BFR Training: Implementation and Impact on Patient Outcomes

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Introduction

Name: Ethan Lam

Where I grew up: Los Angeles, CA

College: California State University, Los Angeles *B.S. Exercise Science*

Areas of interest: Sports, Ortho

UNC DPT Class of 2025

Objectives

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By the end of this presentation, attendees will be able to:

- Recall the historical development of BFR and identify the differences between KAATSU and BFR training modalities
- Explain the physiological mechanisms behind BFR training
- Describe the key indications, contraindications, and benefits for BFR training and the associated side effects and safety considerations.
- Demonstrate how to properly set up BFR equipment as well as choosing the appropriate parameters.
- Identify the appropriate populations and conditions that could benefit from this intervention
- Understand the benefits of utilizing BFR training for post-op ACL reconstruction patients for various training protocols.

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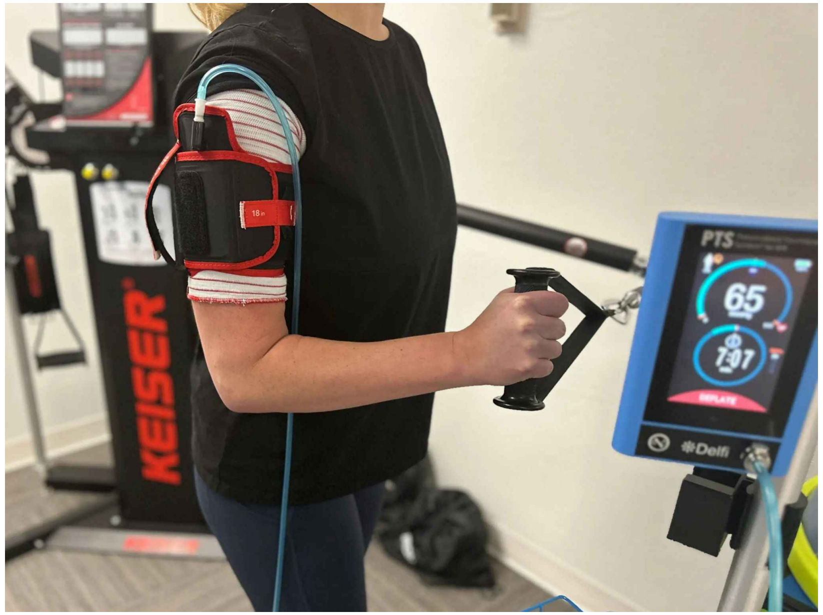
What is BFR Therapy?

Blood Flow Restriction: An Overview[1, 2]

- Therapeutic modality that uses a tourniquet to reduce arterial inflow and restrict venous outflow during resistance exercises.
- Primarily used to enhance muscular growth, strength, and endurance utilizing lighter loads



McVay I. Blood Flow Restriction (BFR): The ultimate shortcut to building muscle? IPA Physio. Published March 22, 2023. Accessed April 4, 2025. https://ipa.physio/blood-flow-restriction-bfr-the-ultimate-shortcut-to-building-muscle/

Bild Clinic. Blood Flow Restriction (BFR) Training: Enhancing Muscular Adaptations, Rehabilitation and Strength. Bild Clinic. Published 2023. Accessed April 4, 2025. https://bildclinic.com/portfolio/blood-flow-restriction/

Background History [3,4]

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- Occlusive training, known as “KAATSU”, was first founded in Japan in the 1960’s by Dr. Yoshiaki Sato
- Sato suffered b/l ankle fractures + MCL tear
  - Opted out of surgery and performed KAATSU training
- KAATSU Training is the original idea behind BFR and is still used today

https://kaatsu.com/pages/history

KAATSU vs BFR[3-6]

KAATSU

- Blood flow moderation
- Air bands (elastic and stretchable)
- Automatically controlled
- Modifies venous flow

KAATSU and BFR

- Simulates "high intensity/load training"
- Light load training
- Increases strength and hypertrophy

BFR

- Blood flow restriction
- Cuffs
- Manually controlled
- Occludes arterial flow and restricts venous flow

Types of Devices

KAATSU

https://kaatsu.com/collections/all/products/kaatsu-c4

BFR

https://www.smarttoolsplus.com/products/smartcuffs-3-0-2-cuffs-set

https://motusspt.com/blood-flow-restriction-therapy-technology/

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Various Theories/Mechanisms Behind BFR

Physiological Response[7,8]

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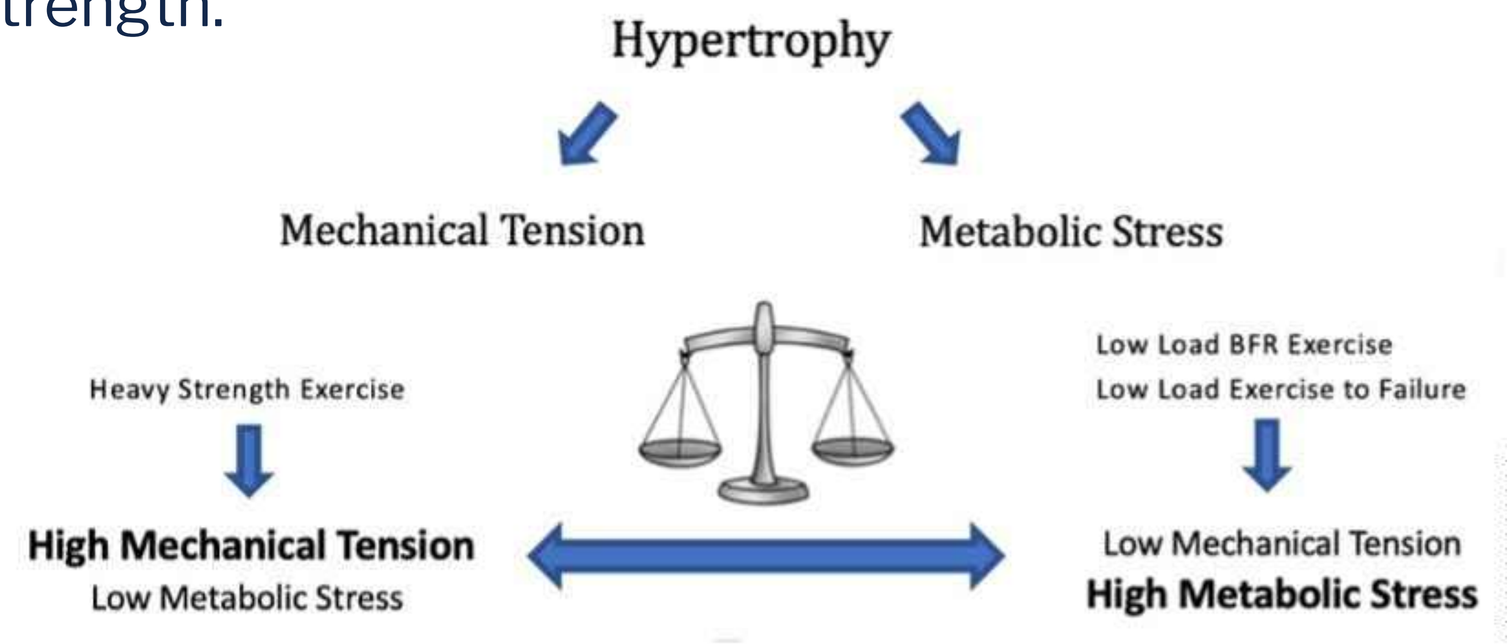
- Many mechanisms have been theorized that have not yet been confirmed
- Combination of metabolic stress caused by vascular occlusion and mechanical tension from resistance training work together to enhance muscle hypertrophy and strength.



https://accelerationaustralia.com.au/how-blood-flow-restriction-can-improve-strength/

Cellular and Metabolic Responses[7-9,10-12]

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- Occlusion has shown to influence metabolites, hormones, cell signaling, cellular swelling, and intracellular pathways

↑ GH, NE, La	→	crucial for muscle growth, recovery, and performance
↑ satellite cell proliferation	→	↑ muscle protein synthesis and myofiber size
activates mTOR pathway	→	↑ muscle protein synthesis and hypertrophy
downregulates MSTN pathway	→	prevents reduction in muscle mass, fiber size, and myonuclei number

GH: growth hormone; NE: norepinephrine; La: lactate; mTOR: mammalian target of rapamycin; MSTN: myostatin

Muscle Recruitment[13-15]

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- BFR has shown to cause:
    - Earlier recruitment of type II muscle fibers
    - Increased motor recruitment in both distal and *proximal* musculature
        - Studies have shown that the proximal muscle groups demonstrated greater levels of motor recruitment compared to the non-BFR group
            - BFR bench press training leads to significant increases in upper arm and chest muscle size and 1RM strength (Yasuda et al.)
            - Low load BFR b/l RTC training leads to greater increases in whole limb *and* shoulder region muscle mass, work capacity, and isometric strength (Lambert et al.)

Summary

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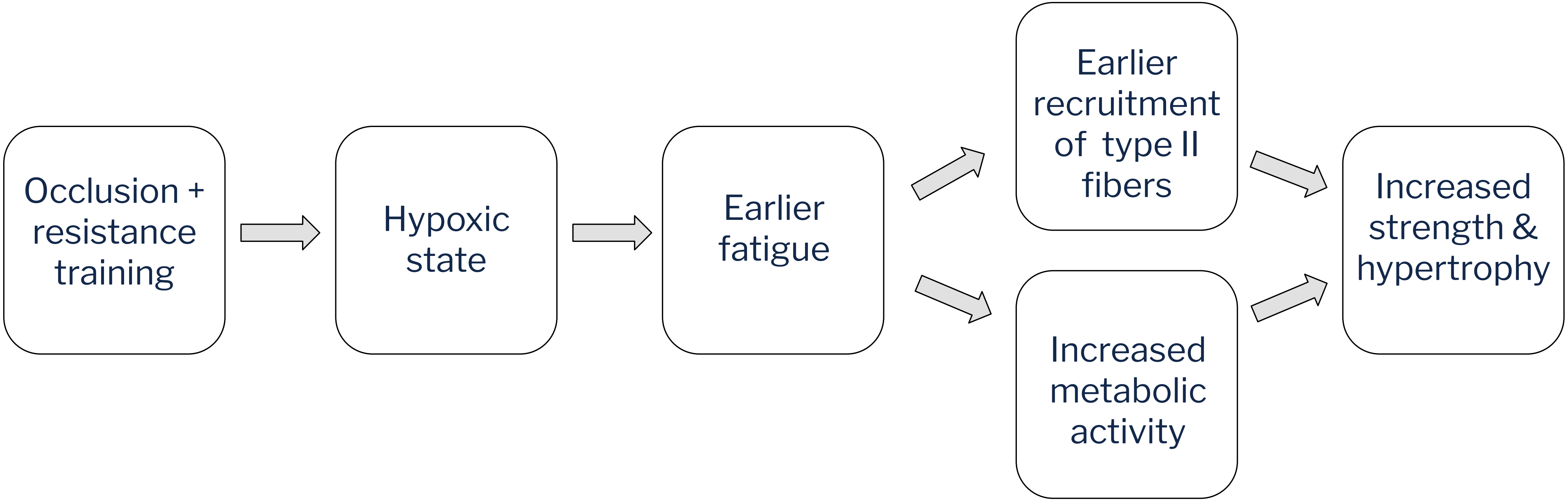

Determining Appropriateness for BFR

Various Populations/Conditions [8,16-20]

- Post-operative patients
- OA
- Inflammatory disorders
- Neurological conditions
- Atrophy
- Generalized weakness
- Sprains/strains
- Tendon Pathologies

Contraindications[21,22]

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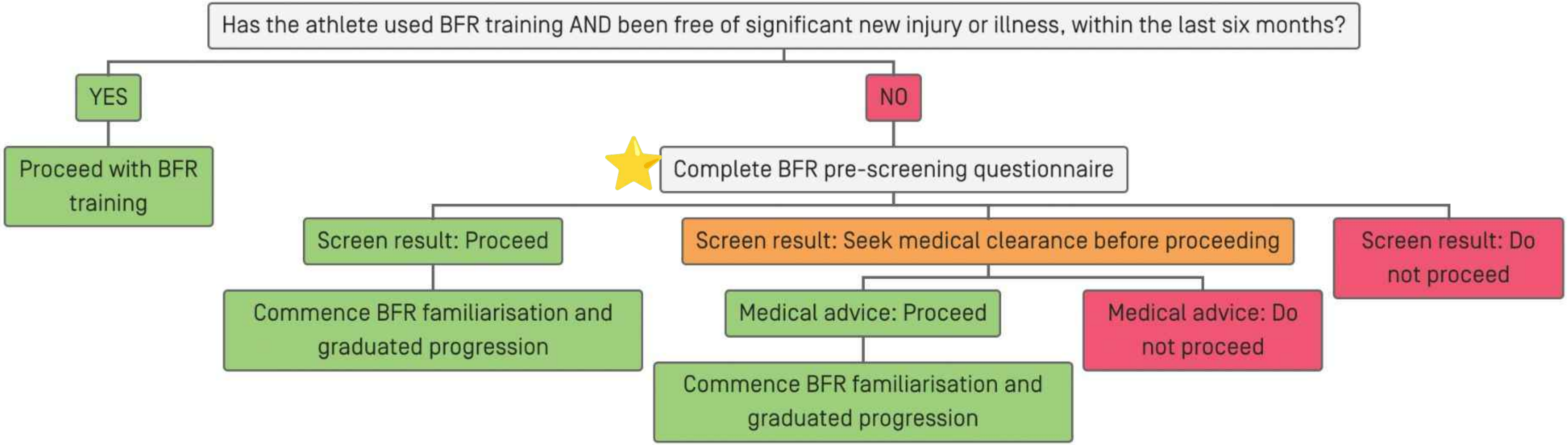
Absolute Contraindications

- Venous Thromboembolism (VTE)
- Severe uncontrolled hypertension (>180/120)
    - (some research has shown that low load BFR can be beneficial for patients with hypertension)
- Peripheral vascular disease or hx of vascular compromise
- Open fractures/wounds
- Cancer
- Active infection
- Previous vascular surgery to the affected limb
- Rhabdomyolysis

Relative Contraindications

- Pregnancy
- Diabetes
- Sickle cell anemia
- Renal compromise
- Lymphedema

Decision Tree[21]



Australian Institute of Sport [AIS]

Link to questionnaire:
https://www.ais.gov.au/__data/assets/pdf_file/0005/995405/36119_Blood-flow-restrictions-questionnaire.pdf

BFR Questionnaire[21]

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APPENDIX 1: BLOOD FLOW RESTRICTION PRE-SCREENING QUESTIONNAIRE

Athlete Name:

Date:

I have been informed about the potential risks and benefits associated with the use of BFR: Yes No

Please request this education before progressing any further with the questionnaire or BFR training.

BFR contradictions

Do you have peripheral vascular disease (circulatory problem involving the arteries to your arms or legs)?	Yes No
Have you had vascular (artery or vein) surgery to your arms or legs before?	Yes No
Have you had a skin graft to your arms or legs?	Yes No
Do you have an arteriovenous fistula in your arms or legs?	Yes No

BFR training is contraindicated in the case of answering yes to any of the questions above. Do not proceed with BFR training. Discuss with your doctor if clarification about your condition or history is required.

BFR precautions

Do you have a cognitive impairment or physical impairment?	Yes No
Have you ever been diagnosed with hypertension / high blood pressure?	Yes No
Do you have a bleeding disorder (e.g. haemophilia)?	Yes No
Do you have a blood clotting disorder (e.g. SLE (lupus), factor-V Leiden thrombophilia)?	Yes No
Do you have a past history of deep vein thrombosis (DVT) or pulmonary embolism (PE)?	Yes No
Have you had surgery in the last 12 weeks?	Yes No
Have you had one or both legs, or arms, immobilised for some reason in the last 4 weeks (e.g. prolonged bed rest, or having your leg or arm in plaster or a 'moon boot')?	Yes No

APPENDIX 1: BLOOD FLOW RESTRICTION PRE-SCREENING QUESTIONNAIRE

Have you ever had a stroke (haemorrhagic or thrombotic) or a transient ischaemic attack (TIA)?	Yes No
Have you ever been diagnosed with cancer?	Yes No
Have you been diagnosed with heart disease?	Yes No
Have you ever had rhabdomyolysis?	Yes No
Have you been diagnosed with diabetes?	Yes No
Do you have sickle cell disease?	Yes No
Have you ever had compartment syndrome?	Yes No
Do you have a history of nerve damage or injury?	Yes No
Have you had a previous complication or adverse event following BFR training?	Yes No
Do you have any other medical conditions not covered above, that you think should be discussed with a doctor prior to commencing BFR training?	Yes No
Are you pregnant?	Yes No

If you answer yes to any of the questions above, do not proceed. Please arrange a consult with a doctor before commencing BFR training, to assess whether it is safe for you

Are you taking the oral contraceptive pill? Yes No

The oral contraceptive pill may slightly increase the risk of blood clots. You may wish to discuss your individual risk further with your doctor before commencing BFR training.

Do you have any other medical conditions not covered above, that you think should be discussed with a doctor prior to commencing BFR training? Yes No

Please arrange a consult with a doctor before commencing BFR training, to assess whether it is safe for you.

It is important to acknowledge that this is not an exhaustive list of medical conditions that should prompt medical review. Any participant with medical concerns should be encouraged to err on the side of caution and seek medical review prior to commencing BFR training.

Link to questionnaire

Common Side Effects[1,24]

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- Pain or discomfort during exercise/activity
- DOMS (delayed onset muscle soreness)
- Temporary paresthesias
- Short-term discoloration

- Increased heart rate
- Increased blood pressure
- Increased stroke volume

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Safety & Risks Associated with BFR

Adverse Outcomes[24]

Of the 25,813 individuals were assessed, 1,672 (~6.4%) experienced an adverse outcome

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Number of individuals with adverse outcome	*n*= 1,662	*n*=9	*n*=1	*n*=0	*n*=0
Percentage related to adverse outcome cohort	99.4	0.54	0.06	0.00	0.00
Percentage of adverse outcomes to total number of individuals	6.44	0.03	0.003	0.00	0.00

BFRT: blood flow restriction therapy; total number of individuals (*n*=25,813).*

Clavien–Dindo classification system

- **Grade 1** - Any deviation from the normal therapeutic course without the need for any pharmacologic, surgical, or radiographic intervention
- **Grade 2** - Complication requiring pharmacologic intervention or supportive/noninvasive therapy
- **Grade 3** - Complication requiring invasive intervention
- **Grade 4** - Life-threatening complication requiring ICU care
- **Grade 5** - Complication resulting in Death

Adverse Outcomes cont. [24]

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- Most commonly reported adverse events:
  - Numbness
  - Dizziness
  - Subcutaneous hemorrhage
  - Rhabdomyolysis
- Unique adverse effects include:
  - Central retinal vein occlusion (CRVO)
  - Paget–Schroetter syndrome (PSS)
    *effort induced thrombosis in UE

Key takeaway:
Adverse events are rare, BUT if used improperly, it could result in harmful outcomes

Adverse Outcomes cont.[25]

- 136 professionals who perform some function related to physical rehabilitation, sports science, or physical conditioning
- Method: Surveyed via online questionnaire
- The main side effects observed were
  - Tingling (71.2%)
  - Delayed Onset Muscle Soreness (DOMS) (55.8%)
  - Excessive pain during exercise (45.2%)
- Less frequent side effects
  - Subcutaneous hemorrhaging (4.8%)
  - Fainting (3.8%)
  - Rhabdomyolysis (1.9%)

Medicine (Baltimore). 2021 May 7;100(18):e25794. doi: 10.1097/MD.0000000000025794

Application and side effects of blood flow restriction technique

A cross-sectional questionnaire survey of professionals

Victor Sabino de Queiros [a,*], Matheus Dantas [a], Gabriel Rodrigues Neto [b], Luiz Felipe da Silva [a], Marina Gonçalves Assis [c], Paulo Francisco Almeida-Neto [a], Paulo Moreira Silva Dantas [a], Breno Guilherme de Araújo Tinôco Cabral [a]

Editor: Sinan Kardes

Author information Article notes Copyright and License information

PMCID: PMC8104249 PMID: 33950976

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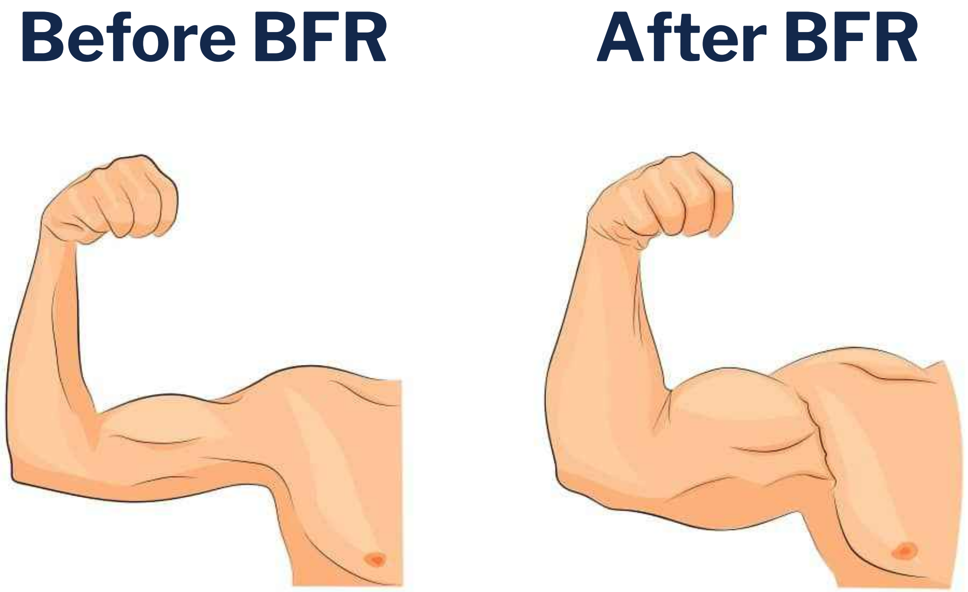
Overall Benefits of BFR

Benefits[8,13-15,25,26]

- Increased strength
- Increased hypertrophy
  - Both proximal AND distal to cuff
- Decreased pain
- Improved function
- Increased endurance



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More Benefits![26-28]

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- Increased VO2 max
- Faster RTS outcomes
  - Jack et al. reported that the BFR group had a significantly shorter time to RTS compared with control group
  - Positive benefits in strength and decreased RTS timelines.

BRIEF REVIEW

Effects of Blood Flow Restriction Training on Aerobic Capacity and Performance: A Systematic Review

Bennett, Hunter; Slattery, Flynn

Author Information

Journal of Strength and Conditioning Research 33(2):p 572-583, February 2019. | ***DOI:*** 10.1519/JSC.0000000000002963

Sports Health | SAGE

Sports Health. 2022 Jun 27;15(3):361–371. doi: 10.1177/19417381221101006

Blood Flow Restriction Therapy Preserves Lower Extremity Bone and Muscle Mass After ACL Reconstruction

Robert A Jack II †, Bradley S Lambert †, Corbin A Hedt †, Domenica Delgado †, Haley Goble †, Patrick C McCulloch †,*

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PMCID: PMC10170230 PMID: 35762124

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Post-Operative Considerations

BFR Post-Op

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- Can be initiated 2-14 days following surgery
- Greatest benefits were seen during the 6-8wk period when patients were non-WBing
- Early post-op phase preferred over mid-late phase

Arthroscopy
The Journal of Arthroscopic and Related Surgery
AANA ADVANCING THE SCOPE

EDITORIAL COMMENTARY · Volume 37, Issue 9, P2870-2872, September 2021 Download Full Issue

Editorial Commentary: Blood Flow Restriction Therapy Continues to Prove Effective

Robert F. LaPrade, M.D., Ph.D.[a] · Jill K. Monson, P.T., O.C.S[b] · Jon Schoenecker, P.T., O.C.S., C.S.C.S.[b]

Affiliations & Notes Article Info

LaPrade RF, Monson JK, Schoenecker J. Editorial Commentary: Blood Flow Restriction Therapy Continues to Prove Effective. Arthroscopy. 2021;37(9):2870-2872. doi:10.1016/j.arthro.2021.04.073

BFR Post-Op cont.[30]

- Primarily used for two reasons:
  - reduce atrophy
  - increase strength
- Studies show that BFR can be used as soon as 1-3 days following surgery

Authors (Year)	Start of BFR Training Postoperatively	No. of Exercises	Exercises	Intensity (Sets × Repetitions)	Frequency	Occlusion Time
Iversen et al.[22] (2016)	2 d	3	Isometric quadriceps contractions, terminal knee extensions, straight-leg raises	5 × 20	2× per day, consecutive	5 min of occlusion, followed by 3 min of reperfusion
Ohta et al.[23] (2003)	2 wk	7	Straight-leg raises, hip abduction, hip adduction, half squats, step-ups, knee flexion with elastic tubing, knee-bending walking	1-3 × 20-60	1× per day, 6 d/wk	NR
Takarada et al.[1] (2000)	0 d	NA	NA	5 × 5 min	2× per day, consecutive	5 min of occlusion, followed by 3 min of reperfusion
Tennent et al.[24] (2017)	2 wk	3	Leg presses, leg extensions, reverse presses	4 × 30, 15, 15, and 15	1× per day, 4 d/wk	5-min occlusion period and 1 min of reperfusion

DePhillipo et al. 2018

Recommended to check with surgeon prior to initiating BFR!

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Practical Applications

Determining Occlusive Pressure[1,2]

1. Measure Arterial Occlusive Pressure (AOP) before initiating BFR therapy
   - BFR unit
   - Doppler ultrasound unit or pulse oximeter could also be used (good reliability)

2. Determine cuff pressure
   - Arbitrary pressure selection
   - Percentage of systolic
   - Limb circumference
   - Intensity scale of tightness
   - Percentage of AOP
     i. *Upper Extremity (UE) - 40-50% of AOP*
     ii. *Lower Extremity (LE) - 60-80% of AOP*

Training occlusion should be based on AOP percentage to standardize pressure for each patient!!!

Factors that affect Cuff Pressure[1,31,32]

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Non-modifiable factors:

- Limb size
- Patient blood pressure
- Sex*
- Race*

Factors that affect Cuff Pressure[1,2,32]

Modifiable factors:

- Tourniquet shape, width, and length
    - The wider the cuff, the lower the overall pressure needed
- Patient positioning
    - Supine preferred

Exercise Parameters[2,8]

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Intensity

- Typically ~20-40% of 1 RM

Set/Repetitions

- 4 sets (1 x 30, 3 x 15)
- Can perform until failure

Rest

- 30-60 seconds
    - Longer rest breaks may impact the effects
- Intermittent occlusion may limit stress for adaptation

Frequency

- 2-3x/week is recommended
- Some research has shown to have benefits training twice daily
- High frequency approaches may be beneficial for short periods of time (1-3 weeks) but 2-3x/week is ideal

Equipment/Set-up

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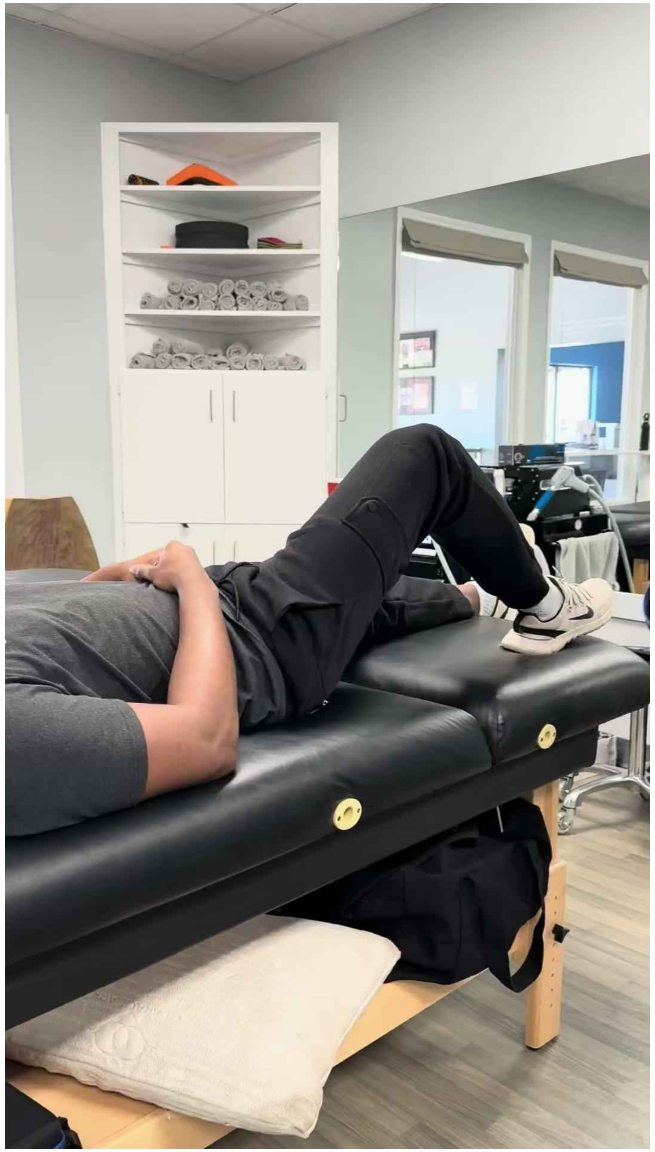

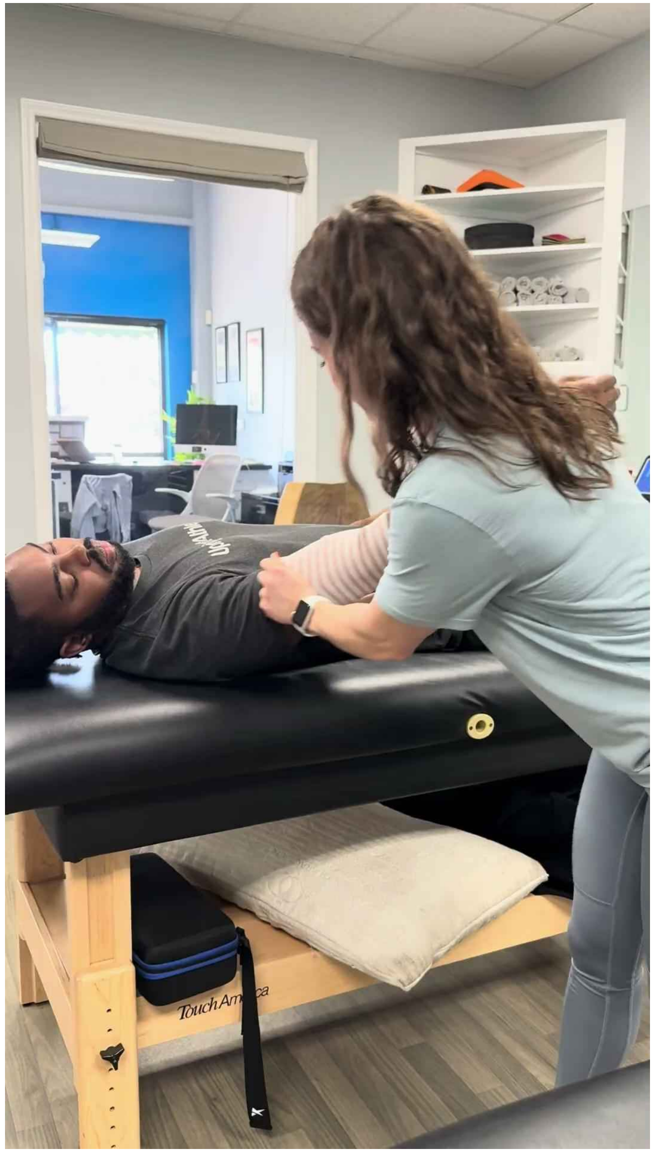

Sample Exercises

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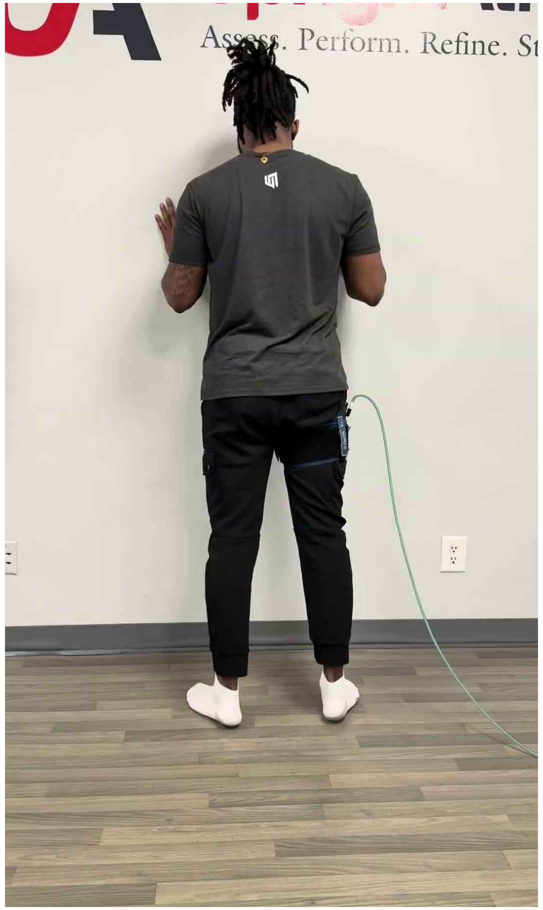

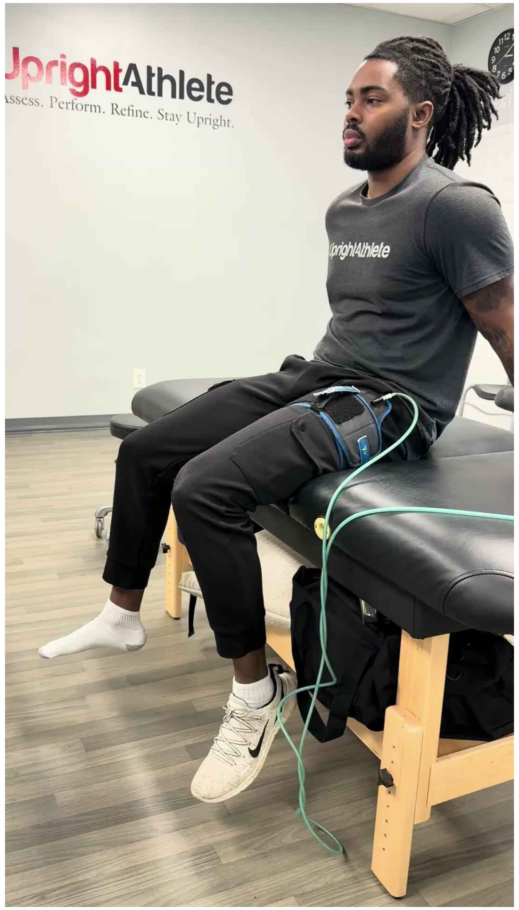

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A Review of the Literature: Using BFR following ACL Tear/Reconstruction

Strength[33-35]

Study Type	Objective	Participants/Methods	Results
Randomized Controlled Trial Vieira et al. 2022	Assessment of Quad/HS strength following exercises with and without BFR doppler used	Men and women (ages 18-59) with confirmed ACL rupture within last 2 months with planned reconstruction <u>Interventions</u>: Leg press, OKC knee extension/flexion Occlusion training took place immediately after hospital discharge	BFR group demonstrated greater gain in extension strength following the 3rd post-surgical period and greater flexion strength following the 2nd post–surgical period BFR group showed a statistically more rapid gain in improvement in quad/HS strength compared to control group
Randomized Controlled Trial Hughes et al. 2019	Comparing BFR resistance training (BFR-RT) to traditional heavy load resistance training (HL-RT) in ACLR patients following surgery. delphi unit used	n=28; 8 week biweekly program following ACLR Occlusion training 2 wks post-op <u>Interventions</u>: Unilateral leg press + standard hospital rehabilitation	No group differences found for 10RM or knee ext/flex peak torque BFR group had greater attenuation of knee extensor peak torque loss at 150°/s and 300°/s and knee flexor torque loss at all speeds.
Randomized Controlled Trial Okoroha et al. 2023	Evaluate post-operative isometric strength in patients following ACLR utilizing a perioperative BFR program	n= 46; 2 wks of prehab + standardized postoperative 12 wk PT protocol <u>Interventions</u>: quad sets, SLR, long arc quad sets, and quarter squats	At 6 wks post-op, the BFR group demonstrated significantly greater strength compared with the controls

Strength cont.[36]

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Study Type	Objective	Participants/Methods	Results
Systematic review Koc et al. 2022	Examine effects of low-load BFR (LL-BFR) compared to non-BFR training in individuals following ACLR .	6 RCTs evaluated Interventions: unilateral leg press, quad isometrics, knee extensions, SLR, hip abduction/adduction, partial squats, step ups	Greater strength improvements were seen in patients that performed LL-BFR compared to the non-BFR group

IJSPT INTERNATIONAL JOURNAL OF SPORTS PHYSICAL THERAPY

Int J Sports Phys Ther. 2022 Apr 1;17(3):334–346. doi: 10.26603/001c.33151

Effect of Low-Load Blood Flow Restriction Training After Anterior Cruciate Ligament Reconstruction: A Systematic Review

Baris B Koc [1,✉], Alexander Truyens [1], Marion JLF Heymans [2], Edwin JP Jansen [1], Martijn GM Schotanus [3]

Author information Article notes Copyright and License information

PMCID: PMC8975583 PMID: 35391871

Hypertrophy/CSA[34,36,37]

Study Type	Objective	Participants/Methods	Results
Randomized Controlled Trial Hughes et al. 2019	Comparing BFR resistance training (BFR-RT) to traditional heavy load resistance training (HL-RT) in ACLR patients following surgery.	n=28 8 week biweekly program following ACL reconstruction Interventions: Unilateral leg press + standard hospital rehabilitation	Significant and comparable increases in muscle thickness and pennation angle (greater capacity for force)
Systematic Review Koc et al. 2022	Examine effects of low-load BFR (LL-BFR) compared to non-BFR training in individuals following ACLR .	6 RCTs evaluated Interventions: unilateral leg press, quad isometrics, knee extensions, SLR, hip abduction/adduction, partial squats, step ups	LL-BFR has shown to have benefits regarding quadriceps mass compared to non-BFR training
Systematic Review Charles et al. 2020	Analyze the effect of utilizing BFR on reducing quadricep atrophy and circumference post ACLR	4 RCTs	Using BFR alongside low load resistance training can have a positive effect on remediating the loss of femoral CSA following ACLR

Hypertrophy/CSA[38]

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Study Type	Objective	Participants/Methods	Results
Takarada et al. 2000	Determine effects of vascular occlusion on quad size without exercise following ACLR	n=16; 2 weeks occlusion began on the post-op day 3, semi-fowler's position, 5min on/3min off, 2x/day	For knee extensors, CSA decreased by 9.4% in the experimental group and 20.7% in the control group For knee flexors, CSA of knee flexors decreased by 9.2% in the experimental group and 11.3% in the control group

CLINICAL SCIENCES: CLINICALLY RELEVANT

Applications of vascular occlusion diminish disuse atrophy of knee extensor muscles

TAKARADA, YUDAI; TAKAZAWA, HARUO; ISHII, NAOKATA

Author Information

Medicine and Science in Sports and Exercise 32(12):p 2035-2039, December 2000.

Pain[33,34,36]

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Study Type	Objective	Results
Randomized Controlled Trial Vieira et al. 2022	Quad/HS strength following exercises with and without BFR	Statistical difference in KOOS pain scores at 4-week follow-up; greater pain reduction observed in the BFR group.
Randomized Controlled Trial Hughes et al. 2019	Comparing BFR resistance training (BFR-RT) to traditional heavy load resistance training (HL-RT) in ACLR patients following surgery.	Significant increase in KOOS pain score and greater reduction in joint effusion after 8 weeks
Systematic Review Koc et al. 2022	Examine effects of low-load BFR (LL-BFR) compared to non-BFR training in individuals following ACLR .	Significant reduction in pain scores were seen in the BFR group compared to the control

Function/Other Outcomes[33-35]

Study Type	Objective	Results
Randomized Controlled Trial Vieira et al. 2022	Assessment of Quad/HS strength following exercises with and without BFR doppler used	Significant improvements in IKDC and Lysholm questionnaires after the 8th and 12th week.
Randomized Controlled Trial Hughes et al. 2019	Comparing BFR resistance training (BFR-RT) to traditional heavy load resistance training (HL-RT) in ACLR patients following surgery.	BFR-RT had significantly greater self-reported function in all measures (IKDC, LEFS, Lysholm) and Y-balance performance
Randomized controlled trial Okoroha et al. 2023	Perioperative BFR program	BFR group had significantly better patient reported outcomes at the 6 weeks post-op (PROMIS and IKDC)

Strength

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Category	Study/Group	Key Findings
Strength	Quad/HS	Greater gains in strength (extension and flexion movements) in BFR group compared to control group.
	HL-RT vs BFR-RT	Both groups showed significant improvements in strength; no group differences in strength outcomes.
	LLRT-BFR vs training w/o BFR	BFR group showed a greater increase in strength compared to non-BFR group
	Perioperative BFR program	BFR group showed greater strength at 6 weeks post-op compared to control group; control group showed a significant strength drop in the operative leg.

Hypertrophy/CSA

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Category	Study/Group	Key Findings
Hypertrophy/CSA	HL-RT vs BFR-RT	Similar significant increases in muscle thickness and pennation angle for both groups.
	LL-BFR vs non-BFR	Significant increase in quadriceps CSA after 14 weeks of LL-BFR compared to non-BFR.
	Using BFR to reduce quad atrophy and circumference	Using BFR + low load resistance exercises can have a positive benefit on remediating the loss of femoral CSA following ACLR
	Occlusion without exercises	Less atrophy in BFR group compared to control

Pain/Function

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Category	Study/Group	Key Findings
Pain	LL-BFR vs non-BFR	Significant decrease in pain scores in the BFR group compared to the non-BFR group.
	Quad/HS	Statistical difference in KOOS pain scores at 4-week follow-up; pain reduction observed in BFR group.
	HL-RT vs BFR-RT	Significant improvement in knee joint pain in BFR-RT group compared to HL-RT group.
Function/Other Outcomes	HL-RT vs BFR-RT	BFR-RT showed significantly greater increases in self-reported function, Y-balance performance, ROM, and effusion.
	Quad/HS	Significant improvements in KOOS, IKDC, and Lysholm questionnaires at 8th and 12th weeks.
	Perioperative BFR program	BFR group had better patient-reported outcomes at 6 weeks post-op (Physical Function and IKDC scores).

Recap

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- ★ BFR therapy is effective for various populations, including athletes, older adults, and post-operative patients.
- ★ It is particularly helpful in post-surgical recovery, preventing muscle loss and improving strength and overall function.
- ★ Abiding by the appropriate parameters and protocols are crucial for overall safety and effectiveness.
- ★ Low load BFR has proven to be more beneficial than non-BFR exercises but cannot and should not be used in replacement of traditional high load resistance training.
- ★ BFR can be combined with other rehabilitation strategies to enhance recovery and improve patient outcomes.

Benefits for Highly Trained Athletes

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american physiological society
JOURNAL OF APPLIED PHYSIOLOGY
J Appl Physiol 130: 1163–1170, 2021.
First published February 18, 2021; doi:10.1152/japplphysiol.00982.2020

REVIEW

Blood flow restriction training and the high-performance athlete: science to application

Christopher Pignanelli,[1] Danny Christiansen,[2] and Jamie F. Burr[1]
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Abstract

The manipulation of blood flow in conjunction with skeletal muscle contraction has greatly informed the physiological understanding of muscle fatigue, blood pressure reflexes, and metabolism in humans. Recent interest in using intentional blood flow restriction (BFR) has focused on elucidating how exercise during periods of reduced blood flow affects typical training adaptations. A large initial appeal for BFR training was driven by studies demonstrating rapid increases in muscle size, strength, and endurance capacity, even when notably low intensities and resistances, which would typically be incapable of stimulating change in healthy populations, were used. The incorporation of BFR exercise into the training of strength- and endurance-trained athletes has recently been shown to provide additive training effects that augment skeletal muscle and cardiovascular adaptations. Recent observations suggest BFR exercise alters acute physiological stressors such as local muscle oxygen availability and vascular shear stress, which may lead to adaptations that are not easily attained with conventional training. This review explores these concepts and summarizes both the evidence base and knowledge gaps regarding the application of BFR training for athletes.

BFR exercise; ischemic training; sport performance; vascular occlusion

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REVIEW ARTICLE

Blood-flow-restricted exercise: Strategies for enhancing muscle adaptation and performance in the endurance-trained athlete

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Abstract

A key objective of the training programme for an endurance athlete is to optimize the underlying physiological determinants of performance. Training-induced adaptations are governed by physiological and metabolic stressors, which initiate transcriptional and translational signalling cascades to increase the abundance and/or function of proteins to improve physiological function. One important consideration is that training adaptations are reduced as training status increases, which is reflected at the molecular level as a blunting of the acute signalling response to exercise. This review examines blood-flow-restricted (BFR) exercise as a strategy for augmenting exercise-induced stressors and subsequent molecular signalling responses to enhance the physiological characteristics of the endurance athlete. Focus is placed on the processes of capillary growth and mitochondrial biogenesis. Recent evidence supports that BFR exercise presents an intensified training stimulus beyond that of performing the same exercise alone. We suggest that this has the potential to induce enhanced physiological adaptations, including increases in capillary supply and mitochondrial function, which can contribute to an improvement in performance of endurance exercise. There is, however, a lack of consensus regarding the potency of BFR training, which is invariably attributable to the different modes, intensities and durations of exercise and BFR methods. Further studies are needed to confirm its potential in the endurance-trained athlete.

KEYWORDS
blood-flow-restricted exercise, capillary, ischaemic training, mitochondria, sport performance

Resources

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- **The Prehab Guys: Blood Flow Restriction Training in a Nutshell**
  - https://theprehabguys.com/blood-flow-restriction-training-in-a-nutshell/
- **Mike Reinold's Ultimate Guide to Blood Flow Restriction Training**
  - https://mikereinold.com/the-science-of-blood-flow-restriction-training/#what-is-blood-flow-restriction-training
- **AAMT BFR Certification**
  - https://spinalmanipulation.org/dates-and-locations/bfr/
- **SmartTools Level I BFR Course**
  - https://courses.smarttoolsplus.com/courses/level-1-blood-flow-restriction-current--36c7e6aa-be93-41e3-8d51-1d8e952a9637/salespage
- **OwensRecovery Science BFR Course**
  - https://owensrecoveryscience.com/bfr-courses/

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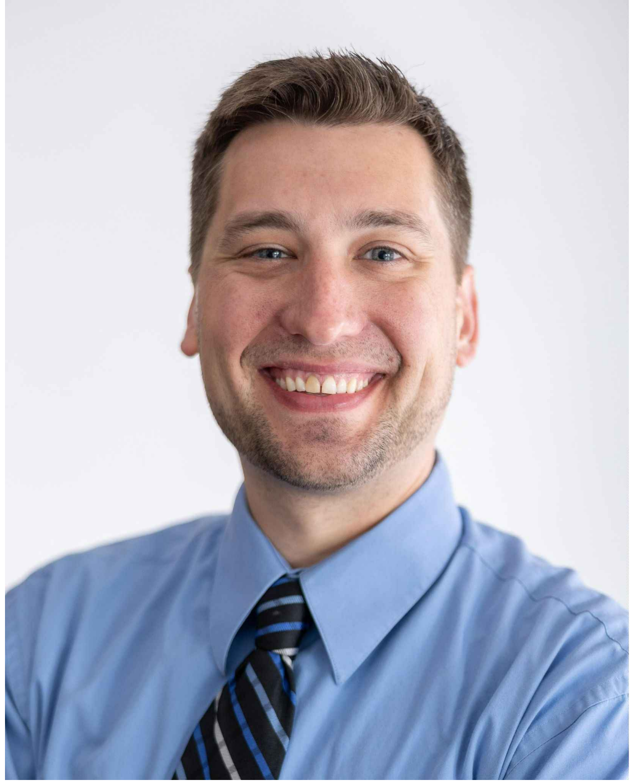

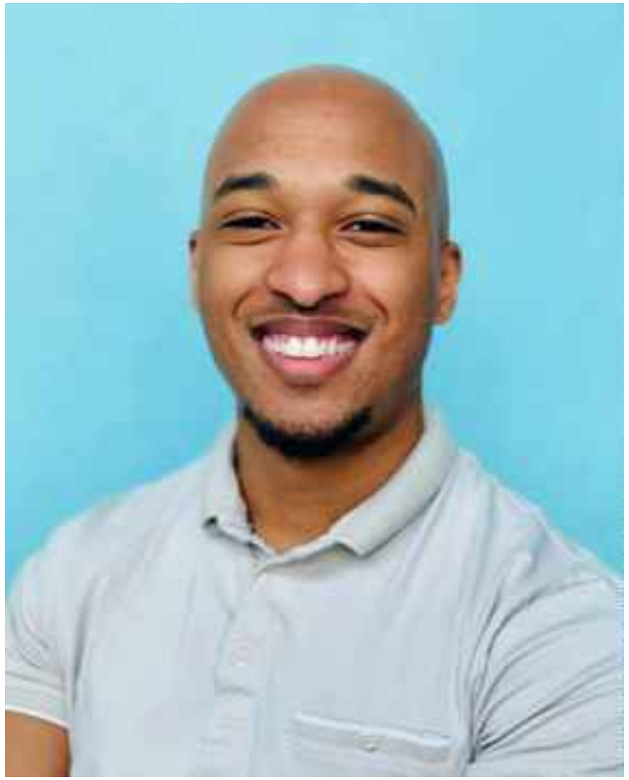

Patient Handout

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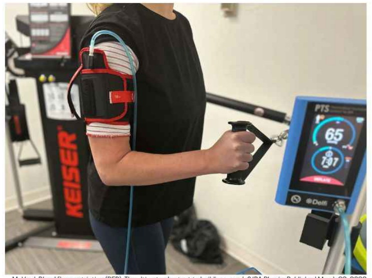
Blood Flow Restriction (BFR)

What is BFR?

A pressurized cuff is placed around your arms or legs that restricts blood flow during exercise.

This can make your muscles feel like they are working hard without lifting heavy weights.



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What are the benefits?

BFR has been shown to help:

- Increase strength
- Increase muscle size
- Decrease pain
- Improve function

What are normal side effects?

- Pain
- Soreness
- Tingling
- Bruising
- Discomfort
- Temporary redness

Can I use BFR?

Your therapist may suggest BFR if you have:

- Recent surgery
- Generalized weakness
- Tendon injuries
- More!

Ask your physical therapist if BFR is right for you.

Safety Considerations

If you have any of the following, talk to a doctor or medical professional before using BFR:

- Circulatory issues
- Heart Conditions
- Pregnancy
- Cancer
- Diabetes

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For more information, visit: https://nhssca.us/wp-content/uploads/2017/10/Free-BFR-Ebook-Gift.pdf

This handout was created by: Ethan Lam, SPT (UNC Class of 2025)

Feedback Survey

Questions???

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