How blood flow restriction (BFR) can assist therapeutic exercise in patients with chronic ankle instability (CAI).

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Introduction

There is a high prevalence of lateral ankle sprains in sports, which is 7-15% of all athletic injuries.1-2 Chronic ankle instability is caused by a recurrence of lateral ankle sprains, 40% can progress to chronic ankle instability.[1,3] Chronic ankle instability is a mechanical issue in the ankle due to ligament laxity around the ankle mortise and the decreased activation of ankle muscles, i.e. fibularis longus.[3] Blood flow restriction has been shown to increase adaptations from therapeutic exercise, including strength, hypertrophy or prevention of atrophy, and muscle activation.[1-5] Blood flow restriction can increase strength, muscle activation, and cross sectional area in patients using low load (20% of one repetition maximum) (1 RM) resistance.

Focused Clinical Question

Is there evidence to suggest that blood flow restriction (BFR) training improves muscle strength, muscle activation and/or cross-sectional area (CSA) of the lower leg musculature in those with chronic ankle instability (CAI)?

Search Strategy

Terms Used to Guide Search Strategy

- Patient group: *patients with CAI*
- Intervention: *blood flow restriction therapy*
- Comparison: *standard rehabilitation without BFR*
- Outcome: *Increased strength, muscle activation or cross-sectional area.*
- Dates searched October 17th to November 30th
- Search Terms: Blood flow restriction and Chronic ankle instability, BFR and CAI, (other combinations).

Sources of Evidence Searched

- PubMed
- Cochrane Library
- Tripdatabase
- Google Scholar
- Additional links/resources found through review of reference lists and hand searching.

Inclusion Criteria

- Pre and Post BFR intervention measurements used in comparison.
- Articles that are peer-reviewed, randomized controlled trails, systematic reviews.
- Adults ages 18-30
- Available in English language
- Studies limited to the past 10 years (2012-2022).
- Level 2 studies of evidence or higher. (Based on the Oxford Centre for Evidence-Based Medicine 2011 levels of evidence).
- Studies must involve the utilization of blood flow restriction training.
- Studies must involve at least one measurement in the outcomes (strength, CSA, muscle activation via EMG).
- Studies that only involve reoccurring lateral ankle sprains or chronic ankle instability.

Exclusion criteria

(articles containing the following criteria were excluded from the review)

- Studies that did not utilize BFR training.
- Studies that investigated BFR in pathologies of the lower extremity other than the ankle and CAI.

Table 1 Summary of Studies

	Killinger et al. 2018 [1]	*Burkhardt et al.* 2020[2]	*Werasirirat et al.* 2021[3]
Type of paper	Case-control cross-over study	Case-control cross-over study	Randomized Control study
Title	The Effects of Blood Flow Restriction on Muscle Activation and Hypoxia in Individuals With Chronic Ankle Instability.	Effects of Blood Flow Restriction on Muscle Activation During Dynamic Balance Exercises in Individuals With Chronic Ankle Instability	Effect of supervised rehabilitation combined with blood flow restriction training in athletes with chronic ankle instability: a randomized placebo-controlled trial
Participants	19 adults (average age 21.8) History of CAI Score of 11+ on Identification of Functional Ankle Instability	25 adults (average age of 20) History of CAI. Score of 11+ on Identification of Functional Ankle Instability	16 adults (average age 20) Collegiate athletics and no significant differences in characteristics between the two groups at baseline.
Intervention	4 sets (30, 15, 15, and 15) EV and DF exercises, with resistance at 30% of maximum voluntary isometric contraction. Once with BFR and once without BFR. Cuff was set to 80% occlusion.	4 sets (30×15×15 ×15) of reaches in anterior, posteromedial, and posterolateral directions. Y-balance test which is a more functional and dynamic stance that requires single leg balance. Once without the BFR cuff and once with the BFR set to 80% occlusion on the thigh.	Randomly allocated to either a BFR group (BFR+R) or no BFR (R group). Supervised rehabilitation program that was 3x/ week for 4 weeks straight. 30 minutes of therapeutic exercise: SL calf raises, SL squats, SL balance, DL balance, and Y-balance. BFR cuff was set to 80% occlusion.
Inclusion and exclusion criteria	Inclusion: history of CAI, adults ages 18-30, Exclusion: having an acute injury within the last 3 months, surgery, fracture in lower extremity. Diagnosed with diabetes, hypertension, sickle cell, or problems with vascular circulation.	Inclusion: History of multiple ankle sprains resulting in ankle "giving way" 2+ within the last 6 months, history of CAI, Exclusion: ankle injury within the last 3 months, fracture requiring surgery in the lower extremity. Diagnosed with hypertension, clotting disorders, cardiovascular problems, sickle cell, diabetes, and arterial disease.	Inclusion: history of unilateral ankle sprain within 12 months, felling ankle "giving way" during activities in the last 6 months, a Cumberland Ankle Instability Tool (CAIT) score of 24 or more. Exclusion: Bilateral ankle instability, pathological joint instability, ankle fracture, surgery to lower extremity, any musculoskeletal disorders.
Outcome measures	EMG: Activation of the Fibularis longus and Tibialis anterior using surface electrodes. Perceived exertion: OMNI-Resistance Exercise Scale was used to record.	EMG: Electrodes were placed to monitor muscle activation of the vastus lateralis, soleus, tibialis anterior, and fibularis longus. Perceived exertion: OMNI-Resistance Exercise Scale was used to record scores. Perceived posture instability: RPE used to record scores.	Prior to and following the intervention, isokinetic muscle strength (dynamometer), CSA (diagnostic US), Y-balance test, and side hop test (SHT) were measured.
Main findings / Results	Muscle activation of fibularis longus was 5.6% greater ($P = .03$), and 7.7% greater for anterior tibialis ($P = .01$) with BFR compared to without BFR. The ratings of perceived exertion had a significant increased score during BFR ($P < .001$).	Muscle activation of the vastus lateralis ($P < .001$, $d = 0.86$ [0.28 to 1.44]) and soleus ($P = .03$, $d = 0.32$ [–0.24 to 0.87]) was greater during BFR. No significant difference found in tibialis anterior ($P = .33$, $d = 0.09$ [–0.46 to 0.65]) or fibularis longus ($P = .13$, $d = 0.06$ [–0.50 to 0.61]). Increase perceived postural instability ($P = .004$) and exertion ($P < .001$) in the BFR data. This contradicts the Killinger study, but note that the supine isometric exercise vs the functional dynamic balance exercise would require more activation of the soleus and vastus lateralis.	The BFR group had significant increases in muscle strength of ankle plantar flexion and eversion, CSA of fibularis longs ($P < 0.05$), increased peak torque in hip extension, hip abduction, ankle dorsiflexion, ankle plantar flexion, and ankle eversion (all, $P < 0.001$). No significant difference in dynamic balance between either group. (all, $P<0.05$).
Level of evidence	2	2	2
Validity score	CEBM GOR B	CEBM GOR B	CEBM GOR B
PEDro	NA	NA	8/10
Conclusion	There was an increase in muscle activation during the low-load isometric exercises with BFR in patients with CAI. Patients with CAI can benefit from the use of BFR to increase demand for low-load exercises to enhance muscle activation.	Individuals with CAI can use BFR with dynamic balance exercise to increase muscle activation of the vastus lateralis and soleus. BFR used with dynamic balance exercises will increase perceived exertion and perceived postural instability in individuals with CAI.	Participating in a rehabilitation program for 4-weeks using BFR can be more effective in increasing muscle strength, size and functional performance in individuals with CAI than just rehabilitation alone.

Evidence of Quality Assessment

The 3 relevant studies identified are in Table 1, based on the CEBM, PEDro and SORT. Two crossover design studies graded at a CEBM level 2. One RCT graded at a PEDro 8/10.

Results

The three studies included in the table found increase in a muscular outcome of either strength, CSA, or muscle activation. Each study found a significant improvement in muscular outcome using BFR training for CAI.

Clinical Bottom Line

There is moderate evidence to support therapeutic exercise with low-intensity BFR training in patients with CAI. The evidence supports a significant improvement in muscle activation in the fibularis longus, anterior tibialis, vastus lateralis, and soleus with BFR training.[1-2] There is moderate evidence suggesting BFR can induce strength gains in the muscles dependent on the exercise selection.[2-3]

Recommendation

Grade B level of recommendation based from the SORT scale.

References

1. Killinger B, Lauver JD, Donovan L, Goetschius J. The effects of blood flow restriction on muscle activation and hypoxia ... Research Gate. https://www.researchgate.net/publication/333157310_The_Effects_of_Blood_Flow_Restriction_on_Muscle_Activation_and_Hypoxia_in_Individuals_With_Chronic_Ankle_Instability. Published April 16, 2018. Accessed November 13, 2022.
2. Burkhardt M, Burkholder E, Goetschius J. Effects of blood flow restriction on muscle activation during dynamic balance exercises in individuals with chronic ankle instability. Human Kinetics. https://journals.humankinetics.com/view/journals/jsr/30/6/article-p870.xml. Published February 4, 2021. Accessed November 13, 2022.
3. Werasirirat P, Yimlamai T. Effect of supervised rehabilitation combined with blood flow restriction training in athletes with chronic ankle instability: a randomized placebo-controlled trial. J Exerc Rehabil. 2022;18(2):123-132. Published 2022 Apr 26. doi:10.12965/jer.2244018.009