Editorial Commentary: Blood Flow Restriction Therapy Continues to Prove Effective

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Abstract: Blood flow restriction (BFR) training continues to look promising to try and maintain muscle mass or to rebuild muscle mass and strength after injury or surgery. Because additional potential benefits include pain control, increased gene expression (leading to atrophy reduction), and muscle excitation, our use of the modality favors earlier over middle- or late-phase postoperative use. We initiate BFR therapy 2-14 days postoperatively, often with reduced cuff pressure in the first several sessions before increasing to the recommended therapeutic occlusion level. We have observed the greatest benefit for individuals who are non–weight-bearing for 6 to 8 weeks and who may have more postoperative restrictions due to the nature of the surgery. Compared with the opposite thigh, we have seen instances in which quadriceps girth has been preserved, although not increased, following the non–weight-bearing period. Ideally, we use 1 to 3 low-load resistance training exercises per session at least 2 times per week for 6 weeks. We also employ BFR following osteotomy or any procedure where bone drilling is used, as researchers have observed improved bone health. Additional benefits relevant to the early postoperative phase, such as effusion and pain reduction, have not been clearly established. Anecdotally, we have seen effusion levels temporarily increase during treatment but then resolve to baseline within 30 to 60 minutes of tourniquet deflation. Further high-level research is necessary to objectively validate BFR use and which patients may best benefit from it.

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The study on "Blood Flow Restriction Training Can Improve Peak Torque Strength in Chronic Atrophic Postoperative Quadriceps and Hamstring Muscles" by Noyes, Barber-Westin, and Sipes reports on the findings of the use of blood flow restriction (BFR) training to assess improvements in peak torque strength and in chronic atrophic postoperative quadriceps and hamstring muscles.[1] The authors performed a prospective study evaluating the ability of BFR to improve the peak torque strength of the quadriceps and hamstrings muscles in patients with postoperative weakness and atrophy. The majority of their patients had been operated on by the senior author (Dr. Noyes) and were following a standard modern supervised rehabilitation program before enrollment in this study. Following a fairly reproducible program of low-resistance BFR exercises, the patients were found to have a >10% increase in quadriceps peak torques of 69% and hamstring peak torques of 75% after 9 sessions. While this was a Level IV study with no control group and the number of BFR sessions were not standardized, the authors' results are encouraging nonetheless because this group of patients is common enough that better means to treat their muscle weakness would be a step forward. However, as the authors well reported, there are very few peer-reviewed scientific studies on the use of BFR, and we encourage that future studies aim for Level I study enrollment with standardized protocols so we can both validate if BFR is beneficial and also possibly for whom it may be beneficial.

It can be difficult for a clinician to apply the BFR concepts found on healthy individuals, in a controlled

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laboratory setting, to a clinical population of individuals with baseline knee pathology or those recovering from injury and/or surgery. Clinical studies often fail to describe their methods in full, which can make it difficult for the reader to replicate the study's findings. For this reason, we commend the authors for detailing the parameters used for their BFR administration on this population: the authors specified cuff type and width, tourniquet pressure (individualized to each patient), starting load and how it was altered as patients acclimated to tourniquet pressure, and weight. Just as load progression is essential for strength gains under typical, non-BFR conditions, intensity must increase as task difficulty decreases when using BFR training. Clearly stating the procedures allows results to be reproducible even as patient baseline presentations vary.

At our facility, therapists use BFR with multiple postsurgical patients each day. Anecdotally, we have observed strength improvements similar to those reported in the present study. However, due to the additional potential benefits for pain control,[2] gene expression levels (leading to atrophy reduction),[3] and muscle excitation,[4] our use of the modality heavily favors earlier over middle- or late-phase postoperative use. As BFR has shown to be safe following surgery,[5-7] we initiate BFR therapy anywhere from day 2 to day 14 postoperatively, depending on patient presentation and tolerance, often with reduced cuff pressure in the first several sessions prior to increasing to the recommended therapeutic occlusion level. We have observed the greatest benefit for individuals who are non–weight-bearing for 6 to 8 weeks and who may have more postoperative restrictions due to the nature of the surgery. Compared with the opposite thigh, we have seen instances in which quadriceps girth has been preserved, although not increased, following the non–weight-bearing period. Ideally, we use 1 to 3 low-load resistance training exercises per session at least 2 times per week[8] for 6 weeks. We also employ BFR following osteotomy or any procedure where bone drilling is used, as researchers have also observed improvements in bone health.[9,10] Additional therapeutic benefits relevant to the early postoperative phase, such as effusion and pain reduction, have not been clearly established. Anecdotally, we have seen effusion levels temporarily increase during treatment but then resolve to baseline within 30 to 60 minutes of tourniquet deflation.

We transition to heavier load strength training as a main rehabilitation focus when patients are out of the early phase and can tolerate greater-intensity training. Patients can then benefit from not only the metabolic stress stimulus, the main mechanism for strength and hypertrophy with low load BFR, but also from muscle tension and breakdown induced strength improvements only associated with high load training.[11] Middle- and late-phase BFR may include tourniquet use with cardiovascular exercise,[12] "off-day" workouts as a break from heavy loading, or with low-intensity resistance training as part of a warm-up or cool-down before or after heavier load training, respectively. Patients who encounter knee pain with progressions of strength training, particularly isolated quadriceps muscle training, may see benefit with BFR training beyond the initial postoperative period, as more of a pain modulator.[13]

In conclusion, it is becoming increasingly evident that BFR therapy has a role in rehabilitation.[14] BFR use presurgery,[15] in the early postoperative phases, and throughout the entire rehabilitation course, as found in the study by Noyes et al., appears to be beneficial for a full patient recovery. The benefits of BFR go beyond muscle strength; it is a useful modality to bridge the gap between early phase rehabilitation, when an individual cannot exercise at high intensities, and late phase when external load can be applied safely without the use of a tourniquet.

Despite excellent anecdotal clinical experiences with BFR and continually emerging promising evidence, recent systematic reviews generally include a small number of studies and cite high risk of bias, significant sample heterogeneity, and low methodologic quality.[12,16-18] Moving forward, it will be important to define clear treatment parameters, as exemplified in the study by Noyes et al., including time under occlusion, rest periods, exercise volume and intensity, and weekly dosing to assist clinicians in maximizing patient outcomes through the addition of BFR to the treatment plan. High-quality, randomized controlled trials within specific clinical populations will be important to narrow the focus on patients who will benefit most from BFR, and how it should be performed to maximize outcomes. This will serve to better align our strong enthusiasm for this modality with an equally strong scientific foundation.

References

1. Noyes F, Barber-Westin SD, Sipes L. Blood flow restriction training can improve peak torque strength in chronic atrophic postoperative quadriceps and hamstring muscles. *Arthroscopy* 2021;37:2860-2869.
2. Hughes L, Patterson SD. Low intensity blood flow restriction exercise: rationale for a hypoalgesia effect. *Med Hypotheses* 2019;132:109370.
3. Kakehi S, Tamura Y, Kubota A, et al. Effects of blood flow restriction on muscle size and gene expression in muscle during immobilization: A pilot study. *Physiol Rep* 2020;8:e14516.
4. Centner C, Lauber B. A systematic review and meta-analysis on neural adaptations following blood flow

restriction training: What we know and what we don't know. *Front Physiol* 2020;11:887.
5. Brandner CR, May AK, Clarkson MJ, Warmington SA. Reported side-effects and safety considerations for the use of blood flow restriction during exercise in practice and research. *Tech Orthop* 2018;33:114-121.
6. DePhillipo NN, Kennedy MI, Aman ZS, Bernhardson AS, O'Brien L, LaPrade RF. Blood flow restriction therapy after knee surgery: Indications, safety considerations, and postoperative protocol. *Arthrosc Tech* 2018;247:e1037-e1043.
7. Minniti MC, Statkevich AP, Kelly RL, et al. The safety of blood flow restriction training as a therapeutic intervention for patients with musculoskeletal disorders: A systematic review. *Am J Sports Med* 2020;48:1773-1785.
8. Hughes L, Paton B, Rosenblatt B, Gissane C, Patterson SD. Blood flow restriction training in clinical musculoskeletal rehabilitation: A systematic review and meta-analysis. *Br J Sports Med* 2017;51:1003-1011.
9. Lambert B, Hedt CA, Jack RA, et al. Blood flow restriction therapy preserves whole limb bone and muscle following ACL reconstruction. Abstract. In: Proceedings from the American Orthopedic Society for Sports Medicine (AOSSM); March 16-2019; Las Vegas, NV.
10. Cabuk HKÇF. Mechanoreceptors of the ligaments and tendons around the knee. *Clin Anat* 2016;29:789-795.
11. Pearson SJ, Hussain SR. A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. *Sports Med* 2015;45:187-200.
12. Bennett H, Slattery F. Effects of blood flow restriction training on aerobic capacity and performance: A systematic review. *J Strength Cond Res* 2019;33:572-583.
13. Giles L, Webster KE, McClelland J, Cook JL. Quadriceps strengthening with and without blood flow restriction in the treatment of patellofemoral pain: A double-blind randomised trial. *Br J Sports Med* 2017;51:1688-1694.
14. DePhillipo NN, Kennedy MI, Aman ZS, Bernhardson AS, O'Brien LT, LaPrade RF. The role of blood flow restriction therapy following knee surgery: Expert opinion. *Arthroscopy* 2018;34:2506-2510.
15. Žargi T, Drobnič M, Stražar K, Kacin A. Short-term preconditioning with blood flow restricted exercise preserves quadriceps muscle endurance in patients after anterior cruciate ligament reconstruction. *Front Physiol* 2018;9:1150.
16. Lu Y, Patel BH, Kym C, et al. perioperative blood flow restriction rehabilitation in patients undergoing ACL reconstruction: A systematic review. *Orthop J Sports Med* 2020;8:2325967120906822.
17. Grantham B, Korakakis V, O'Sullivan K. Does blood flow restriction training enhance clinical outcomes in knee osteoarthritis: A systematic review and meta-analysis. *Phys Ther Sport* 2021;49:37-49.
18. Slysz J, Stultz J, Burr JF. The efficacy of blood flow restricted exercise: A systematic review & meta-analysis. *J Sci Med Sport* 2016;19:669-675.