Blood Flow Restriction Training
Integration into Physical Therapy Practice

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Objectives

• Define what blood flow restriction (BFR) therapy/training is, its physiological effect, and contraindications for use.
• Discuss the use and integration of BFR training is the rehab continuum.
• Review the limitations and applications where BFR training is effective.
• Evaluate the effectiveness on BFR training systems and their desired systemic, physiological, and healing effectiveness.
Disclosures

• Research projects I am a co-investigator for have received research grant funding from Owens Recovery Science and BStrong Training Systems for current research involving use of BFR and serum stem cell count.

• The research grants and funding received in no way effect the use, demonstration, and clinical application to treatments or the use of their name in this presentation.
What is BFR Training

• Blood Flow Restriction Training:
  – Is a training strategy involving the use of a device that restricts/limits arterial blood flow to a limb as well as prevents venous return of blood while performing resistive training at lower loads of a person’s 1 rep max to gain strength, muscle hypertrophy, improve vascular efficiency, and improve endurance.
According to the APTA

- BFRT is:
  - “Achieved through the application of external pressure over the extremities. The pressure applied is sufficient to maintain arterial inflow while occluding venous outflow distal to the occlusion site. The goal is to enable patients to make greater strength gains while lifting lighter loads, thereby reducing the overall stress placed on the limb.”
  - “PTs have an existing firm foundation in anatomy, physiology... as well as clinical reasoning which are the components of the safe application of BFRT. PT education provides PTs with requisite knowledge to perform and monitor this type of TE.”

http://www.apta.org/PatientCare/BloodFlowRestrictionTraining/
According to the APTA

• BFRT is:
  – “BFRT is part of the professional scope of practice for PTs.”
    • APTA bolded this part!
  – Each provider should review their state’s practice act to ensure they meet the requirements necessary to practice BFRT.

http://www.apta.org/PatientCare/BloodFlowRestrictionTraining/
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BFR
BFR History - KAATSU

• Invented in Japan in 1966 by Yoshiaki Sato
• He continued to experiment on himself using bicycle tubes, ropes, and bands.
• In 1973: he experimented on himself by applying different sizes of bicycle tubes, ropes and bands at different pressures on various parts of his body.
  – Kept track of which pressure was safe and work best.

www.katsu-global.com
BFR History- KAATSU

• In 1973 Sato fractured his ankle and tore several ligaments in his knee.
  – Rehabbed himself with elastic bands by repeatedly doing isometrics with the pressure on.
  – Initial treatment was 30 seconds on, 3-5 sec off, 3x/day.
• Sato performed several studies over the next decade figuring out appropriate protocols, guidelines, and developing his equipment.
• In 1994, Sato applied for his first patents in Japan, Europe, and USA and began to manufacture the first KAATSU training bands and the first BFR “Equipment system.”

www.katsu-global.com
BFR History- KAATSU

• In 1997: Sato introduced the KAATSU Instructor educational program.
  – It was introduced in English in the United States in 2014.
• KAATSU means: KA means “additional”, ATSU means “pressure”
• KAATSU 192 page training manual is available to download online- Free.
• Published over 100 articles.

www.katsu-global.com
BFR History - KAATSU
• Johnny Owens, DPT working at Center For the Intrepid in San Antonio, TX working with limb salvage patients.
  – Unable to build muscle on patients to return to PLOF.
  – Started BFR using ABI with Doppler on calf with BP cuff as tourniquet, measured pressures and assessed occlusion and calculated appropriate pressures.
    • Very time consuming
• Went to surgical tourniquet company, Delfi, and custom designed a device
• Only FDA approved device
• Only device that modulates pressure in real time to deliver near exact levels of 80% limb occlusion pressure (LOP) based off 100% personalized tourniquet pressure.
Delfi & Owens Recovery Science

Original

2.0

- “Higher levels of tourniquet pressure and higher pressure gradients beneath tourniquet cuffs are associated with a higher risk of nerve–related injury.”
- “Measurement of limb occlusion pressure can help minimize tourniquet pressure levels and gradients for individual patients.”
- “Selective use of pneumatic, wider, and contoured tourniquet cuffs reduces tourniquet pressures levels and applied pressure gradients.”
Delfi Cuffs

• Weatherholt et al., 2019:
  – LOP measured with Doppler probe distally
  – Delfi had lower pressure to achieve LOP than KAATSU
  – KAATSU wasn’t able to achieve 100% LOP at max pressure (500 mmHG)
    • Can’t calculate 80% LOP
  – If can’t calculate LOP accurately BFR can be unsafe (Hughes et al., 2018, McEwen et al., 2018)
BFR Indications

- Post surgical:
  - Ligament reconstruction/repair
    - UE/LE
  - Rotator/labrum/SAD/biceps tenodesis
  - Tendon repairs
  - Meniscus repair/-ectomy

- Muscle strains and repairs, ligament sprains

- Pre/post game & Regeneration

- During training cycles for variability

- Atrophied/weakened muscles
  - Chronic or acute

- Chondral defects

- Conditions requiring strengthening while avoiding shear forces
BFR Myths

• You don’t have to be trained to use BFR... simple Wikipedia training will suffice.
• More pressure equals better results.
• Any occlusion will work.
• BFR is safe for everyone.
• I can tell when something is unsafe for me to use
• Any set and rep scheme will work
• Calculated pressures are not needed
• **BFR is a substitute for traditional strength training**
BFR Facts

• When used appropriately:
  – Should not be used if patient has not been properly screened by MD and or trained medical professional
  – BFR has positive training effects
  – There are precautions and contraindications with BFR training
    • It is not for everyone
  – Not everyone can tolerate BFR
  – BFR has a systemic physiological effect
  – BFR can be dangerous
  – Not all BFR systems are the same
  – BFR is a bridge to gain muscle hypertrophy and strength to return to strength training faster than without its use.
  – BFR has a plateau effect.
Contraindications

- Venous thromboembolism
- Impaired circulation/peripheral vascular compromise
- Extremities with dialysis access
- Acidosis
- Sickle cell anemia
- Infection
- Tumor
- Medications known to increasing clotting risk
- Open fracture
- Cancer
- Increased intracranial pressure
- Open soft tissue injuries
- Post-traumatic length hand reconstructions
- Severe crush injuries
- Severe hypertension
- Elbow surgery-with concomitant excess swelling
- Skin grafts
- Secondary or delayed procedures after immobilization
- Vascular grafting
- Lymphectomies

Precautions

- Arterial calcification
- Abnormal clotting times
- Diabetes
- Sickle cell trait
- Tumor
- General infection
- HTN
- Cardiopulmonary conditions
- Renal compromise
- Clinically significant acid base imbalance.
- Atherosclerotic vessels
- People taking anti-hypertensives and Creatine supplements

Other Brands/Bands

• **Occlusion Cuff** - Self proclaimed “best BFR system in the world.”
• **Rogue fitness bands** - rubber wraps
• **BFR Bands** - Straps or hand pump
• **Edge Restriction System** - hand pump
• **E20 BFR system** - rapid inflation
• **Gait belts**
• **BP cuffs**
  – Prices between $20-$5000.
ACSM Guidelines

• ACSM guidelines state “Hypertrophy can be achieved through moderate to high intensities of resistance that utilize 8-10 upper and lower body exercises. These exercises should target major muscle groups 2-3 days/week training at more than 65% of the subjects 1 rep max.”
  – Training at 75-85% for 12-16 weeks is necessary to make changes to the muscles
  – Sufficient load must be placed on muscle to induce adaptive changes.

ACSM, Meyer, 2006, Donnelly, 2009
How Does BFR Work

• Restricted blood flow to musculature with occlusion of venous flow to simulate physiological response to muscular loading at heavy loads to improve muscle hypertrophy.
  – When holding a barbell in back squat position with 75% of 1 RM you have 100% venous occlusion and near 100% arterial occlusion
  • Thus fatigue sets in

• Muscle deprived of O2 -> fatigue -> muscle breakdown -> muscle repair/increased size/strength

www.owensrecoveryscience.com, Nielsen et al., 2012, Abe et al., 2004, Abe et al., 2006, Evans et al., 2010, Fatela et al., 2016, Slysz et al., 2015, Burd et al., 2010
How Does BFR Work?

• BFR: Perform exercises at 15-30% of 1 RM
  – 80% limb occlusion pressure (LOP) for LE, 50% LOP for UE.
  – Can perform with:
    • cardio exercises
    • stretching/mobility exercises
    • Plyometric/med ball drills
    • Balance tasks
  – Can go above 30% of 1 RM
    • Some studies as high as 50-60% 1 RM
  – Sets/reps: 30/15/15/15

www.owensrecoveryscience.com, Nielsen et al., 2012, Abe et al., 2004, Abe et al., 2006, Evans et al., 2010, Fatela et al., 2016, Slyszt et al., 2015, Burd et al., 2010
What does BFR mean for PT?

• Allows **stressing of tissues** prior to joints and tissues being able to tolerate loads/stress sufficient to increase strength.
  
  — Strengthening leads to:
  
  • Improved joint biomechanics (PFJ, Hip, STJ, etc.)
  • Decreased joint reaction forces- longer deceleration period
  • Increased capacity for work- delays fatigue
  • Decreased pain

  — 65-95% of 1RM training necessary for hypertrophy and strength improvements-

  • Body due to injury or pathology is **unable** to tolerate that load

Blood Flow Restriction Therapy

• Decreased stress to joints
• Net Protein Balance = Muscle protein synthesis – Muscle Protein Breakdown
  – > NPB = MPS-MPB
• Leads to systemic physiological response:
  – LE > UE

www.owensrecoveryscience.com, Nielsen et al., 2012, Abe et al., 2004, Abe et al., 2006, Evans et al., 2010, Fatela et al., 2016, Slysz et al., 2015, Burd et al., 2010
Muscle Fiber Type

- Type I- Oxygenated, slow twitch, slow to fatigue, low force generation, oxidative systems for energy
- Type II- anaerobic, fast twitch, fast fatigue, high force generation, glycolytic/phosphagen systems for energy.
Why 30/15/15/15

• **Hypothesis:**
  • 30- to “ring out” all O2 and energy in muscles.
    – Since using 20-30% 1 RM you start using Type I fibers
    – Don’t want to re-oxygenate muscles
  • 15- Krebs cycle has no O2 so more muscles are recruited and lactate released from cycle and pyruvate builds up
  • 15- as metabolites increase, body is hurting for O2 as are muscles due to increased lactate and as a result need to recruit more type II muscle fibers. Lactate continues to build up freely
    – No O2 so body has to recruit more type II fibers
  • 15- metabolites build up, recruit all fibers, total fatigue leads to failure to complete task.
    – Simulates physiological response of 1-3 RM training

Schoenfeld, 2013, Meyers, 2006,
Kaatsu vs BFR- Function
BFR Metabolite Theory

• Increases in Growth Hormone
  – Improved healing through collagen synthesis
• Increases in VEGF
  – Improved vascularity
• Increased mobilization and activation of satellite cells and myogenic stem cells
  – Increased muscle hypertrophy
• Increased Insulin like Growth Factor (IGF-1) production
  – Increases muscle hypertrophy
• Increased M-TORC1 pathway production
  – Increased protein synthesis
• Decreased activity of myostatin
  – Protein responsible for stopping protein synthesis

Takarada et al., 2000, Doessing et al., 2010, Abe et al, 2005, Takano et al., 2005, Fry et al., 2010, Drummond et al., Gundermann et al., 2014 Fujita et al., 2007, Nielsen et al., 2012, Gualano et al., 2010, Mendias 2012, Bo et al., 2012.
What does BFR mean for PT?

• Girth creates capacity & foundation for strength
  – Unable to lift sufficient loads due to pain, injury, or surgery =
    • Muscle/Tissue ATROPHY- decreased bone/collagen density/organization, decreased muscle CSA
    • LOSS OF STRENGTH

• Restriction limits blood flow to muscles -> simulating muscle under heavy load:
  – Body responds by releasing signals indicating muscle hypertrophy is necessary
    • CORE PRINCIPAL BEHIND STRENGTH TRAINING
  – Use only 15-30% of 1RM with BFR
    • Joints not loaded and stressed at levels necessary for traditional strength training.
What does BFR mean for PT?

• What this means:
  – Strength training can begin earlier
    • Restoring normal joint reaction forces and joint biomechanics
  – Decreases atrophy/ increases hypertrophy
  – Leads to systemic orthobiologic response and release of positive healing factors to promote faster recovery
  – DOES NOT apply undue, excessive, or unnecessary stress on joint, cartilaginous structures, or healing tissues
    • OA, OCDs, Ligamentous repairs/reconstructions, healing fractures, muscle strains
Set Up- KAATSU

- Pump cycling
- 30 reps first then 15 progressively decreasing through a total of 4 sets
- 30 sec rest breaks for LE, 15 sec for UE
- Frequency- up to 3x/day and as little as 1x/week
- 15 minute application for UE, 20 min application for LE - max occlusion time consecutively.
Set Up- KAATSU

• Secure cuff as proximal as possible to desired limb.
• Begin inflating
  – Bands apply pressure for 20 seconds followed by a 5 sec release.
  – Pressure incrementally increased during 3 min process to ensure safety and optimal pressure.
• Assess for hand capillary refill
  – Ensure refill is 2-3 seconds or less at all times.
• Exercise
  – 20-30 first set, 10-15 reps for 3-4 sets after with rest breaks listed earlier.

www.katsu-global.com
<table>
<thead>
<tr>
<th>Pro</th>
<th>Con</th>
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<tbody>
<tr>
<td>• Accurate pressure read out</td>
<td>• When detached no pressure modulation</td>
</tr>
<tr>
<td>• Detachable</td>
<td>• No measurement of specific arterial occlusion</td>
</tr>
<tr>
<td>• System for measuring appropriate pressures</td>
<td>• Small surface area of pressure</td>
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<td>• Aquatic version</td>
<td>• Easily deflated when detached (valve)</td>
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<td>• Multiple limbs per unit can be inflated</td>
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Delfi

**Pro**
- Sets pressure based off Doppler reading for accurate LOP
- Modulates pressure
- Larger tapered cuff to dissipate force/pain
- Built in timer
- 1 min automatic break without inflation upon timer completion

**Con**
- Not portable
  - Length of hose only
- Expensive!
- Poor battery life unless on charging portal
- People don’t tolerate pressures
- Limited exercise availability due to cords
- 1 limb per unit
- Hoses and cords get tangled and difficult to manage.
Set Up- Delfi
BStrong

**Pro**
- Objective value for pressure
- Portable
- Well tolerated by patients
- Able to perform variety of exercises
- System for application and recommended pressures
- Convenient storage

**Con**
- No arterial occlusion
- Poor accuracy on limb occlusion pressures
- Difficult to replicate accurate application
- Difficult to get lactate spike and RPE due to minimal pressures.
Set Up- BStrong

- Snugly apply strap
- Take patient through algorithm on website
  - Age, weight, limb circumference, activity level, health status, cuff size, exercise duration/intensity
- Inflate to recommended pressures
  - If RPE no significantly increased increase pressure 50 mmHG
- Perform 3 sets of 30 reps for exercises or 30, 15 x 3
  - Exercise dependent
- Rest is 30 seconds
- Between exercises leave cuff inflated
- No more than 20-25 minutes consecutively
How We Use BFR
Post Operative
Balance and Plyometrics
Chronic Knee Injuries-Non-operative
Shoulder
Cardiovascular
Exercises

- BFR Leg press
- BFR Lunge
- BFR Leg extension
- BFR Squat
- BFR RFES
- BFR 2” lift
- BFR Stationary Bike
BEWARE OF THE ADVERTISING!!

• This field is unregulated!
• There are a lot of imposters, loft claims, and lack of safety regulation
  – No vetting of claims
• False information
  – BFR is for “everyone”
  – “Our system is better because...” with no actual science.
  – “Our BFR system has optimal occlusion” with no way of measuring.
Hard Uncomfortable Truths

• Similar to dry needling, Stem cell therapies, and PRP:
  – **If the medical field and the BFR industry is not careful, it will be taken away, regulated, and require legislation to get it back!**
    • If you abuse it you lose it

• Needs to be performed only by trained individuals.
  – Safety concerns if no medical background or someone unfamiliar with effects of tourniquets.

• PT schools adopting BFR training but majority of PT’s practicing today and people using BFR have had **NO** BFR training or are **not even** trained medical professionals.
Hard Uncomfortable Truths

• Deregulation -> false claims, misleading information to public, and fabricated outcomes

• Overregulation leads to stifled growth, lack of ingenuity, and lost efficiency with resource allocation
Directly off www.occlusioncuff.com

- “No greater health risk than traditional exercise.”
- “Prevents or slows atrophy with even just 20 min of walking daily.”
- Application: “wrap the cuff to “medium” tightness. Inflate the pump to desired pressure...follow our guidelines.”
- Guidelines: “upper limb pressures between 100-220 mmHG and lower limb 150-250 mmHG.”
  - “pressure should feel 7/10 intensity and wear Occlusion Cuff continuously for 10-30 minutes.”
- IMAGINE WEARING A BP CUFF AT 200 mmHG for 30 minutes!!!
Directly off www.occlusioncuff.com

- “Research”- Not 1 research article published using The Occlusion Cuff on their website
- “Disclaimer: Use of the Occlusion Cuff is at the risk of the user and no responsibility is taken by Occlusion Cuff for any injury or harm caused directly or indirectly when using the Occlusion Cuff”
Variability with Exercise

• Hughes et al., 2018:
  – E20 BFR system had 10-20mmHG greater pressure than set pressure during exercise.
  – Occlusion Cuff was 47-62mmHG greater than set pressure.
    • If reads 200 actually was 247-262mmHG
  – Delfi showed no significant differences with set pressures and interface pressures.
Variability with Exercise

• Hughes et al., 2018:
  – Occlusion Cuff showed greater pain rating, RPE, and mean arterial pressure compared to all other systems tested
  – E20 showed statistically significant increases in mean arterial pressure compared to Delfi system.
BFR

• Important for clinicians to be certified to prevent misuse and avoid poor public perception
  – Kaatsu
  – Delphi
  – B-Strong
  – May be regulated/removed from practice acts if not used properly by medical personnel

• Can be used for more than just hypertrophic effects
  – Mobility
  – Dynamic Warm Up
  – Plyometric training- modify sets and reps
  – Cardiovascular training
  – (VO2 Max study with walking**)

• USE APPROPRIATELY!!
Word to the Wise

• This is what happens when an industry is operating in the absence of regulation and is successful... everyone tries to cut corners to make it cheaper and achieve the same results and safety of our patients is sacrificed.
Summary

- BFR is a safe adjunct to therapy that is beneficial to promote healing, improve muscle hypertrophy, and increase strength under proper supervision, instruction and programming.
- BFR has systemic effects on the body and healing process
- Be creative with BFR exercise prescription
- We treat patients not protocols
THANK YOU

- The Andrews Institute
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