Blood Flow Restriction Therapy:

Is this a real advance in muscle growth and recovery ?

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UCSF

Many thanks to one of the advanced practitioners of this treatment

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Objectives

- Understand basics of BFRT: what is it – how do you do it
- Explore the literature on the safety and efficacy of BFRT
- Highlight the concerns and contraindications
- Explore which of our patients this may be of benefit for

basics

- Skeletal muscle is constantly adapting
- Atrophy is common
- Traditionally need greater than 70% 1RM to stimulate and build muscle – many time our patients can't achieve this

Basis of Exercise measurement : One Repetition Maximum (1RM)

- Defined as the maximum amount of weight that a person can possibly lift for one repetition
- maximum amount of force that can be generated in one maximal contraction
- can either be calculated directly using maximal testing or indirectly using submaximal estimation
- The submaximal estimation method is preferred as it is safer, quicker, and less unnerving for inexperienced exercisers

Rep Max (1 RM)

- There are many Formulas

- **Epley Formula**

$$1\,\text{RM} = w\left(1 + \frac{r}{30}\right), \text{ assuming } r > 1.$$

- **Brzycki Formula**

$$1\,\text{RM} = w \cdot \frac{36}{37 - r} = \frac{w}{\frac{37}{36} - \frac{1}{36}r} \approx \frac{w}{1.0278 - 0.0278r}$$

Suggested goals

- 50% 1RM : Explosive power
- 70% 1RM : Endurance
- 80% 1RM : Muscle toning
- 90% 1RM : Power
- 95% 1RM : Strength

Mens Health 2019

Typical Exercise RX for Strength and Hypertrophy

- Based on Good form to **failure**
- **Measured by Rep Max (1RM)**

Typical Exercise RX for Strength and Hypertrophy

- 65%-105% 1RM
- Microtearing
- Loaded Tissue Damage
- Increased chance injury
- Higher loading forces
- Intense local Inflammatory responses

Alternative:
Blood Flow Restriction Training (BFR)

- 20-40% 1RM
- Less mechanical damage
- Decreased loading forces
- Larger Biochemical response

BFR origins

- was originally developed in Japan in the late 1970s: Was termed KAATSU training/sometimes call occlusion training

- Recent surge of interest - 2000 publications since 2015

- combines metabolic and mechanical stress to stimulate muscle strength, hypertrophy, and angiogenesis.

- Now mainstream and heavily marketed in the exercise industry.

BFR marketing

basics

- Metabolic stress occurs through vascular occlusion with the use of a tourniquet on the proximal upper or lower extremity. This occludes venous outflow while maintaining arterial inflow, creating a hypoxic environment, which drives anaerobic metabolism

- Mechanical stress occurs through low-load resistance exercise, with loads as low as 20% of 1RM

basics

- In our world this is attractive for rehabilitation of
  - **injured and postoperative**
  - **the elderly**
  - **Any unable to tolerate high-resistance training routines**.

- Maybe helpful for athletic performance training

- adjunct to traditional training routines to decrease musculoskeletal stress on the athlete.

evidence

Review Article

Blood Flow Restriction Therapy: Where We Are and Where We Are Going

Bryan G. Vopat, MD
Lisa M. Vopat, MD
Megan M. Bechtold, DPT
Kevin A. Hodge, MD

- J Am Acad Orthop Surg 2020;28:e493-e500 ; DOI: 10.5435/JAAOS-D-19-00347

evidence

- *Hughes L, Paton B, Rosenblatt B, GissaneC, Patterson SD: Blood flow restrictiontraining in clinical musculoskeletalrehabilitation: A systematic review and meta-analysis. Br J Sports Med 2017;51:1003-1011.*

- Twenty studies, pooled data
- Compared low load training with low load training and BFR
- Moderate effect on increasing strength, less effective than heavy load training

Does Blood Flow Restriction Therapy in Patients Older Than Age 50 Result in Muscle Hypertrophy, Increased Strength, or Greater Physical Function? A Systematic Review

Breanne S. Baker, PhD, Michael S. Stannard, MS, Dana L. Duren, PhD, James L. Cook, DVM, PhD, and James P. Stannard, MD

Clin Orthop Relat Res. 2020 Mar; 478(3): 593–606. PMCID: PMC7145054
Published online 2019 Dec 18. doi: 10.1097/CORR.0000000000001090 PMID: 31860546

- Level 2 study
- Highlights the heterogeneity of the studies
- Concludes the benefits are still there in the older than 50 year old age group

Meta-Analysis (Arriaga and Koch 2018, UCSF)

The Effectiveness of BFR in Attenuating Muscle Atrophy and Increasing Strength Following Knee Surgery

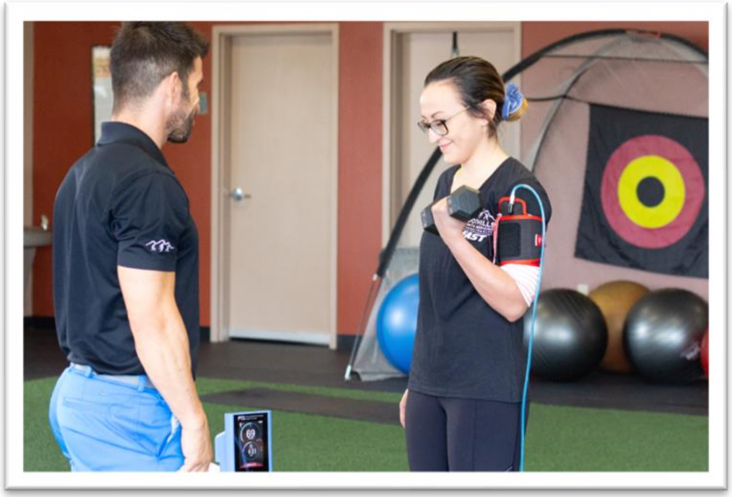
Findings for knee strength and CSA

- BFR protocol + standard rehabilitation attenuates quadriceps atrophy & strength compared to standard rehabilitation alone
- BFR may positively impact hamstring strength, but not statistically significant

Other Considerations

- No serious adverse effects reported
- Proper training and equipment is required $$$
- Specific protocol & BFR parameters unclear

Rehab: Why and who



Clinical applications and rehab:

- Post surgical atrophy
- Strength gains
- Aerobic capacity
- Ischemic Preconditioning
- Bone health
  - (Raschke 2007- 26% faster bone healing after Fx)

- Populations:
  - Ages 10 – geriatric
  - Ortho, Sports, neurologic

BFRT Investigations in the Elderly Cohort

Study	Exercise	Frequency/ Duration	BFR (Size)	Outcome
Abe et al[18] (N = 19)	Treadmill walking (20 min at 67 m/min)	5 d per wk for 6 wk	160-200 mm Hg (size not recorded)	Significant increase in knee extension isometric (11%) and extension/flexion isokinetic (7–16%) strength, CSA (5.8%) with no change in control. Improved TUG and chair to stand performance.
Bryk et al[19] (N = 34)	Knee extensions (3× 20 reps, 30% 1RM)	3 d per wk for 6 wk	200 mm Hg (size not recorded)	Significant increase in quadriceps strength (72% in BFRT versus 39% in control; no difference in between group analysis), lower NPRS knee pain score compared with high-load training (2.5 versus 6.2).
Segal et al[20] (N = 40)	Leg press (30-15-15-15, 30% 1RM)	3 d per wk for 4 wk	160-200 mm Hg (6.5 cm)	Significant increase in isokinetic knee extension strength compared with body mass (0.07 versus −0.05 nm/kg), increased isotonic leg press strength (28.3 versus 15.6 kg), and stair climb power (improved in both groups).
Yasuda et al[21] (N = 17)	Arm curls; triceps pull-downs (4 sets of 30-15-15–15, elastic resistance bands)	2 d per wk for 12 wk	180-270 mm Hg (3 cm)	Significant increase in elbow flexor and extensor strength (7.8% and 16.1%) and CSA (17.6% and 17.4%) with no change in control.

1RM = one maximum repetition, BFRT = blood flow restriction therapy, CSA = cross-sectional area, NPRS = Numerical Pain Rating Scale, TUG = Timed Up and Go

BFRT Investigations in Injured and Postoperative Rehabilitation Patients

Study	Focus	Exercise	Frequency/ Duration	BFR (size)	Outcome
Ohta et al[3] (N = 44)	ACL reconstruction	Straight leg raise Hip joint abduction/ adduction Half squat Elastic tube knee bending Knee-bending walking (20–60 reps for 1–3 times per d, bodyweight)	6 d per wk for 14 wk	180 mm Hg (size not recorded)	Significantly increased knee extensor CSA (101% BFRT versus 92%) and strength (surgical side/healthy side: 84% versus 63% extensor, 72% versus 62% flexor at IM60) compared with matched control.
Takarada et al[2] (N = 16)	ACL reconstruction	BFR alone (5 × 5 min of occlusion)	2 times per d for 12 d	200-260 mm Hg (9 cm)	Significant reduction in postsurgical atrophy of approximately 50% compared with control.
Iverson et al[22] (N = 24)	ACL reconstruction	Quadriceps exercise programs (5 × 20 reps, low load)	2 times per d for 13 d	130-180 mm Hg (14 cm)	No significant change in postsurgical atrophy compared with control.
Tennent et al[23] (N = 17)	Nonreconstructive knee arthroscopy	Leg press Leg extension Reverse press (30-15-15-15, 30% 1RM)	2 d per wk for 6 wk	80% AOP	Significantly increased thigh girth (1.75 cm increase compared with no change in control), strength (74% improvement in BFRT group versus 34% in control), improved timed stair ascent.

1RM = one maximum repetition, ACL = anterior cruciate ligament, AOP = arterial occlusion pressure, BFRT = blood flow restriction therapy, CSA = cross-sectional area, IM60 = isometric contraction at 60 degrees of knee flexion

BFRT Investigations in Athletic Performance Training

Study	Focus	Exercise	Frequency/Duration	BFR (Size)	Outcome
Takarada et al[24] (N = 17)	Rugby (n = 17)	Knee extension (4× to failure, 50% 1RM)	2 times per wk for 8 wk	196 ± 6 mm Hg (3.3 cm)	Improved isokinetic strength (14.3% versus 3.2%) and endurance (change in mechanical work and force production after 50 repeated contractions) compared with control. Increased knee extensor CSA (12.3%), however, not measured in control.
Yamanaka et al[16] (N = 32)	College football	Bench press and squat (30-20-20-20, 20% 1RM)	3 times per wk for 4 wk in addition to normal training routine	Practical BFRT	Improved 1RM for bench press (7%) and squat (8%) compared with no significant difference in control.
Park et al[25] (N = 12)	College basketball	Treadmill walking (5 sets of 3 min at 4-6 km h^{-1})	2 times per wk for 2 wk	160-200 mm Hg (11 cm)	Significantly increased VO_{2max} (11.6%) and VE_{max} (10.6%) and anaerobic capacity (2.5%) compared with no change in control.
Cook et al[26] (N = 20)	Semiprofessional rugby	Bench press, squat, weighted pull-up (5 sets × 5 reps, 70% 1RM)	3 times per wk for 3 wk	180 mm Hg (10.5 cm)	Significant increase in squat (7.8% versus 4.3%) and bench press (5.4% versus 3.3%) 1RM.

1RM = one maximum repetition, BFRT = blood flow restriction therapy, CSA = cross-sectional area, VE_{max} = maximum minute ventilation, VO_{2max} = maximum oxygen uptake

Application

In standard protocol:

- compression devices apply a pressure high enough to occlude up to 80% LE of Arterial Occlusion pressure (AOP) to the muscle

AOP

- The optimal percentage of AOP is controversial

- Similar effects on muscle development were obtained at 40% of AOP compared with 90% at 8 weeks

Counts BR, Dankel SJ, Barnett BE, et al: Influence of relative blood flow restriction pressure on muscle activation and muscle adaptation. Muscle Nerve 2016;53: 438-445.

Choices: marketing and Market

- Delphi
- Smartcuffs
  - Pump vs auto Pro
- Katsu
- Rockcuff
- AirBands
- B-strong, Edge, H+, Fitcuff…
- All the other straps and bands

Application

- There are two options of restriction cuff:
  - Individualized BFRT
  - Practical BFRT

How: Calibrating and assessing

BFR optimization

- *Assessing 100% limb arterial occlusion*
- *Calculate % desired from that number*

(Scott et al 2014)

How: Likely Mechanism

- It is really REALLY tough = Max motor firing recruitment
- “Altitude training for your muscles”
  - BURN

How: Proposed Mechanisms

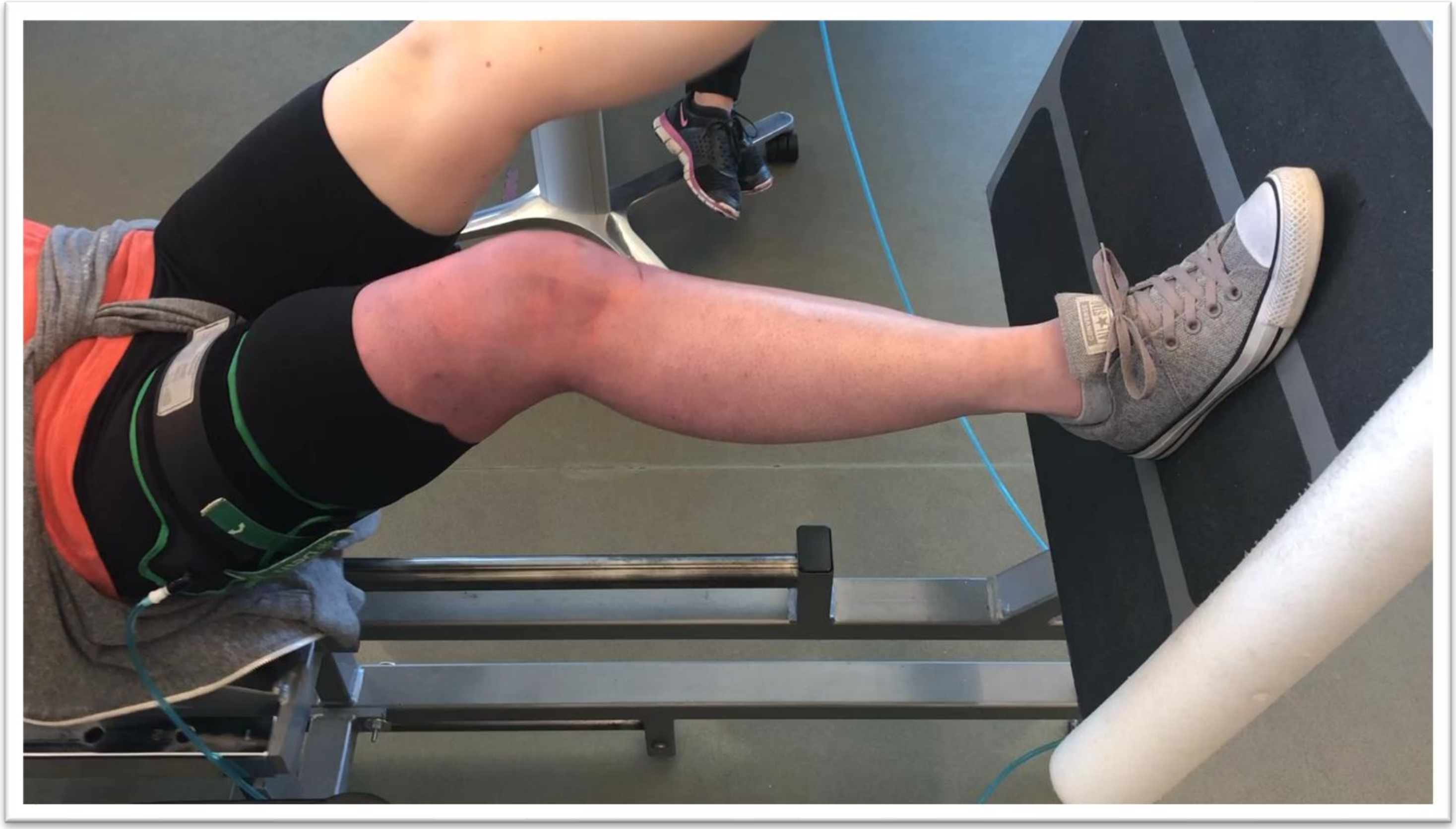
- Mechanism not fully clear
- Combination of mechanical and metabolic stress
- Act together to signal secondary mechanisms: tissue hypoxia, build-up of metabolites,and cellular swelling
- promotes autocrine and paracrine signaling pathways that lead to protein synthesis, type 2 muscle fiber recruitment, local and systemic anabolic hormone synthesis, and stimulation of myogenic stem cells

Pearson SJ, Hussain SR: A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. Sports Med 2015;45:

How:

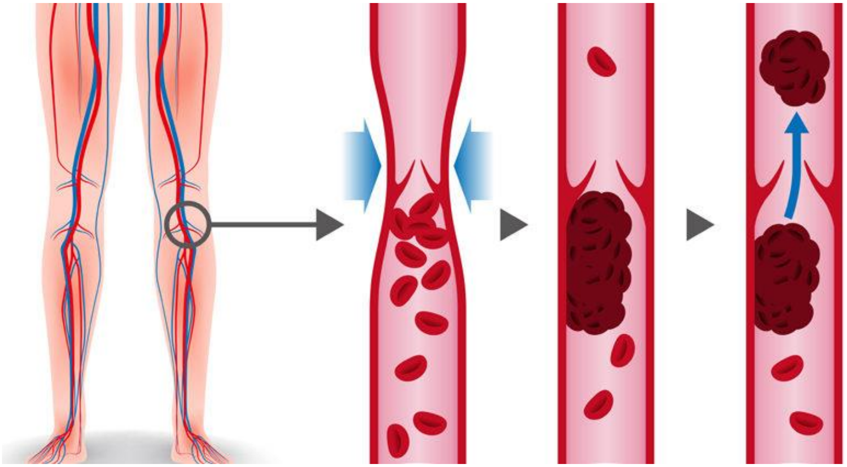
MECHANISMS
Arterial Reduced Flow
Muscle Activation/Metabolites
Lactate/HGH
IGF1/VEGF/Progenitor Cells
MPS
Venous Blocked Flow
Metabolite Stress
Myocyte Swelling
Stroke Volume

How:



RISKS: DVT

- **Risk of Serious Adverse Events**
- **Nakajima Study: 13,000 patients**



Less than 0.1% occurrence

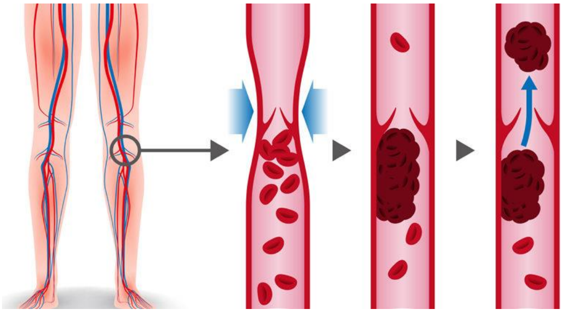
Nakajima T, Kurano M, Iida H, et al: Use and safety of KAATSU training: Results of a national survey. Int J KAATSU Train Res 2006;2:5-13.

DVT risk

- No elevation of fibrinogen or D-dimer
- May actually stimulate the fibrinolytic system !

Patterson SD, Brandner CR: The role of blood flow restriction training for applied practitioners: A questionnairebased survey. J Sports Sci 2018;36: 123-130.

Additional Adverse Events



- Subcutaneous hemorrhage: 13%
- Numbness: 1.3%
- Lightheadedness: 0.3%

Nakajima T, Kurano M, Iida H, et al: Use and safety of KAATSU training: Results of a national survey. Int J KAATSU Train Res 2006;2:5-13.

(Nakijima et al 2006) Arriaga 2018

Exercise Pressor Reflex: EPR

- Normal response to exercise, with elevated metabolites such as lactate and hydrogen ions and sympathetic activity
- BFR causes an exaggerated EPR
- potential to cause adverse cardiac events including arrhythmias, stroke, myocardial infarction, or sudden cardiac death
- Exercise caution in patients with underlying cardiovascular morbidity

Other concerns

- Venous hypertension leading to damage of the valves and venous insufficiency
- Muscle damage and Rhabdomyolysis
- potential to cause adverse cardiac events including arrhythmias, stroke, myocardial infarction, or sudden cardiac death
- Exercise caution in patients with underlying cardiovascular morbidity

Contraindications:

- poor circulatory flow to extremity
  - shinny or scaly skin; brittle, dry nails; and extremity hair loss.
  - Consider capillary filling time – nail beds
- clotting issues – platelet count, thrombocytopenia
- Diabetes
- Sickle cell trait
- Hypertension
- Cardiopulmonary conditions, blood thinners
- Atherosclerotic vessels
- obese or with limb tissue that is loose
  - Sliding of the cuff
- Pinching of skin
  - Protect with sleeve between skin and cuff
  - Most proximal position possible

Contraindications:

- Cardiovascular disease
  - Coronary heart disease
  - Unstable hypertension
  - Peripheral vascular disease
  - Venous thromboembolism
  - Hypercoagulable states (blood clotting disorders)
  - Cardiopulmonary conditions
  - Atherosclerotic vessels causing poor blood circulation
  - Silent myocardial ischemia
  - Left ventricular dysfunction
  - Hemophilia
  - Vascular endothelial dysfunction
  - Varicose veins
  - Induration/Marfan syndrome
- Musculoskeletal injury
  - Recent muscle trauma or crush injuries
  - Postsurgical excess swelling
  - Open fractures
  - Open soft tissue injuries
  - Skin graft
- Lifestyle
  - Age
  - Smoking
  - Body mass (eg, obesity)
  - Pregnancy
  - Uncontrolled diabetes mellitus
  - Dyslipidemia
  - Dehydration
- Family medical history
  - Clotting disorders
  - Sickle cell anemia
  - Atrial fibrillation or heart failure
  - Cancer
- Medications
  - Those known to increase blood clotting risk

On the basis of authors review of the literature and in consultation with medical professionals.

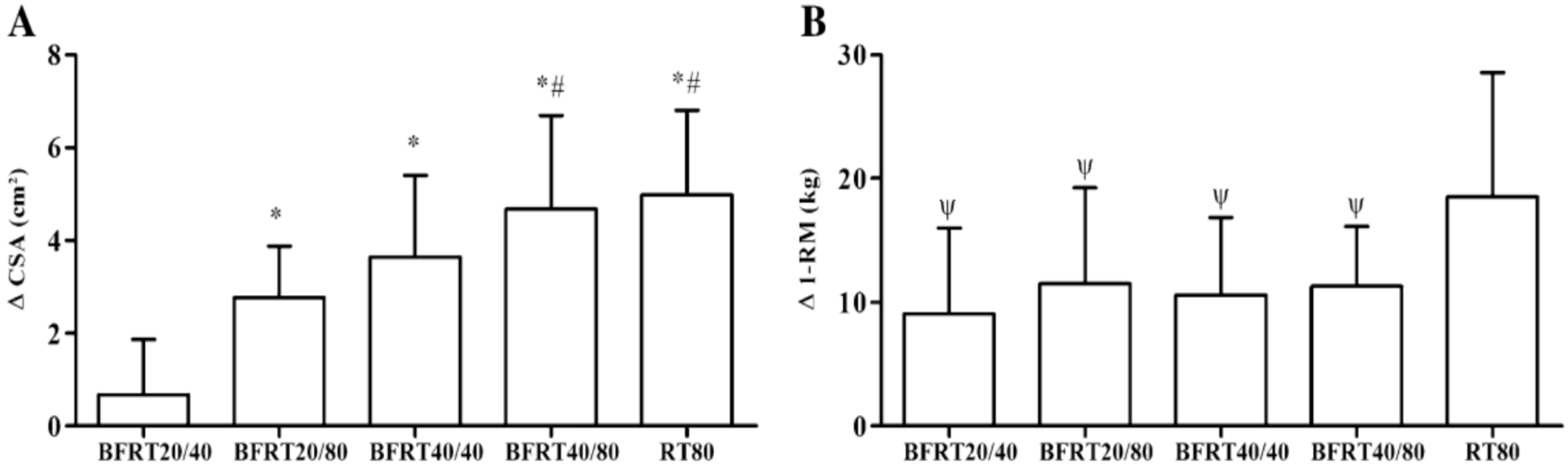
BFR indicates blood flow restriction.

Contraindications/Caution:

- Significant cardiovascular disease
- Open wounds/significant soft tissue damage
- Venous insufficiency
- Pregnancy
- History of VTE. or strong family history of VTE
- Active Cancer

Other considerations

- Higher intensity resistance training is still the best for BOTH strength gains and CSA
- BFR doesn't't always have to be 80% for LE



(Lixandrão 2015)

Future research in BFR:

UCSF Meniscus Disorder Trial: Blood Flow Restriction After Meniscus Repair

Learn about this Meniscus Disorder and Torn Meniscus study at UCSF

clinicaltrials.ucsf.edu

NIH U.S. National Library of Medicine

ClinicalTrials.gov

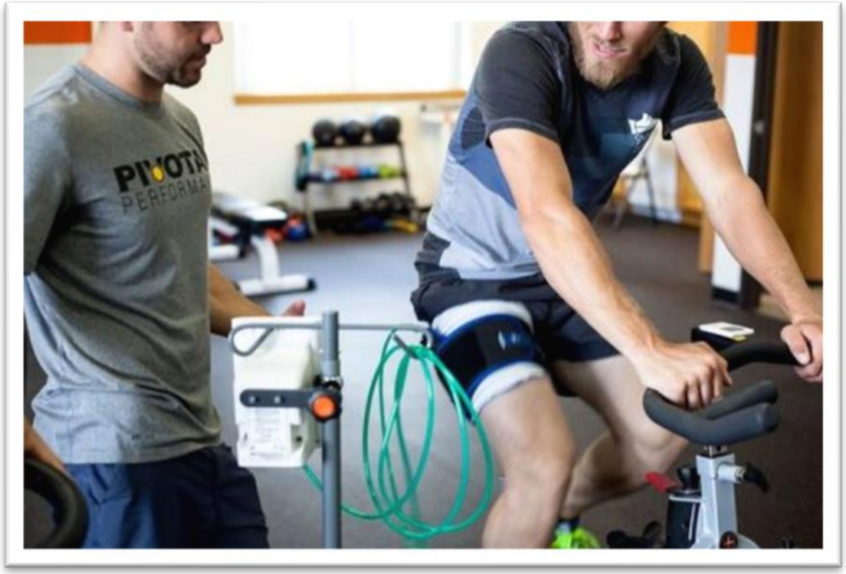
Blood Flow Restriction After Meniscus Repair - Full Text View - ClinicalTrials.gov

The investigators will conduct a double-blinded, single-institution, randomized controlled trial to compare patients undergoing arthroscopic meniscus repair with post-operative rehabilitation protocol as (1) a standard-of-care rehabilitative protocol with a non-occlusive blood pressure cuff (inflated to 20-30 mm Hg) applied to the operative extremity versus (2) blood flow restriction training ...

clinicaltrials.gov

Future research: Aerobic capacity

- Aerobic losses after injury are sometimes the biggest hurdle to overcome with lack of fitness
- New research looking at changes in VO2 max and stroke volume
  - Sometimes in a little as 2 weeks



Sprick 2017, Abe 2010, Miguel 2018

Future research: Tendon Health

- Achilles tendon cross sectional area and Mechanical stiffness (tensile strength) improved over a 14 week period of LL-BFR

Centner 2019

Future research in BFR:

- Limb occlusion assessments in the position of the exercise (Hughs 2018, Sieljacks 2018)
- Adjunct to typical workout regiments and standardized frequency and dosage: Performance and recovery
- Multimodal with other modalities in combo
  - Biofeedback, neuromuscular stim, Myofascial Decompression

Summary

- Consider BFR for your patients:
  - Elderly
  - Post-op
  - Athletes

Thank you !

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References

1. Hughes L, Paton B, Rosenblatt B, Gissane C, Patterson SD. Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis. *British Journal of Sports Medicine*. 2017;51(13):1003-1011. doi:10.1136/bjsports-2016-097071.
2. Gornitzky AL, Lott A, Yellin JL, Fabricant PD, Lawrence JT, Ganley TJ. Sport-Specific Yearly Risk and Incidence of Anterior Cruciate Ligament Tears in High School Athletes. *The American Journal of Sports Medicine*. 2016;44(10):2716-2723. doi:10.1177/0363546515617742.
3. Fingar K, Stocks C, Weiss A, Steiner C. Most Frequent Operating Room Procedures Performed in U.S. Hospitals, 2003–2012. *Healthcare Cost and Utilization Project (H-CUP)*. 2014;70:1-15. https://www.hcup-us.ahrq.gov/reports/statbriefs/sb186-Operating-Room-Procedures-United-States-2012.pdf. Accessed January 4, 2018.
4. Cullen KA, Hall MJ, Golosinskiy A. Ambulatory surgery in the United States, 2006. *Natl Health Stat Report*. 2009;(11):1-25.
5. Gerber JP, Marcus RL, Dibble LE, Lastayo PC. The Use of Eccentrically Biased Resistance Exercise to Mitigate Muscle Impairments Following Anterior Cruciate Ligament Reconstruction: A Short Review. *Sports Health: A Multidisciplinary Approach*. 2009;1(1):31-38. doi:10.1177/1941738108327531.
6. Rooks DS, Huang J, Bierbaum BE, et al. Effect of preoperative exercise on measures of functional status in men and women undergoing total hip and knee arthroplasty. *Arthritis & Rheumatism*. 2006;55(5):700-708. doi:10.1002/art.22223.
7. Lubowitz JH, Ayala M, Appleby D. Return to Activity After Knee Arthroscopy. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*. 2008;24(1). doi:10.1016/j.arthro.2007.07.026.
8. Grinsven SV, Cingel REHV, Holla CJM, Loon CJMV. Evidence-based rehabilitation following anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2010;18(8):1128-1144. doi:10.1007/s00167-009-1027-2.
9. Takarada Y, Nakamura Y, Aruga S, Onda T, Miyazaki S, Ishii N. Rapid increase in plasma growth hormone after low-intensity resistance exercise with vascular occlusion. *Journal of Applied Physiology*. 2000;88(1):61-65. doi:10.1152/jappl.2000.88.1.61.

References

10. Takarada Y, Tsuruta T, Ishii N. Cooperative Effects of Exercise and Occlusive Stimuli on Muscular Function in Low-Intensity Resistance Exercise with Moderate Vascular Occlusion. *The Japanese Journal of Physiology*. 2004;54(6):585-592. doi:10.2170/jjphysiol.54.585.
11. Scott BR, Loenneke JP, Slattery KM, Dascombe BJ. Exercise with Blood Flow Restriction: An Updated Evidence-Based Approach for Enhanced Muscular Development. *Sports Medicine*. 2014;45(3):313-325. doi:10.1007/s40279-014-0288-1.
12. Kubota A, Sakuraba K, Sawaki K, Sumide T, Tamura Y. Prevention of Disuse Muscular Weakness by Restriction of Blood Flow. *Medicine & Science in Sports & Exercise*. 2008;40(3):529-534. doi:10.1249/mss.0b013e31815ddac6.
13. Ohta H, Kurosawa H, Ikeda H, Iwase Y, Satou N, Nakamura S. Low-load resistance muscular training with moderate restriction of blood flow after anterior cruciate ligament reconstruction. *Acta Orthopaedica Scandinavica*. 2003;74(1):62-68. doi:10.1080/00016470310013680.
14. Iversen E, Røstad V, Larmo A. Intermittent blood flow restriction does not reduce atrophy following anterior cruciate ligament reconstruction. *Journal of Sport and Health Science*. 2016;5(1):115-118. doi:10.1016/j.jshs.2014.12.005.
15. Tennent DJ, Hylden CM, Johnson AE, Burns TC, Wilken JM, Owens JG. Blood Flow Restriction Training After Knee Arthroscopy. *Clinical Journal of Sport Medicine*. 2017;27(3):245-252. doi:10.1097/jsm.0000000000000377.
16. Gaunder CL, Hawkinson MP, Tennent DJ, Tubb CC. Occlusion Training: Pilot Study for Postoperative Lower Extremity Rehabilitation Following Primary Total Knee Arthroplasty. *The United States Army Medical Department Journal*. 2017:39-43.
17. Nakajima T, Kurano M, Iida H, et al. Use and safety of KAATSU training: Results of a national survey. *International Journal of KAATSU Training Research*. 2006;2(1):5-13. doi:10.3806/ijktr.2.5.

References

18. Sieljacks P, Knudsen L, Wernbom M, Vissing K. Body position influencesarterial occlusion pressure: implications for the standardization of pressure during blood flow restricted exercise. Eur J Appl Physiol. 2018 Feb;118(2):303-312

19. Centner C, Lauber B, Seynnes OR, Jerger S, Sohnius T, Gollhofer A, König D. Low-load blood flow restriction training induces similar morphological and mechanical Achilles tendon adaptations compared with high-load resistance training. J Appl Physiol . 2019

20. Dankel SJ, Jessee MB, Abe T, Loenneke JP. The Effects of Blood Flow Restriction on Upper-Body Musculature Located Distal and Proximal to Applied Pressure. Sports Med. 2016 Jan;46(1):23-33

21. Clarkson MJ, May AK, Warmington SA. Chronic Blood Flow Restriction Exercise Improves Objective Physical Function: A Systematic Review. Front Physiol. 2019 Aug 21;10:1058

22. Baker BS, Stannard MS, Duren DL, Cook JL, Stannard JP. Does Blood Flow Restriction Therapy in Patients Older Than Age 50 Result in Muscle Hypertrophy, Increased Strength, or Greater Physical Function? A Systematic Review. Clin Orthop Relat Res. 2020 Mar;478(3):593-606

23. Lixandrão ME, Ugrinowitsch C, Laurentino G, Libardi CA, Aihara AY, Cardoso FN, Tricoli V, Roschel H. Effects of exercise intensity and occlusion pressure after 12 weeks of resistance training with blood-flow restriction. Eur J Appl Physiol. 2015 Dec;115(12):2471-80

24. Ferraz RB, Gualano B, Rodrigues R, Kurimori CO, Fuller R, Lima FR, DE Sá-Pinto AL, Roschel H. Benefits of Resistance Training with Blood Flow Restriction in Knee Osteoarthritis. Med Sci Sports Exerc. 2018 May;50(5):897-905

25. Hughes L, Jeffries O, Waldron M, Rosenblatt B, Gissane C, Paton B, Patterso SD. Influence and reliability of lower-limb arterial occlusion pressure atdifferent body positions. PeerJ. 2018 May 2;6:e4697