

Blood flow restriction therapy (BFRT) provides its primary clinical benefit by enabling **muscle strength gains and hypertrophy at low loads (20–40% of 1RM)**, producing results comparable to high-load resistance training ($\geq 70\%$ 1RM) while minimizing mechanical stress on joints and healing tissues. This makes it particularly valuable for patients who cannot tolerate heavy loading, including postoperative, elderly, and arthritic populations.

Muscle Strength and Hypertrophy

The most robust and recent evidence comes from a 2026 BJSM systematic review and meta-analysis of **45 RCTs (1,652 participants)** with musculoskeletal conditions, which found that low-load BFR exercise was **superior to low-load exercise alone** for muscle strength (SMD = 0.82) and disability (SMD = 0.63), and showed **no clear difference from high-load exercise** for muscle strength (SMD = 0.08), confirming that BFR achieves comparable strength gains at substantially lower loads. In adults over 50, a systematic review of 30 studies found average effect sizes of **0.75 for hypertrophy and 1.15 for strength**, supporting utility in combating age-related sarcopenia.

Knee Osteoarthritis

This is one of the best-studied clinical applications. A landmark RCT of 120 patients with knee OA demonstrated that BFR-enhanced exercise produced significantly greater improvements in **KOOS pain (ES = 0.58), quadriceps strength (ES = 0.81), and functional tests** compared to traditional exercise at 12 weeks. Critically, the **1-year follow-up** showed sustained superiority in pain, symptoms, ADL, and quality of life, with the BFR group being **1.5 hours/week more active** and having **3.6 times lower odds of receiving knee injections** (63.4% reduction). A 2025 network meta-analysis of 14 RCTs (866 patients) confirmed BFR significantly reduced knee pain, improved function, and increased strength compared to low-intensity training, with comparable or slightly better outcomes than high-intensity training and fewer adverse effects.

Postoperative Knee Surgery

After ACL reconstruction and knee arthroscopy, BFR in the postoperative period significantly **reduces quadriceps muscle atrophy** as measured by cross-sectional area on MRI/ultrasound, though patient-reported outcome measures have not consistently shown differences. Expert opinion supports

initiating BFR as early as **2–14 days postoperatively**, often with reduced cuff pressure initially, with the greatest benefit observed in patients who are non-weight-bearing for 6–8 weeks. Preoperative BFR ("prehabilitation") significantly enhanced postoperative muscle strength (SMD = 0.97, $p = 0.03$) in a meta-analysis of 241 patients.

Mechanisms of Action

BFRT induces adaptations through several pathways:

- **Metabolic stress:** Venous occlusion creates a hypoxic, metabolite-rich environment (lactate accumulation, cellular swelling) that stimulates anabolic signaling
- **Fast-twitch fiber recruitment:** The ischemic environment forces earlier recruitment of type II muscle fibers despite low loads
- **Hormonal response:** Acute increases in growth hormone, IGF-1, and activation of the mTOR pathway for muscle protein synthesis
- **Vascular adaptations:** Enhanced reactive hyperemia, improved flow-mediated dilation, and angiogenesis
- **Neuromuscular adaptations:** Reduced peripheral fatigue development and improved exercise performance (~17% greater peak power output vs. control in one study)

Safety Profile

BFRT is generally well tolerated, with adverse event rates **comparable to conventional resistance training** (RR = 0.92 vs. low-load; RR = 1.08 vs. high-load exercise). A comprehensive review of 25,813 individuals found 1,672 reported adverse events, most commonly **numbness, dizziness, subcutaneous hemorrhage, and delayed-onset muscle soreness**. Tingling was reported by 71.2% of practitioners as the most common side effect, while serious events such as rhabdomyolysis (1.9%) and fainting (3.8%) were rare.

*******Contraindications and cautions** include:

- Active or recent deep vein thrombosis
- Peripheral vascular disease or severe peripheral arterial disease
- Uncontrolled hypertension (exaggerated metaboreflex pressor response)
- Known thrombophilia (Factor V Leiden, prothrombin mutations)

- Severe autonomic dysreflexia (in spinal cord injury patients)
- Pregnancy (individualized monitoring recommended)
- Cardiovascular disease warrants careful risk stratification, as BFRT can trigger significant reflex increases in blood pressure (mean arterial pressure +18 mmHg) and cardiac output via muscle metaboreflex activation

References

**** Anderson, K. D., Rask, D. M. G., Bates, T. J., & Nuelle, J. A. V. (2022). Overall Safety and Risks Associated with Blood Flow Restriction Therapy: A Literature Review. *Military medicine*, 187(9-10), 1059–1064. <https://doi.org/10.1093/milmed/usac055>

Baker, B. S., Stannard, M. S., Duren, D. L., Cook, J. L., & Stannard, J. P. (2020). Does Blood Flow Restriction Therapy in Patients Older Than Age 50 Result in Muscle Hypertrophy, Increased Strength, or Greater Physical Function? A Systematic Review. *Clinical orthopaedics and related research*, 478(3), 593–606. <https://doi.org/10.1097/CORR.0000000000001090>

Chen, J., Wu, L., Li, C., & Yan, H. (2025). The effects of low-load resistance training combined with blood flow restriction on knee rehabilitation in middle-aged and elderly patients: A systematic review and meta-analysis. *PloS one*, 20(6), e0323388. <https://doi.org/10.1371/journal.pone.0323388>

*****Cristina-Oliveira, M., Meireles, K., Spranger, M. D., O'Leary, D. S., Roschel, H., & Peçanha, T. (2020). Clinical safety of blood flow-restricted training? A comprehensive review of altered muscle metaboreflex in cardiovascular disease during ischemic exercise. *American journal of physiology. Heart and circulatory physiology*, 318(1), H90–H109. <https://doi.org/10.1152/ajpheart.00468.2019>

****da Cunha Nascimento, D., & Vilaça E Silva, K. H. C. (2026). Blood Flow Restriction Training in Athletes: Endothelial Phenotype, Thromboembolism Risk, and Tailored Safety Protocols. *Seminars in thrombosis and hemostasis*, 10.1055/a-2863-5770. Advance online publication. <https://doi.org/10.1055/a-2863-5770>

DePhillipo, N. N., Kennedy, M. I., Aman, Z. S., Bernhardson, A. S., O'Brien, L. T., & LaPrade, R. F. (2018). The Role of Blood Flow Restriction Therapy Following Knee

Surgery: Expert Opinion. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, 34(8), 2506–2510.

<https://doi.org/10.1016/j.arthro.2018.05.038>

****de Queiros, V. S., Dantas, M., Neto, G. R., da Silva, L. F., Assis, M. G., Almeida-Neto, P. F., Dantas, P. M. S., & Cabral, B. G. A. T. (2021). Application and side effects of blood flow restriction technique: A cross-sectional questionnaire survey of professionals. *Medicine*, 100(18), e25794.

<https://doi.org/10.1097/MD.00000000000025794>

Ferlito, J. V., Rolnick, N., Kamiş, O., de Queiros, V. S., Lopez, P., & Hughes, L. (2026). Do blood flow restriction exercises offer additional benefits when compared to conventional exercises in musculoskeletal rehabilitation? A systematic review and meta-analysis. *British journal of sports medicine*, bjsports-2025-111452. Advance online publication. <https://doi.org/10.1136/bjsports-2025-111452>

Hwang, P. S., & Willoughby, D. S. (2019). Mechanisms Behind Blood Flow-Restricted Training and its Effect Toward Muscle Growth. *Journal of strength and conditioning research*, 33 Suppl 1, S167–S179. <https://doi.org/10.1519/JSC.0000000000002384>

LaPrade, R. F., Monson, J. K., & Schoenecker, J. (2021). Editorial Commentary: Blood Flow Restriction Therapy Continues to Prove Effective. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, 37(9), 2870–2872.

<https://doi.org/10.1016/j.arthro.2021.04.073>

Lavigne, C., Mons, V., Lemineur, C., Meste, O., Lefthériotis, G., & Blain, G. M. (2025). Physiological mechanisms underlying enhanced performance with blood flow restriction training: neuromuscular, vascular and metabolic adaptations. *The Journal of physiology*, 10.1113/JP289806. Advance online publication.

<https://doi.org/10.1113/JP289806>

****Nascimento, D. D. C., Rolnick, N., Neto, I. V. S., Severin, R., & Beal, F. L. R. (2022). A Useful Blood Flow Restriction Training Risk Stratification for Exercise and Rehabilitation. *Frontiers in physiology*, 13, 808622.

<https://doi.org/10.3389/fphys.2022.808622>

Jacobs, E., Stroobant, L., Victor, J., Elewaut, D., Tampere, T., Wallaert, S., Witvrouw, E., Schuermans, J., & Wezenbeek, E. (2025). Vascular occlusion for optimising the functional improvement in patients with knee osteoarthritis: a randomised controlled trial. *Annals of the rheumatic diseases*, 84(2), 341–350.

<https://doi.org/10.1136/ard-2024-226579>

Pearson, S. J., & Hussain, S. R. (2015). A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. *Sports medicine (Auckland, N.Z.)*, 45(2), 187–200. <https://doi.org/10.1007/s40279-014-0264-9>

Perera, E., Zhu, X. M., Horner, N. S., Bedi, A., Ayeni, O. R., & Khan, M. (2022). Effects of Blood Flow Restriction Therapy for Muscular Strength, Hypertrophy, and Endurance in Healthy and Special Populations: A Systematic Review and Meta-Analysis. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine*, 32(5), 531–545. <https://doi.org/10.1097/JSM.0000000000000991>

Vopat, B. G., Vopat, L. M., Bechtold, M. M., & Hodge, K. A. (2020). Blood Flow Restriction Therapy: Where We Are and Where We Are Going. *The Journal of the American Academy of Orthopaedic Surgeons*, 28(12), e493–e500.

<https://doi.org/10.5435/JAAOS-D-19-00347>

Wengle, L., Migliorini, F., Leroux, T., Chahal, J., Theodoropoulos, J., & Betsch, M. (2022). The Effects of Blood Flow Restriction in Patients Undergoing Knee Surgery: A Systematic Review and Meta-analysis. *The American journal of sports medicine*, 50(10), 2824–2833. <https://doi.org/10.1177/03635465211027296>

Yang, H., Xiong, L., Wang, P., Zeng, Y., Zhao, Z., He, C., Chen, Z., & Xiao, T. (2025). Comparative Efficacy and Safety of Blood Flow Restriction Training for Knee Osteoarthritis: A Network Meta-Analysis. *American journal of physical medicine & rehabilitation*, 104(12), 1086–1094. <https://doi.org/10.1097/PHM.0000000000002824>