



Blood Flow Restriction: The Science & Evidence

Sarah Hayes, PT, DPT, ATC
Sports & Orthopaedic Specialists, part of Allina Health

7th Annual Allina Health Sports Medicine Conference
Allianz Field, June 27, 2019




Objectives

- Understanding of what blood flow restriction (BFR) training.
- Understand the possible mechanisms by which BFR works.
- Understand effects of BFR on endurance and bone.
- Understand proximal gains related to BFR.

Sports & Orthopaedic Specialists

What is Blood Flow Restriction (BFR)?

- "BFR is the application of external pressure over the extremities. The applied pressure is sufficient to maintain arterial inflow while occluding venous outflow to the distal occlusion site." – APTA website



Sports & Orthopaedic Specialists

How does BFR work?

- Theories of proposed mechanism of BFR:
 - Increased fiber recruitment
 - Metabolic accumulation
 - Activation of protein synthesis
 - Cell swelling

Scott & Arbanowski, Sports Med

Metabolic Accumulation

- Increase in lactate production > increase motor unit recruitment > increase in serum growth hormone (GH) > promotes collagen synthesis for tissue repair and recovery.
- Increased GH produces an increase in insulin-like growth factor-1 (IGF-1), which is a protein linked to muscle growth.
- IGF-1 enhances satellite cell proliferation > increased muscle mass.

Scott & Arbanowski, Sports Med

Metabolic Accumulation cont.

- Myostatin is the switch that allows myogenic stem cell proliferation and muscle hypertrophy.
- mTORC1 pathway activation necessary for muscle protein synthesis.
 - Need for increased muscle protein synthesis to have increased muscle hypertrophy.

Scott & Arbanowski, Sports Med

Cell Swelling

- A dehydrated myocyte cannot undergo protein synthesis.
- Acute cellular swelling > increase protein synthesis and is linked to activation of the mTORC1 pathway.
- Lipker et al 2018
 - 10 days of intermittent BFR while immobilized in knee brace from post op day 3-14. Resulted in less atrophy of quadriceps than sham BFR with knee immobilization.

Sports & Orthopaedic Specialists

BFR & Endurance

- Low intensity BFR aerobic training has shown significant improvements in cardiorespiratory endurance.
 - Due to increase in vascular endothelial growth factor (VEGF).
- BFR aerobic training has also shown significant improvements in muscular strength and hypertrophy.
 - Centner et al 2019 showed a mean muscle mass gain of 3% with BFR + walking, and 0.7% gain with walking only.

Sports & Orthopaedic Specialists

BFR & Bone

- Bittar et al 2018.
 - Pooled data from 4 studies found increase in bone-specific alkaline phosphatase and decrease in bone reabsorption biomarkers.
 - Both aerobic and anaerobic BFR with low load training demonstrated these results.

Sports & Orthopaedic Specialists

Proximal Gains with BFR

- Bowman et al 2019.
 - Randomized controlled trial of healthy individuals
 - Control group of low load training. Experimental group of low load BFR.
 - Training session 2x/wk for 6 weeks total of SLR, SL hip abduction, long arc quad extension, and standing hamstring curl.
 - Results: BFR group demonstrates significantly greater increase in thigh and leg girth, isokinetic knee extension, **hip abduction and extension**, plantarflexion and number of SL heel raises
 - **Non-BFR limb** in experimental group also showed significantly increased thigh girth, quadriceps peak torque, and number of SL heel raises

Sports & Performance Sciences

Conclusion

- We are not sure of the exact mechanism by which BFR works.
- Low load BFR training produces gains in strength and hypertrophy but less than high load resistance training.
 - Good intervention early on after injury/surgery for our patients and athletes.
- BFR is also showing positive results of improving cardiovascular endurance and bone healing.

Sports & Performance Sciences

References

1. Owens, J. (2015). Personalized Blood Flow Restriction Rehabilitation.
2. Takarada, Y., Takazawa, H., Sato, Y., Takebayashi, S., Tanaka, Y., & Ishii, N. (2000). Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans. *J Appl Physiol* (1985), 88(6), 2097-2106.
3. Doering S, Heinemeler KM, Holm L, et al. Growth hormone stimulates the collagen synthesis in human tendon and skeletal muscle without affecting myofibrillar protein synthesis. *J Appl Physiol*. 2007; 103:903-910.
4. Nielsen, J, La Aagaard, O., Beck, R. D., Nygaard, T., Hoj, L. G., Westberg, M., Frandsen, U. (2012). Proliferation of myogenic stem cells in human skeletal muscle in response to low-load resistance training with blood flow restriction. *J Physiol*, 590(P17), 4351-4361. 773-782.
5. Kadi F, Scherling P, Andersen LL, Charif N, Madan JL, Christensen LR & Andersen JL (2004). The effects of heavy resistance training and detraining on satellite cells in human skeletal muscles. *J Physiol* 558, 1005-1012.
6. Laurentino, G. C., Ugrasowitsch, C., Raschel, H., Aoki, M. S., Soares, A. G., Neves, M. Jr., Tricoli, V. (2012). Strength training with blood flow restriction diminishes myostatin gene expression. *Med Sci Sports Exerc*, 44(3), 406-412.
7. Drummond MJ, Fry CS, Glynn EL, Dreyer HC, Dhawan S, Timmerman KL, Volpi E, Rasmussen BB. Rapamycin administration in humans blocks the contraction-induced increased in skeletal muscle protein synthesis. *J Physiol* 587: 1535-1546, 2009.
8. Sato, Y. The history and future of KAATSU training. *Int J Kaatsu Training Res* 2005; 1: 1-5.
9. Loenneke JP, Faha CA, Thiebaut RS, et al. The acute muscle swelling effects of blood flow restriction. *Acta Physiol Hung* 2012;99:400-410.
10. Vanwyke, WR., Weatherholt, AM., Mikesky, AE. Blood flow restriction training: implementation into clinical practice. *Int J Exerc Sci* 10(5): 649-654, 2017.

Sports & Performance Sciences

References cont.

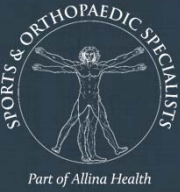
- Hughes L, Pater B, Rosenblatt B, Cizza C, Patterson SD. Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis. *Br J Sports Med* 2017;51:1003-1011.
- Centner C, Wiegand P, Gallhofer A, Kniig D. Effects of blood flow restriction training on muscular strength and hypertrophy in older individuals: a systematic review and meta-analysis. *Sports Medicine* (2019) 49:95-108.
- Lipker LA, Persinger CR, Michalko BS, Durall CJ. Blood flow restriction therapy vs standard care for reducing quadriceps atrophy after anterior cruciate ligament reconstruction. *Journal of Sport Rehabilitation* <https://doi.org/10.1123/jr.2018.0062>
- Bitar ST, Pfeiffer PS, Santos HH, Cirilo-Sousa MS. Effects of blood flow restriction exercises on bone metabolism: a systematic review. *Clin Physiol Funct Imaging* (2018) 38, pp920-925.
- Bowman EN, Elhazek R, Milligan W, Jee G, Mohr K, Brown P, Watariba DM, Umpstead O. Proximal, distal, and contralateral effects of blood flow restriction training on the lower extremities: a randomized controlled trial. *Sports Health* 11(2): 149-156, 2019.
- APTA. 2019, May 24. Blood-Flow Restriction Training (BFRT). Retrieved from <https://www.apta.org/PatientCare/BloodFlowRestrictionTraining>
- Gundersmann DM, Walker DK, Reidy PT, Borack MS, Dickinson JM, Valoj E, Rasmussen SS. (2014) Activation of mTORC1 signaling and protein synthesis in human muscle following blood flow restriction exercises is inhibited by rapamycin. *Am J Physiol Endocrinol Metab.* 306(10), E1198-1204.
- Kubota, Atsushi, et al. "Blood flow restriction by low compressive force prevents disuse muscular weakness." *Journal of Science and Medicine in Sport* 14:2 (2011): 95-99.
- Park D, Kim JK, Choi HW, Kim HC, Beekley MD, Nho H. (2010) Increased in maximal oxygen uptake following 2-week walk training with blood flow occlusion in athletes. *European Journal of Applied Physiology.* 109, 591-600.

Sports & Orthopaedic Specialists

Thank You!

Sarah Hayes, PT, DPT, ATC
Sarah.Hayes@allina.com

952-946-9777
www.sportsandortho.com
facebook.com/sportsandortho
[@sportsandortho](https://twitter.com/sportsandortho)



Sports & Orthopaedic Specialists
