DVT, 0.008% for PE, and 0.008% for rhabdomyolysis).[8]

Given the minimal evidence to date regarding adverse effects from BFR, there are currently no absolute contraindications, though conditions which increase risk of blood clots are relative contraindications for performing BFR training. BFR should be discontinued if a patient is unable to tolerate the pain during exercise or if they undergo any of the previously mentioned severe adverse effects.

There are no specific guidelines for return to sport following BFR therapy. BFR training is indicated for any athlete who is unable to perform high-load resistance training. Thus, BFR is an excellent tool to bridge an athlete from the date of surgery or injury to the time when they can perform traditional high-load resistance training.[1,6] While previously mentioned risks exist, there is no evidence to suggest any greater risk of BFR compared with traditional resistance training for the acutely injured or postoperative athlete. Providers should make the clinical determination regarding return to sport on an individual basis as they would for any athlete undergoing rehabilitation.

Low-load BFR training generates increased muscle strength compared with low-load training alone.[2,6] Hughes et al performed a systematic review of 20 studies investigating BFR for clinical rehabilitation.[2] Low-load BFR training had a moderate effect on increasing strength compared with low-load training alone.[2] However, low-load BFR was less effective than heavy load training.[2] Another systematic review comprising 13 studies investigated high-load training versus low-load BFR and found high-load training generated greater increase in muscle strength.[6]

BFR training demonstrates an increase in muscle mass greater than low-load resistance training alone and comparable to that of high-load resistance training.[6,10] Lixandrao et al conducted a systematic review of 13 studies and concluded low-load resistance training with BFR generated comparable gains in muscle mass compared with high-intensity training.[6] A randomized controlled trial in postmenopausal women also found low-load BFR to generate equivalent gains in muscle mass compared with high-load resistance training.[10]

Patient surveys have been used to investigate the effects of BFR training on perceived exertion and pain scores.[3,5] In a randomized controlled trial of healthy young men, patients reported BFR training to have decreased pain scores and decreased perceived exertion compared with traditional high-intensity resistance training.[5] Korakakis et al a randomized controlled trial in 40 men suffering from anterior knee pain.[3] This study demonstrated that low-load BFR training decreased pain scores to a greater extent than did low-load resistance training alone.[3]

Low-load BFR training generates increased muscle strength compared with low-load training alone.[2,6]

Blood flow restriction training demonstrates an increase in muscle mass greater than low-load resistance training alone and comparable to that of high-load resistance training.[2,6,10]

Patient surveys have shown BFR training to have less perceived exertion and decreased pain scores compared with high-intensity resistance training.[3,5]

Further research is required to more precisely determine clinical indications for BFR.

This concludes our video on the use of BFR training for musculoskeletal rehabilitation. Thank you.

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