Journal of Advances in Developmental Research (IJAIDR)

E-ISSN: 0976-4844 ● Website: www.ijaidr.com ● Email: editor@ijaidr.com

Blood Flow Restriction Training in Musculoskeletal Physiotherapy: Efficacy, Safety and Clinical Prescription - A Narrative Review

Dr. Siva Bali Reddy Katasani[1], Dr. S Purna Chandra Shekhar[2], Dr. Amaresh Mohan[3], Dr. Sama Raju[4]

[1]Head of the Department, Seven Hills Physiotherapy & Rehabilitation, Nandyal, Andhra Pradesh, India.ORCID: https://orcid.org/0009-0009-8282-8250

[2]Head of the Department, Chandras Homoeopathy Physiotherapy, Boduppal, Telangana, India ORCID: https://orcid.org/0009-0008-8214-2569

[3]Associate Professor, Dept. of Physiotherapy, Health City Hospital & Institute of Paramedical Sciences, Lucknow, Uttar Pradesh, India

ORCID: https://orcid.org/0009-0000-1461-610X

[4]Research Scholar, Mahatma Gandhi University, Daramdin, Soreng, Sikkim, India.

Abstract:

Background: Blood flow restriction (BFR) training combines external limb compression with low-load exercise to stimulate adaptation when heavy resistance is poorly tolerated. Its rapid uptake in musculoskeletal physiotherapy has created interest alongside questions about patient selection, cuff pressure, dosage and safety. Objective: To synthesize evidence published from 2012 through 2022 and translate it into a clinically cautious prescription framework. Methods: A structured narrative review considered English-language peer-reviewed trials, systematic reviews, meta-analyses and methodological guidance published between January 2012 and December 2022. Results: Low-load BFR generally produces greater strength and hypertrophy than comparable low-load exercise without BFR, while high-load training may remain superior for maximal strength. Potential applications include postoperative weakness, knee osteoarthritis, older adults and periods of load intolerance. Outcomes depend on individualized limb occlusion pressure, cuff characteristics, exercise dose, supervision and adherence. Minor effects such as discomfort, numbness, bruising and dizziness occur; rare serious events and uncertainty in higher-risk populations require screening and escalation procedures. Conclusion: BFR is an adjunct rather than a replacement for progressive resistance exercise. Physiotherapists should use individualized pressures, conservative progression, explicit monitoring and a transition toward conventional loading when clinically appropriate.

Keywords: blood flow restriction; physiotherapy; resistance training; rehabilitation; muscle strength; hypertrophy; safety.

Introduction

Progressive resistance exercise is central to musculoskeletal rehabilitation, yet many patients cannot initially tolerate the mechanical load usually associated with strength and hypertrophy. Pain, joint irritability, recent surgery, immobilization and fear can limit conventional high-load training. Blood flow restriction (BFR) training has emerged as one strategy for applying a strong metabolic stimulus while using relatively light external loads.

BFR uses a pneumatic cuff or specialized band placed proximally on an arm or leg. The cuff partially restricts arterial inflow and more substantially restricts venous return during exercise. Low-load contractions performed under this condition produce metabolite accumulation, fatigue and recruitment patterns that may stimulate muscle adaptation. The practical promise is appealing: improve strength or muscle size while reducing joint and tissue loading.

Enthusiasm has sometimes moved faster than clinical standardization. Studies differ in cuff width, pressure, exercise mode, set structure and patient population. Commercial devices range from automated systems that estimate limb occlusion pressure to elastic straps with uncertain pressure. These are not equivalent exposures. A safe programme requires more than attaching a cuff and copying a repetition scheme from social media.

Physiotherapists need to decide who may benefit, how risk is screened, how pressure is selected, what outcomes are realistic and when conventional loading should resume. This review synthesizes evidence from 2012 to 2022 and develops a practical framework for BFR use in musculoskeletal care without overstating certainty.

Review Aim and Method

The review aimed to examine efficacy, safety and prescription of BFR exercise in musculoskeletal physiotherapy. Questions included whether low-load BFR improves strength and hypertrophy, how it compares with high- and low-load conventional exercise, which clinical groups have been studied, how limb occlusion pressure should be determined and which adverse responses require action.

A structured narrative method was selected because populations, devices and protocols were heterogeneous. PubMed-indexed systematic reviews, meta-analyses, randomized studies, cohort studies and expert methodology papers published in English from January 2012 through December 2022 were prioritized. Search concepts combined blood flow restriction, occlusion, KAATSU, resistance exercise, rehabilitation, knee, surgery, osteoarthritis, safety and adverse events.

Evidence was interpreted for clinical application rather than pooled anew. Reviews and trials were used to establish effect direction and uncertainty, while methodological sources informed prescription. Findings from healthy participants were not assumed to apply automatically to postoperative or medically complex patients. No original patient data were collected or analysed.

Physiological Rationale

The cuff creates a local environment in which low-load exercise becomes metabolically demanding. Reduced venous outflow promotes accumulation of metabolites, cell swelling and early fatigue. These signals may increase motor-unit recruitment and anabolic signalling despite the light external load. Repeated exposure can support muscle hypertrophy and strength development.

The mechanism is not simply complete interruption of blood supply. Proper BFR maintains some arterial inflow and allows controlled reperfusion after cuff release. Excessive pressure can increase discomfort, alter movement and add unnecessary risk without ensuring a better training effect. Individual anatomy, blood pressure, cuff width and limb circumference influence the pressure needed to produce a given restriction.

Strength gains arise from both muscular and neural adaptation. High-load exercise provides a specific mechanical and neural stimulus that low-load BFR may not reproduce fully. This explains why BFR can outperform ordinary low-load training yet remain less effective than high-load resistance for maximal strength in some analyses. Hypertrophy may be more comparable because metabolic stress contributes strongly to muscle growth.

Clinical reasoning should separate load tolerance from effort. The external load may be low, but a well-designed BFR set becomes difficult as fatigue develops. Patients who cannot tolerate discomfort, maintain technique or understand stop rules may not be suitable even when joint loading is acceptable. The method reduces mechanical load; it does not make exercise physiologically trivial.

Evidence for Strength and Hypertrophy

Systematic review evidence consistently suggests that adding BFR to low-load resistance exercise improves adaptation compared with the same low load performed freely. Slysz et al. (2016) reported that BFR augmented strength and muscle-size changes across dynamic exercise studies. Centner et al. (2019) found that low-load BFR and walking with BFR can stimulate hypertrophy in older adults.

Comparisons with high-load resistance require nuance. High-load programmes commonly produce greater maximal strength, reflecting specificity and larger mechanical tension. Low-load BFR may produce similar hypertrophy in some contexts but should not be described as universally equivalent. The 2022 review by Fabero-Garrido et al. found smaller strength gains with low-load BFR than high-load exercise in healthy adults over 60, whereas BFR outperformed traditional low-load training for strength and hypertrophy.

These average effects support BFR when high loads are temporarily inappropriate, not when a patient can safely complete effective conventional training. If maximal force or high-load task performance is the final goal, a later transition to heavier resistance is usually required. BFR may help preserve or rebuild capacity during the transition.

Study quality and protocol variability limit precision. Some trials have small samples and short follow-up. Muscle size may be estimated by different imaging methods, while strength tests can favour the trained movement. Device pressure and cuff width are not always reported adequately. Clinicians should therefore avoid promising a specific percentage gain or assuming one published protocol fits every patient.

Pressure Determination and Cuff Selection

Pressure is a dose variable. The preferred approach determines limb occlusion pressure (LOP), the minimum pressure required to stop distal arterial flow under standardized resting conditions. Training pressure is then prescribed as a percentage of that individualized value. Lower-limb pressures are commonly higher than upper-limb pressures, but a fixed universal millimetre-of-mercury value is inappropriate.

Cuff width influences the pressure required for occlusion. A wider cuff generally achieves restriction at a lower absolute pressure than a narrow cuff. Limb circumference, tissue composition, cuff shape and body position also matter. For this reason, pressures cannot be transferred directly between devices or between patients.

Automated cuffs that regulate pressure may improve consistency, while validated Doppler or pulse-detection methods can estimate LOP. If reliable individualized pressure cannot be determined, clinicians should recognize the additional uncertainty rather than compensate with an arbitrary high setting. Elastic wraps judged only by perceived tightness are difficult to standardize and may create unknown pressure.

LOP should be reassessed when limb size, swelling, blood pressure, cuff or clinical status changes. Measurement conditions are documented, including position and device. The selected training percentage should produce the desired stimulus with tolerable symptoms and preserved technique. More pressure is not automatically more effective.

The cuff is placed proximally to distribute pressure over soft tissue and avoid compressing structures near joints. Skin is inspected before and after treatment. Clothing folds, tubing position and device fit are checked. A cuff intended for clinical BFR is preferable to improvised equipment because pressure control and emergency release are central to safety.

Exercise Prescription

A typical resistance programme uses low external loads, often expressed as a percentage of one-repetition maximum, and multiple sets with short rest intervals. The familiar 30-15-15-15 repetition sequence is common in research, but it is not a mandatory formula. Load, sets, repetitions, rest, pressure and cuff time should be adjusted to the patient's status and goal.

Early sessions establish tolerance. The therapist may begin with fewer sets, lower pressure or a simpler exercise while observing pain, colour, sensation, dizziness and technique. Progression should not change pressure, load and volume simultaneously. A conservative sequence increases completed work, then external load, while maintaining individualized pressure within the chosen range.

The cuff may remain inflated during sets and brief rests, then be deflated between exercises. Total continuous inflation time is controlled and documented. Reperfusion periods allow symptom review. Long, unsupervised occlusion is not a rehabilitation goal.

Exercise selection follows ordinary biomechanical reasoning. Quadriceps weakness may be addressed with knee extension, leg press, squat variants or functional tasks depending on tissue precautions. Upper-limb programmes consider surgical restrictions, nerve symptoms and vascular access. Technique must remain acceptable as fatigue rises.

Perceived exertion and discomfort are different measures. Muscular effort should increase, but sharp pain, severe cuff pain, progressive numbness or systemic symptoms are not normal targets. The patient receives clear stop rules. If the method remains poorly tolerated despite adjustment, conventional low-load exercise, neuromuscular stimulation, aquatic exercise or other approaches may be preferable.

Frequency depends on rehabilitation phase and recovery. Two or three weekly resistance sessions may be practical in many outpatient programmes. Higher-frequency protocols used in research require careful monitoring and cannot be assumed superior. Progress is assessed through strength, functional performance, muscle size when relevant and the ability to advance toward unrestricted loading.

Postoperative Rehabilitation

After surgery, muscle atrophy and inhibition can develop quickly while tissue-healing precautions limit loading. BFR may allow an early strengthening stimulus without heavy joint or graft stress. It has been studied particularly after anterior cruciate ligament reconstruction and knee surgery.

Postoperative use requires clearance regarding wound status, vascular risk and surgical precautions. A cuff should not compromise an incision, drain or fragile skin. Swelling, pain and sensory change are assessed before each session. The presence of postoperative thrombosis risk does not mean BFR is automatically safe because the external load is low.

Exercise progression follows healing. Early applications may use isometric or low-load open-chain contractions and then advance to closed-chain and functional tasks. BFR does not authorize movement or load that the surgical protocol otherwise prohibits. It modifies the muscular stimulus within permitted activity.

Quadriceps outcomes after ACL reconstruction are of particular interest. Some studies report improved strength or reduced atrophy, but protocols and findings vary. Adolescents in the pilot study by Prue et al. (2022) completed numerous supervised sessions with mostly minor effects, yet the sample was small and cannot establish safety for every young patient.

The therapist plans an exit strategy. As pain, effusion and tissue tolerance improve, external resistance should progress. BFR can be reduced or discontinued when conventional loading provides an adequate stimulus. Long-term dependence on light-load BFR may underprepare the patient for sport, work or high-force tasks.

Knee Osteoarthritis and Pain-Limited Loading

Knee osteoarthritis is a plausible indication because heavy resistance may exacerbate symptoms in some patients. Low-load BFR can reduce external joint loading while challenging the quadriceps. Trials and reviews have evaluated strength, pain and function, but results are not uniformly superior to conventional exercise.

Wang et al. (2022) concluded that BFR may not provide greater efficacy than comparison exercise for knee osteoarthritis, although it did not appear to produce a higher overall risk of adverse events in included studies. This finding argues against presenting BFR as a special cure. It is one option within exercise therapy.

Patient selection depends on the reason heavy loading is limited. If pain is driven by poor technique or excessive progression, correcting those factors may be sufficient. If a patient can tolerate conventional moderate loading, BFR may add complexity without clear advantage. Conversely, a temporary BFR block may help when joint irritability prevents an effective strength dose.

Pain response is monitored during exercise and over the following day. BFR discomfort should not be confused with joint pain. Functional outcomes such as sit-to-stand, stair performance and walking matter more than isolated quadriceps force alone. Education, aerobic activity, weight management and broader self-management remain important components of osteoarthritis care.

Older Adults and Other Applications

Older adults may benefit when frailty, joint symptoms or low confidence make heavy resistance difficult. Reviews indicate that low-load BFR can improve strength and muscle size beyond ordinary

low-load training. However, cardiovascular disease, medication, skin integrity and balance problems may be more common and require careful screening.

Walking with BFR has been studied as a low-load conditioning stimulus. It may support muscle adaptation, but altered gait, cuff discomfort and cardiovascular response require monitoring. It should not replace ordinary walking volume, balance training or progressive resistance when those are tolerated.

Applications have also been explored for patellofemoral pain, tendinopathy, immobilization and upper-limb rehabilitation. The evidence is not equally strong across diagnoses. A physiological rationale is not a clinical outcome trial. Clinicians should state when use is extrapolated and obtain an observable baseline against which benefit can be judged.

Athletic rehabilitation often uses BFR during periods when heavy loading is restricted. The method can maintain training stimulus, but return-to-sport demands include high force, rate of force development, plyometric capacity and skill. BFR alone cannot prepare all of these qualities. It belongs within a staged programme.

For medically complex patients, consultation may be needed before use. The absence of reported complications in healthy participants cannot establish safety in people with vascular disease, uncontrolled hypertension or clotting risk. Clinical convenience should never override risk stratification.

Safety and Adverse Events

Commonly reported effects include pressure discomfort, delayed muscle soreness, bruising, transient numbness, light-headedness and exercise intolerance. Most are minor and resolve with cuff release or dose adjustment, but they provide information about fit, pressure and patient response. Anderson et al. (2022) identified numbness, dizziness and subcutaneous haemorrhage among reported events and also noted rare serious complications in the literature.

Minniti et al. (2020) reviewed safety after musculoskeletal surgery and found many studies reported no adverse events, while rare events included deep vein thrombosis and rhabdomyolysis. These reports do not prove causation in every case, but they show why BFR should not be treated as risk free.

Severe pain, persistent sensory change, unusual swelling, loss of distal pulse outside the intended measurement procedure, chest pain, breathlessness, syncope or signs of thrombosis require immediate cessation and appropriate medical evaluation. Dark urine, extreme weakness or disproportionate muscle pain raise concern for rhabdomyolysis.

Vital-sign monitoring is considered when cardiovascular response is relevant. BFR can increase blood pressure and sympathetic demand. The therapist avoids breath holding and checks recovery. Patients with limited communication or sensation may be unable to report warning symptoms reliably.

Equipment hygiene, calibration and maintenance are safety issues. The clinician must be able to release pressure promptly. Documentation includes cuff, limb, LOP method, training pressure, exercise, inflation time, symptoms and response. This record supports reproducibility and clinical review.

Risk Stratification and Contraindications

Risk assessment considers personal and family history of thrombosis, vascular disease, uncontrolled hypertension, cardiac disease, diabetes complications, pregnancy, active infection, cancer status, medication and recent surgery. The framework proposed by da Cunha Nascimento et al. (2022)

emphasizes structured screening because BFR may provoke cardiovascular and vascular responses relevant to susceptible patients.

Lists of absolute and relative contraindications vary because direct evidence is limited. Clinical decisions should use local policy, medical input and device guidance. Suspected or active thrombosis, severe uncontrolled cardiovascular disease, compromised circulation, acute infection and inability to communicate symptoms generally require avoidance or specialist clearance.

A patient taking anticoagulants is not assessed by medication name alone; the underlying reason, bleeding risk and medical advice matter. A history of cancer or surgery does not create a single universal decision. Risk is individualized and revisited when health status changes.

Screening is not a one-time form. New swelling, illness, medication, pregnancy or cardiovascular symptoms can alter suitability. The patient is encouraged to report changes before treatment. When uncertainty is meaningful, a safer conventional exercise option should be used while clarification is obtained.

Informed consent explains expected discomfort, possible minor effects, uncertainty and alternative exercises. The patient should understand that declining BFR does not reduce access to rehabilitation. Consent is especially important when the method is novel or promoted as superior.

Patient Tolerance and Communication

Tolerance influences adherence and technique. Prue et al. (2022) found that some adolescent sessions could not be completed and some required pressure reduction, despite no reported serious events. This illustrates that a programme can be broadly feasible while still requiring session-by-session adjustment.

The therapist distinguishes expected muscular burning from warning symptoms. Before inflation, the patient is told what sensations may occur and how to request immediate release. A simple rating for cuff discomfort can be recorded alongside exertion and pain.

Communication should avoid competitive language that encourages enduring excessive pressure. Completing every planned repetition is not more important than safety. Stopping a set, lowering pressure or selecting another intervention is legitimate clinical management.

Patients may perceive BFR as advanced technology and expect rapid results. Education explains that adaptation still requires repeated training, nutrition, recovery and progression. The device does not bypass tissue healing or replace high-load preparation for demanding goals.

Home use deserves caution. Unsupervised BFR requires reliable equipment, appropriate training, capacity to follow instructions and a low-risk presentation. Improvised bands and self-selected tightness are difficult to endorse. Many postoperative or medically complex patients should remain supervised until technique and response are established.

Clinical Decision-Making Framework

A practical decision pathway begins by identifying the limitation. If heavy loading is restricted by pain, tissue precautions or profound weakness, BFR may be considered. If effective conventional loading is already tolerated, the additional complexity may offer little value.

The second step is risk stratification and consent. Relevant medical history, vascular status, sensation, skin, swelling, medications and communication capacity are reviewed. Clearance is sought when risk exceeds the physiotherapist's authority or available evidence.

The third step establishes individualized LOP with appropriate equipment. The therapist documents measurement conditions and selects a conservative training percentage. A familiar low-load exercise is introduced so the cuff response can be observed without excessive task complexity.

The fourth step monitors immediate and next-day effects. Successful exposure produces substantial muscular effort with tolerable cuff discomfort, preserved technique and no concerning neurological, vascular or systemic symptoms. Pressure, volume or exercise is modified when response is excessive.

The fifth step progresses toward the rehabilitation goal. Repetitions and load may rise, functional exercises are added and conventional resistance is advanced as tolerated. Outcomes are reviewed after a defined block. If strength or function does not improve, the rationale, adherence and diagnosis are reconsidered rather than continuing indefinitely.

Finally, BFR is withdrawn when it is no longer necessary or useful. A patient returning to sport, manual work or unrestricted daily activity needs exposure to appropriate mechanical load. The transition is part of the original plan, not evidence that BFR failed.

Implementation and Governance

Services introducing BFR need written procedures for screening, LOP measurement, device use, infection control, monitoring, emergency release and documentation. Clinicians require practical training rather than relying only on a product demonstration.

Competency includes understanding physiology, recognizing adverse responses, selecting exercises and adapting pressure. Periodic review of technique and equipment calibration supports consistency. Adverse events and near misses should be recorded and discussed through ordinary clinical-governance processes.

Procurement should consider the ability to individualize pressure, cuff range, maintenance, cleaning and technical support. Cost does not establish clinical superiority. Devices should fit the patient population and local risk-management capacity.

Audit can examine whether LOP was measured, screening documented, consent obtained, pressure and inflation time recorded, and outcomes reassessed. These process indicators are useful even when patient numbers are too small for comparative effectiveness analysis.

Interprofessional communication is important after surgery and in medically complex care. The rehabilitation plan should state that BFR modifies exercise loading but does not change surgical precautions. Clear communication prevents conflicting advice and supports timely escalation.

Detailed Session Planning and Progression

A BFR session should begin before cuff inflation. The therapist reviews interval medical changes, current pain, swelling, skin condition, sensation and recovery from the previous session. Baseline observations provide a comparison if symptoms develop. The exercise sequence and expected sensations are explained, and the cuff's rapid-release mechanism is confirmed.

Warm-up may use unrestricted low-intensity movement to assess current tolerance. The first BFR exercise should be familiar and technically simple. This reduces the chance that poor performance will be attributed incorrectly to pressure when the true problem is motor learning. Position should remain consistent with the LOP measurement assumptions or the clinician should recognize that effective pressure may change.

Initial inflation is followed by a brief check of comfort, distal colour and sensation. The therapist does not rely on colour alone to determine appropriate restriction. Exercise begins at the planned low load, and the clinician observes tempo, range and compensations. A rapid decline in technique is a reason to end or modify the set, even if the target repetitions have not been reached.

Between sets, short rests preserve the metabolic stimulus, but the patient remains under direct observation. Questions should be specific: new tingling, unusual pain, nausea, dizziness or breathlessness. Vague encouragement to tolerate discomfort can suppress important reporting. After the final set, the cuff is released promptly and the limb is reassessed.

The next-day response guides progression. Expected local soreness that resolves does not necessarily require change. Marked swelling, persistent sensory symptoms, severe pain or functional deterioration prompts review and possible medical escalation. When response is acceptable, progression can increase exercise load modestly while retaining the same pressure. Re-estimation of strength is needed periodically because a load that was initially challenging may become too light.

Progression should reflect the reason BFR was chosen. In an early postoperative phase, success may be completing a low-load quadriceps programme without increasing effusion. Later, success may be tolerating moderate conventional resistance. In knee osteoarthritis, the target may be greater functional loading with acceptable pain. The BFR variables are therefore subordinate to the rehabilitation objective.

Deloading is appropriate after illness, treatment interruption or increased joint irritability. The patient should not resume automatically at the highest previous dose. A brief tolerance session can re-establish response. This approach is particularly important when LOP or limb circumference may have changed.

Session documentation should be detailed enough for another trained clinician to reproduce the exposure. It includes device, cuff size, side, LOP and method, percentage used, external load, sets, repetitions, rest, continuous inflation time, symptoms and modifications. Recording only that “BFR was performed” is inadequate for safety or dose interpretation.

Comparing BFR With Alternative Rehabilitation Strategies

BFR is one of several ways to address weakness when heavy resistance is limited. Ordinary low-load exercise remains useful for motor control, endurance and early activation, although it may provide a smaller hypertrophy stimulus. Neuromuscular electrical stimulation may assist severe postoperative inhibition. Aquatic exercise reduces weight-bearing, while isometrics can load tissue within a protected range. The correct comparison is therefore not BFR versus no treatment, but BFR versus the best feasible alternative.

The choice should consider patient preference, equipment, supervision and the impairments being targeted. A patient who dislikes cuff pressure may adhere better to a slower conventional progression. Another patient may value BFR because it provides a sense of challenging training without aggravating the joint. Neither preference proves physiological superiority, but adherence influences real-world effectiveness.

Mechanical loading has benefits that metabolic stress cannot fully replace. Bone, tendon, cartilage and task-specific performance respond to loading characteristics. A programme using only light-load BFR may improve muscle while underdosing other tissues. Tendon rehabilitation, for example, often requires progressive mechanical loading matched to symptoms and stage. BFR can supplement this process but should not become a reason to avoid necessary loading indefinitely.

Cost and time also matter. Measuring LOP, fitting cuffs and monitoring sessions require resources. If outcomes are similar to a simpler programme, routine BFR may not be justified. Conversely, preventing profound postoperative atrophy or enabling earlier effective exercise may justify the added effort in selected patients. This is a clinical and service decision, not solely a physiological one.

Shared decision-making should present alternatives neutrally. The patient is told what BFR is expected to add, what remains uncertain and how benefit will be evaluated. A time-limited trial with predefined outcomes prevents continuation based only on novelty. If no meaningful improvement occurs, the programme returns to other evidence-based strategies.

Outcome Evaluation

Outcome evaluation should separate short-term tolerance from rehabilitation effectiveness. A patient may complete BFR comfortably without gaining meaningful strength, while another may report discomfort yet achieve functional progress. Baseline measures should therefore be selected before treatment begins.

Strength can be assessed through standardized dynamometry, repetition testing or a safe functional proxy. Muscle size may be relevant in research or severe atrophy but is not always practical in routine care. Functional measures such as sit-to-stand performance, stair ability, gait, lifting capacity and return to activity connect impairment change with participation.

Pain, joint swelling and next-day recovery determine whether the reduced-load strategy is meeting its purpose. Patient-reported confidence and willingness to progress are also important. Improvement should be interpreted against natural recovery and the broader programme because BFR is rarely the only intervention.

A planned review after several weeks asks whether BFR enabled training that otherwise would not have been possible, whether the selected outcome improved and whether conventional loading can now advance. If the answer is no, continued exposure needs a new rationale. Clear stopping criteria protect time and resources and prevent technology-driven care.

Clinical Handover

When care transfers between clinicians, the handover should specify cuff type, individualized occlusion pressure, training percentage, tolerated exercises, recent symptoms and progression limits. This prevents accidental use of another patient's settings and supports consistent monitoring. The receiving clinician should reassess suitability rather than treating the earlier prescription as permanent.

Limitations and Research Priorities

BFR literature is heterogeneous in cuff width, pressure, exercise dose, comparator and outcome. Many studies involve healthy young participants or small clinical samples. Follow-up is often short, so durability and rare adverse events remain uncertain.

Future trials should report individualized LOP, cuff characteristics, inflation time, adherence and adverse events consistently. Pragmatic comparisons with well-designed conventional rehabilitation are needed. Research should determine which patients benefit enough to justify added equipment and supervision.

Safety studies require larger samples and transparent reporting rather than assuming that absence of an event in a small trial proves safety. Registries may help identify uncommon complications. Higher-risk populations should be studied with appropriate safeguards.

Dose-response research should separate pressure, load and volume. Functional outcomes, quality of life, return to work and return to sport deserve emphasis alongside muscle size. Economic evaluation is needed for routine service decisions.

Until stronger evidence is available, clinicians should match claims to the population studied and avoid presenting one protocol as universal.

Conclusion

Low-load BFR training can improve strength and hypertrophy more than comparable low-load exercise without restriction and may provide a useful bridge when heavy resistance is not tolerated. High-load training may remain superior for maximal strength and is often necessary for final functional preparation.

Safe application requires individualized pressure, appropriate cuffs, risk screening, informed consent, supervised familiarization and clear stop rules. Minor adverse effects and intolerance are not uncommon; rare serious events and limited evidence in higher-risk groups justify caution.

BFR should be integrated into ordinary physiotherapy reasoning rather than treated as a stand-alone technology. The clinician identifies a load problem, selects an appropriate patient, measures response and plans transition toward conventional loading. Used in this way, BFR is a potentially valuable adjunct within progressive musculoskeletal rehabilitation.

REFERENCES:

1. Anderson, K. D., Rask, D. M., Bates, T. J., & Nuelle, J. A. (2022). Overall safety and risks associated with blood flow restriction therapy: A literature review. Military Medicine, 187(9-10), 1059-1064.
2. Centner, C., Wiegel, P., Gollhofer, A., & König, D. (2019). Effects of blood flow restriction training on muscular strength and hypertrophy in older individuals: A systematic review and meta-analysis. Sports Medicine, 49(1), 95-108. https://doi.org/10.1007/s40279-018-0994-1
3. da Cunha Nascimento, D., 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
4. Fabero-Garrido, R., Gragera-Vela, M., Del Corral, T., Izquierdo-García, J., Plaza-Manzano, G., & López-de-Uralde-Villanueva, I. (2022). Effects of low-load blood flow restriction resistance training on muscle strength and hypertrophy compared with traditional resistance training in healthy adults older than 60 years: Systematic review and meta-analysis. Journal of Clinical Medicine, 11(24), 7389. https://doi.org/10.3390/jcm11247389
5. Hughes, L., Paton, B., Rosenblatt, B., Gissane, C., & Patterson, S. D. (2017). Blood flow restriction training in clinical musculoskeletal rehabilitation: A systematic review and meta-analysis. British Journal of Sports Medicine, 51(13), 1003-1011. https://doi.org/10.1136/bjsports-2016-097071

6. Minniti, M. C., Statkevich, A. P., Kelly, R. L., Rigsby, V. P., Exline, M. M., Rhon, D. I., & Clewley, D. (2020). The safety of blood flow restriction training as a therapeutic intervention for patients with musculoskeletal disorders: A systematic review. American Journal of Sports Medicine, 48(7), 1773-1785. https://doi.org/10.1177/0363546519882652
7. Patterson, S. D., Hughes, L., Warmington, S., Burr, J., Scott, B. R., Owens, J., Abe, T., Nielsen, J. L., Libardi, C. A., Laurentino, G., Neto, G. R., Brandner, C., Martin-Hernandez, J., & Loenneke, J. (2019). Blood flow restriction exercise: Considerations of methodology, application, and safety. Frontiers in Physiology, 10, 533. https://doi.org/10.3389/fphys.2019.00533
8. Prue, J., Roman, D. P., Giampetruzzi, N. G., Fredericks, A., Lolic, A., Crepeau, A., Pace, J. L., & Weaver, A. P. (2022). Side effects and patient tolerance with the use of blood flow restriction training after ACL reconstruction in adolescents: A pilot study. International Journal of Sports Physical Therapy, 17(3), 347-354. https://doi.org/10.26603/001c.32479
9. Slysz, J., Stultz, J., & Burr, J. F. (2016). The efficacy of blood flow restricted exercise: A systematic review and meta-analysis. Journal of Science and Medicine in Sport, 19(8), 669-675. https://doi.org/10.1016/j.jsams.2015.09.005
10. Wang, H. N., Chen, Y., Cheng, L., Cai, Y. H., Li, W., & Ni, G. X. (2022). Efficacy and safety of blood flow restriction training in patients with knee osteoarthritis: A systematic review and meta-analysis. Arthritis Care & Research, 74(1), 89-98. https://doi.org/10.1002/acr.24487