Clinical Application of Bloodflow Restriction Training in Orthopedic Rehabilitation

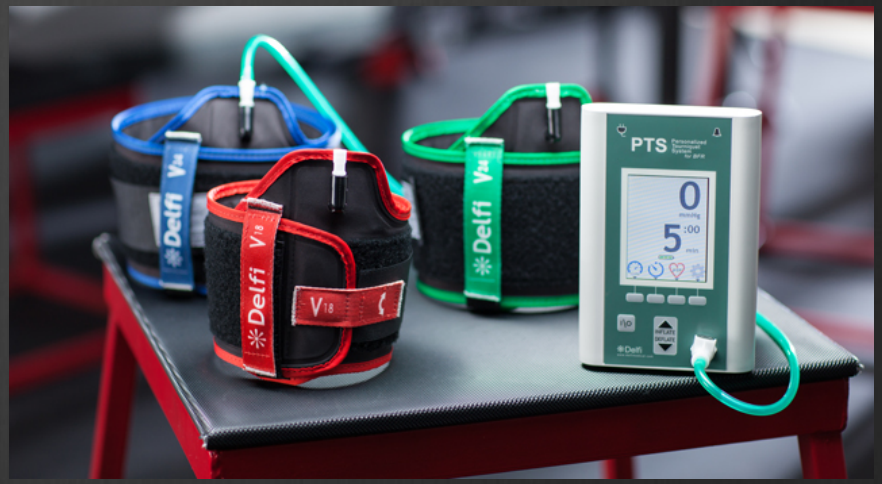
Michael Fronczek PT, DPT, OCS

Learning Objectives

- What is BFR training?
- What are the effects of BFR?
- Is BFR safe?
- How do I select patients appropriately for BFR training?

What is BFR Training?

- Blood Flow Restriction (BFR) is a training method that partially restricts arterial inflow and fully restricts venous outflow in working musculature during exercise.[1]
- Involves use of pneumatic or elastic cuffs around proximal upper and lower extremities to desired level of compression to restrict circulation.



Why is it useful?

- ACSM recommends training at loads of 70% 1RM for strength (HL-RE)[2]
- BFR training (BFR-RE) produces similar strength gains and equivalent hypertrophy to HL-RE at 20-30% 1 RM [3]
- Better strength gains than LL-RE alone[3]
- for rehab population
  - NWB/PWB
  - Repaired or healing tissue
  - OA

History of BFR

- Originally described by Dr Yoshiaki Sato in 1966 and used in Japan for decades.
- Current protocols developed by 1973 by Dr. Sato
- Originally termed “KAATSU” or “muscle training with increased pressure”

Types of Tourniquets

- Delfi PTS (Personalized Tourniquet System) PBFR
  - Similar model to those used in orthopedic surgical procedures
  - Able to calculate accurate limb occlusion pressure (LOP)
  - FDA approved
- Pneumatic Bands (NO BP CUFF)
- Elastic Bands (Safe?)
  - UE application to subjective tightness of 5/10*
  - LE application to subjective tightness of 7/10*
  - Check peripheral pulses or capillary refill (<2sec)
- Varied effects due to limb circumference and cuff widths

Proposed Mechanisms for Effects of LL-BFR

- Hypothesized that hypoxic and ischemic muscular environment causes high levels of metabolic stress.[3]
- Combination of mechanical stress and metabolic stress results in hypertrophy.[3]
- "Primary Hypertrophy Factors"

Proposed Mechanisms for Effects of LL-BFR

- Systemic increase in HGH (290x increase from rest)[5]
  - Greater than LLRE and HLRE (100x at 70% 1rm)[6]
- Increased type II fiber recruitment [7,8,9]
- Cellular Swelling [11]
- Increased anabolic/anticatabolic signaling [12]
- Effects observed in musculature both distal and proximal to cuff in upper and lower extremities.[18]

Training Protocol

Frequency	2-3 times / week (>3 weeks)
Load	20-40% 1RM
Restriction Time	8 min per exercise (reperfusion between exercises)
Sets	2-4 (4 is optimum)
Repetitions	75 reps (30/15/15/15) with 30 sec rest between sets
Pressure	40-80% LOP (UE 50%, LE 80%)
Speed	1-2 seconds (Con and Ecc)
Duration	Until concentric failure or rep scheme is completed.

Exercises using BFR

- Upper Extremity
  - Resisted ER
  - Push-up Progression
  - Bicep Curls
  - Resisted wrist flexion/extension
- Lower Extremity
  - Quad Set
  - SLR
  - Leg Press
  - Squat variations
  - Step Up
  - Heel Raise
  - Stationary Bike

What patients should use BFR?

- Most research in rehab on ACLR
- Other indications?
  - Knee Arthroscopy
  - TKA
  - Age related sarcopenia
  - Patellar Tendinosis
  - Disuse atrophy
  - Cartilage repairs

Safety

- Concern over DVT due to constriction of blood flow and venous pooling.
- NO clinical studies reporting increased incidence of DVT above normal population. [1]
  - Multiple studies looking at acute and chronic markers (12 wks) show no increased DVT markers
  - Large epidemiologic survey in Japan looked at 12,000 participants using KAATSU and reported DVT and PE incidence of 0.055% and 0.008% respectively (general risk is 0.2-0.26% in Asia)[13]

Safety

- Muscle Damage
- Rhabdomyolysis – Serious condition where trauma (direct or indirect) leads to breakdown of muscle tissue allowing contents to be released into bloodstream. Can lead to kidney damage, kidney failure and other life threatening sequelae

Safety

- Current evidence does not suggest increased risk of rhabdomyolysis by using LL-BFR over general population
- 3 published case reports of Exertional Rhabdomyolysis after BFR [14,15,16]
- Unclear if risk is greater due to use of BFR or greater than using HL-RE
- May be related to non-standard training program, use of non-medical grade equipment and co-morbidities.
- The application of BFR does not appear to induce a muscle damage response when using single exercise protocol up to 5 sets to volitional failure.[1]

Is BFR Training for Everyone?

- Contraindications
- Ideal patient selection

Contraindications to LL-BFR Training

- Open fractures of the limb
- History of DVT, clotting disorders
- Pregnancy
- Active infection
- Severe hypertension
- Compromised peripheral circulation
- Diabetes
- Varicose veins in indicated limb
- Cancer

Patient Selection

- Very Important!
- Ideal candidate[17]:
  - No absolute contraindications
  - Can ambulate freely
  - Generally active
  - Do not have a known temporary or permanent condition that alters the flow of blood
  - Can perform traditional resistance exercise safely albeit not at intensities associated with traditional resistance training
  - Less traumatic injuries/surgeries
  - Limited endothelial damage
  - No open soft tissue injuries
  - Operative site not directly underneath cuff.

Limitations of Research

- Wide variety of protocols and devices
- Very few studies assess functional outcomes or quality of life improvement
- Majority of research is conducted with healthy subjects – limited analysis in clinical musculoskeletal rehab population.
- More research needed on establishing optimum training protocol.

Case Report

- 57 y/o Male
- Avid athlete, Crossfit 5x weekly
- 7/13/19 MVA. Frontal impact
- Suffered L Acetabular Fracture. ORIF 7/14/19
- Hospitalized 5 Days, Then home with Home Care PT 6 weeks
- 4 weeks NWB, 2 Weeks PWB 50% with Axillary Crutches

Case Report

- 9/2/19 Cleared for FWB on L LE
- Presents for PT Evaluation on 9/4/19
- Eval:
  - Amb with SPC
  - + Trendelenberg when ambulating without AD
  - PROM L Hip flexion 90°, AB 35°, Ext 10°, ER to 30° in 90° of flexion. IR deferred
  - Strength: Hip Ab 2/5, Ext 3/5, Flexion 4/5, Knee Ext 4/5
  - Unable perform sit->stand without UE support
  - Unable perform 8" step unilaterally on L
  - Severe L LE atrophy - Girth 20cm above mid-patella: R 55cm, L 51.5 cm
- No history/symptoms of DVT, PE, HTN, varicosities, clotting disorder.

Case Report

- 2x weekly PT
- BFR initiated on 2nd treatment
- Treatment protocol: 4 sets U Leg press (30, 15, 15, 15) at 60-80% LOP
- Progressed to Air Squats (4 Sets) after 3 sessions as pain subsided.
- Clinic and Home Exercise program targeting all major muscle groups as well as gait training and proprioceptive training.

Case Report

Case Report

Case 1

- After 5 sessions
  - Thigh circumference from 51.5cm to 53.5 cm
- After 12 sessions (6 Weeks)
  - Thigh circumference to 54.2 cm
  - STS 5X – 12 sec
  - 3x8 reps 10” step without compensation

Conclusions

- Research indicates that BFR is an effective tool to promote strength gains and hypertrophy using low loads and mechanical stress
- Provided patients are selected properly, BFR is safe for use in orthopedic clinical populations
- BFR can be particularly useful in rehab where tolerance to heavy loads is low or where loading is contraindicated.
- More research is needed to refine safe application protocols and establish concrete patient selection criteria

Thank You!

- Questions?

References

- 1. Patterson S, et al. Blood Flow Restriction Exercise Position Stand: Considerations of Methodology, Application and Safety. Front in Phys. 2019; 10: 1-15
- 2. American College of Sports Medicine. American college of sports medicine position stand. Progression models in resistance training for healthy adults. Med Sci Sports Exerc 2009;41:687-708
- 3. Hughes L, Paton B, Rosenblatt B, et al. Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis. Br J Sports Med 2017; 51: 1003-1011
- 4. Loenneke J, et al. Low intensity blood flow restriction training: a meta-analysis. Eur J Appl Physiol. 2012; 112(5) 1849-59
- 5. Takarada Y, et al. Rapid increase in plasma growth hormone after low intensity resistance exercise with vascular occlusion. J Appl Physiol. 2000; 88:61-65

References

- 6. Manini T, Yarrow J, Buford T. Et al. Growth hormone responses to acute resistance exercise with vascular restriction in young and old men. Growth horm IGF res. 2012:22;167-172
- 7. Moore D, et al. Neuromuscular adaptations in humans muscle following low intensity resistance training with vascular occlusion. Eur J Appl Physiol. 2004:92; 399-406
- 8. Yasuda T, Bruchue WF, Fujita T, Shirakawa j, Sato Y, Abe T. Muscle activation during low intensity muscle contractions with restricted blood flow. J Sports Sci. 2009;27. 479-489
- 9. Yasuda T, Fujita T, Miyagi Y, Kubota Y, Sato Y, Nakajima M, Abe T. Electromyographic response of arm and chest muscle during bench press exercise with and without KAATSU. Int J KAATSU Training Res. 2006;2 15-18

References

- 11. Loenneke J, Fahs C, Rossow L, et al. The anabolic benefits of venous blood flow restriction training may be induced by muscle cell swelling. Med Hypotheses. 2012b;78:151-4
- 12. Fry C, Glynn E, Drummond, et al. Blood flow restriction exercise stimulates mTORC1 signaling and muscle protein synthesis in older men. J Apl Physiol. 2010;108:1199-2006
- 13. Nakajima T, Kurano M, Iida H, Takano H, et al. Use and safety of KAATSU training: results of a national survey. Int J KAATSU Train. 2006; 2:5-13
- 14. Tabata S, Suzuki Y, et al. Rhabdomyolysis after performing blood flow restriction training: a case report. J Str Cond Res. 2016: 30;2064-68
- 15. Clark B, Manini T. Can KAATSU exercise cause rhabdomyolysis? Clin J Sport Med. 2017 Jan;27 (1): e1-e2.doi:10.1097/JSM.00000000000000309
- 16. Iverson E, Rstad V. Low-load ischemic exercise induced rhabdomyolysis. Clin J Sport Med. 2010: 20 218-219

References

- 17. Bond C, Hackney K, Brown S, Noonan B. Blood Flow Restriction Exercise as a Rehabilitation Modiality Following Orthopaedic Surgery: A Review of Venous Thromboembolism Risk. JOSPT. 2019: 49(1). 17-27

- 18. Dankel S, Jessee M, Abe T. The Effects of Blood Flow Restriction on Upper-Body Musculature Located Distal and Proximal to Applied Pressure. Sport Med. 2016: 46(1). 23-33