Blood Flow Restriction:
You Should be Doing This!

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Objectives

1) Summarize the history and literature of the BFR field
2) Describe mechanism of how BFR works
3) Identify diagnoses where BFR may be beneficial
4) Prepare 2 BFR training sessions

BFR Sample Patient Session

- Band application
- UE – one arm
- Biceps curls

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History of BFR

Judo Belts

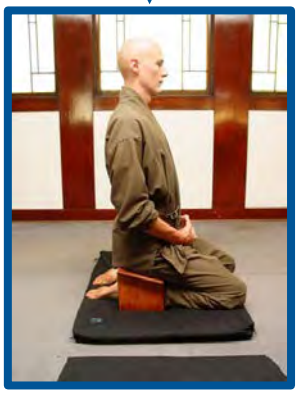
Bicycle inner tube

60s-70s

80s

90s-2000s

2010-beyond



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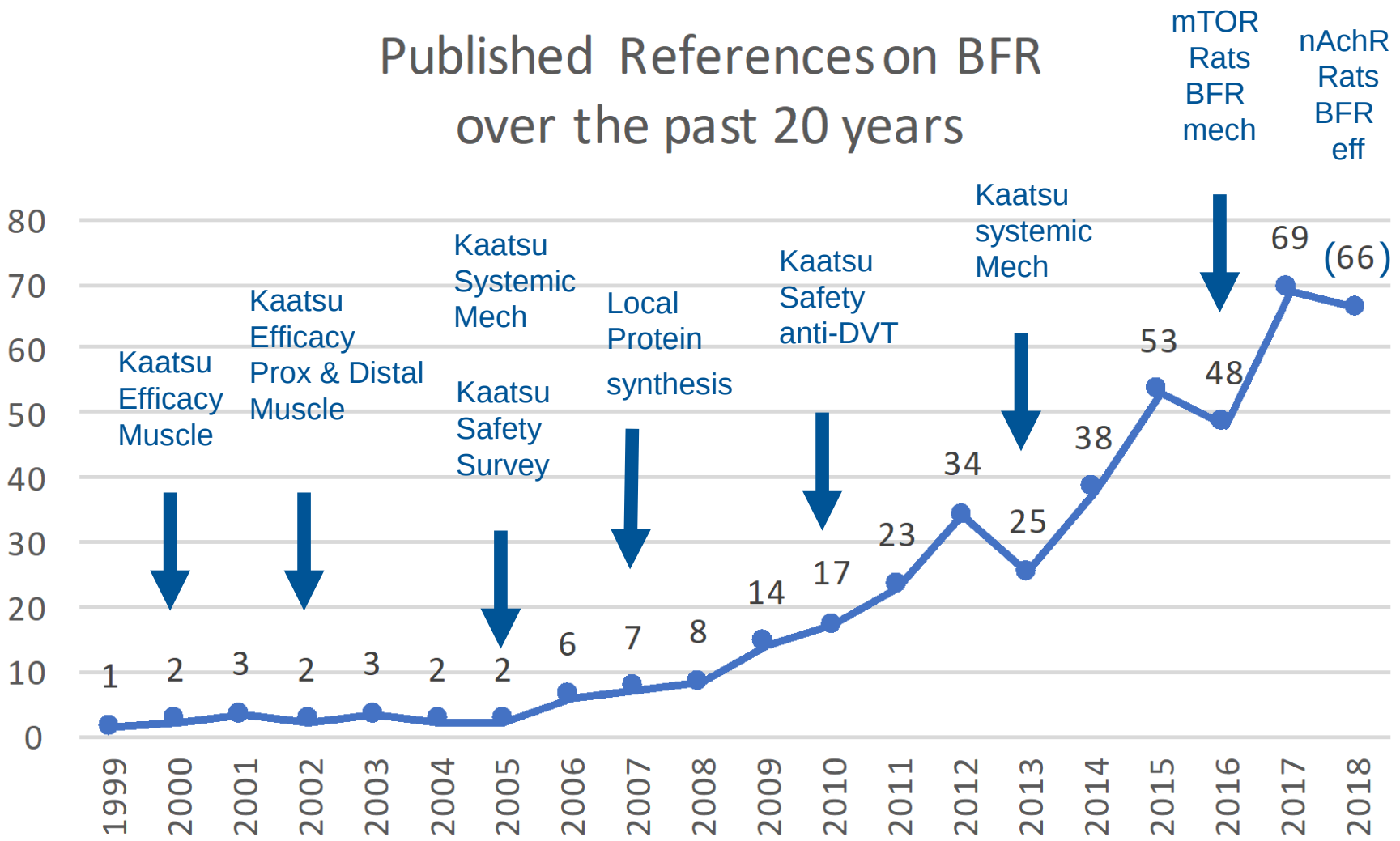

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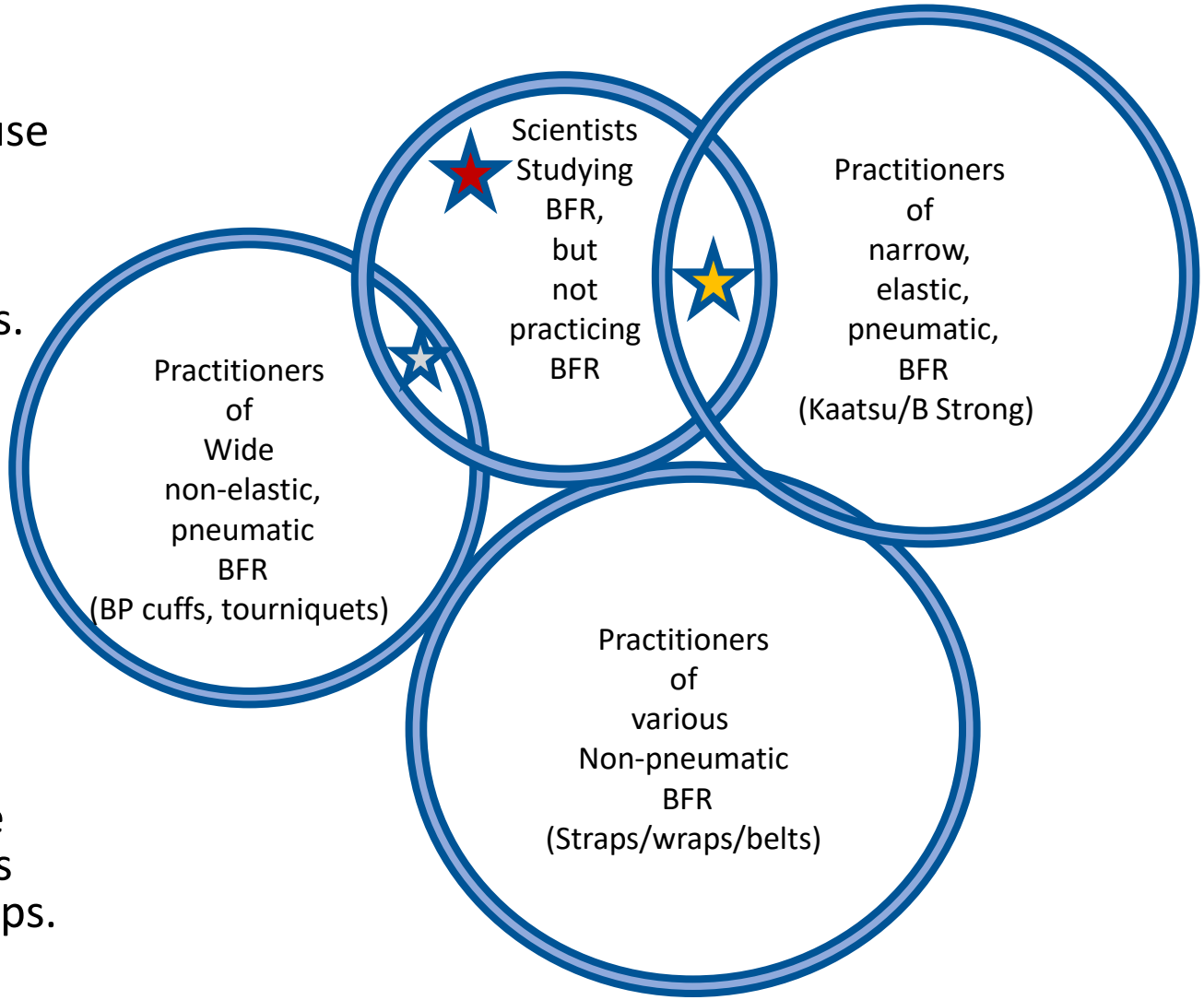
Published Literature Mis-Match

1. Most scientists use equipment that isn't used in practice (Hokkanson cuffs.
2. Most scientists study a single joint/muscle.
3. Practitioners mostly use equipment that hasn't been studied.
4. Practitioners use many or all joints and muscle groups.



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Reviews on BFR Training

Manini TM, Clark BC.	Blood flow restricted exercise and skeletal muscle health	Exerc Sport Sci Rev. 2009 Apr;37(2):78-85.
Abe T, Loenneke JP, Fahs CA, Rossow LM, Thiebaud RS, Bemben MG.	Exercise intensity and muscle hypertrophy in blood flow-restricted limbs and non-restricted muscles: a brief review.	Clin Physiol Funct Imaging. 2012 Jul;32(4):247-52.
Loenneke JP, Abe T, Wilson JM, Thiebaud RS, Fahs CA, Rossow LM, Bemben MG.	Blood flow restriction: an evidence based progressive model (Review).	Acta Physiol Hung. 2012 Sep;99(3):235-50.
Loenneke JP, Wilson JM, Marín PJ, Zourdos MC, Bemben MG.	Low intensity blood flow restriction training: a meta-analysis.	Eur J Appl Physiol. 2012 May;112(5):1849-59.
Pope ZK, Willardson JM, Schoenfeld BJ.	Exercise and blood flow restriction.	J Strength Cond Res. 2013 Oct;27(10):2914-26.
Park SY, Kwak YS, Harveson A, Weavil JC, Seo KE.	Low intensity resistance exercise training with blood flow restriction: insight into cardiovascular function, and skeletal muscle hypertrophy in humans.	Korean J Physiol Pharmacol. 2015 May;19(3):191-6.
Pearson SJ, Hussain SR.	A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy.	Sports Med. 2015 Feb;45(2):187-200.
Scott BR, Loenneke JP, Slattery KM, Dascombe BJ.	Exercise with blood flow restriction: an updated evidence-based approach for enhanced muscular development.	Sports Med. 2015 Mar;45(3):313-25.
Neto GR, Novaes JS, Dias I, Brown A, Vianna J, Cirilo-Sousa MS.	Effects of resistance training with blood flow restriction on haemodynamics: a systematic review.	Clin Physiol Funct Imaging. 2016 Apr 20.
Scott BR, Loenneke JP, Slattery KM, Dascombe BJ.	Blood flow restricted exercise for athletes: A review of available evidence.	J Sci Med Sport. 2016 May;19(5):360-7.
Slysz J, Stultz J, Burr JF.	The efficacy of blood flow restricted exercise: A systematic review & meta-analysis.	J Sci Med Sport. 2016 Aug;19(8):669-75.
Hughes L, Paton B, Rosenblatt B, Gissane C, Patterson SD.	Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis.	Br J Sports Med. 2017 Mar 4.
Patterson SD, Brandner CR.	The role of blood flow restriction training for applied practitioners: A questionnaire-based survey.	J Sports Sci. 2017 Feb 1:1-8.

Need more and better studies!

- Safety (18): need surveys of actual use in the many environments, they are used practically.
- Efficacy (146): decent for elastic pneumatic bands, but many more needed with other products and in special populations and conditions.
- Mechanism (207): decent, but need confirmation studies on various aspects and with various devices/products.
- Chronic Training studies (10-20): huge need here, focusing on the use of current products, various populations with various outcomes. For example, the use of BFR training as anti-aging medicine.

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BFR Mechanism

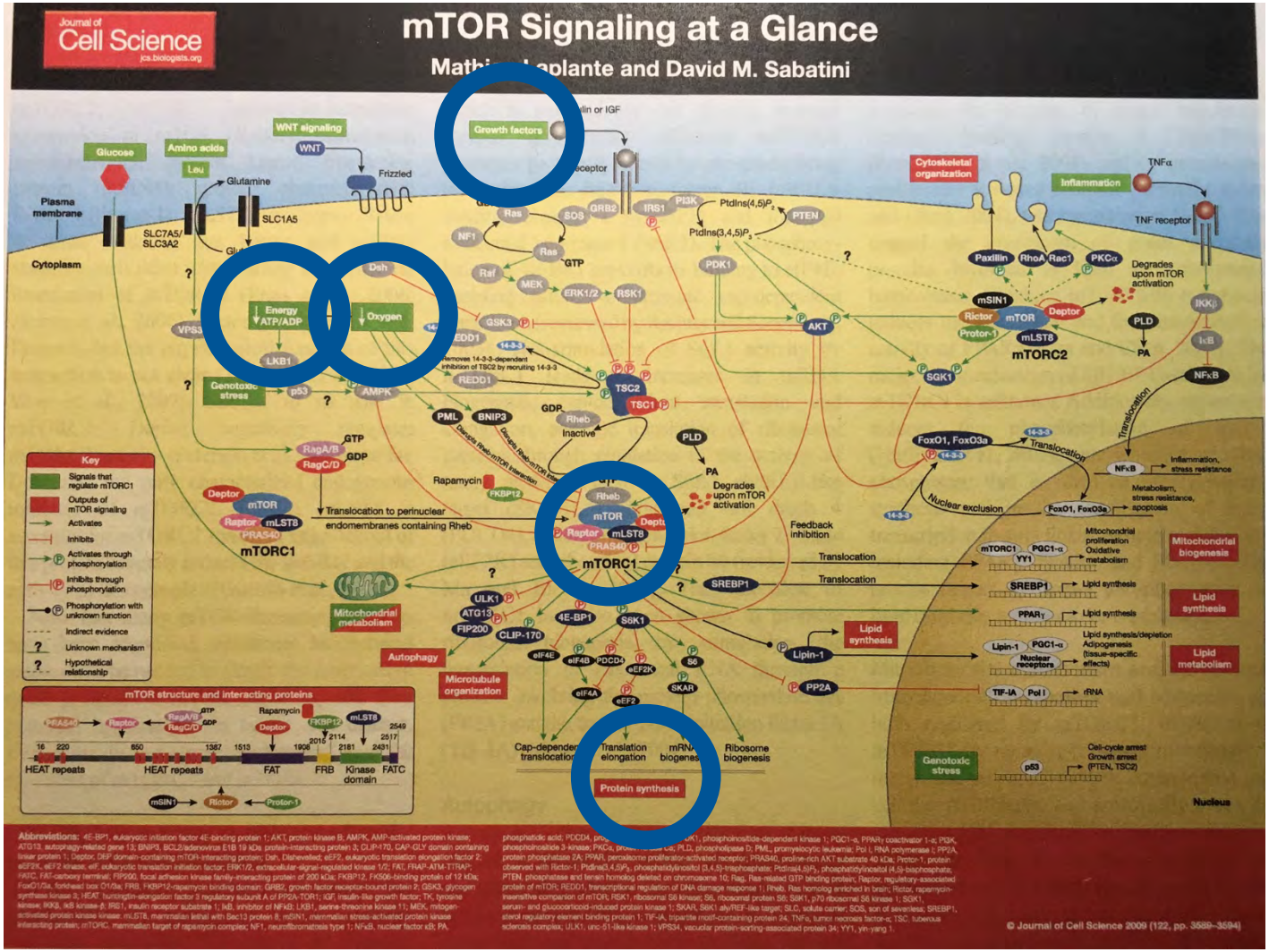
Two Local Mechanisms:

1. mTOR pathway to up-regulate protein synthesis
2. Recruitment of additional motor units as initial ones drop out

One Systemic Mechanism:

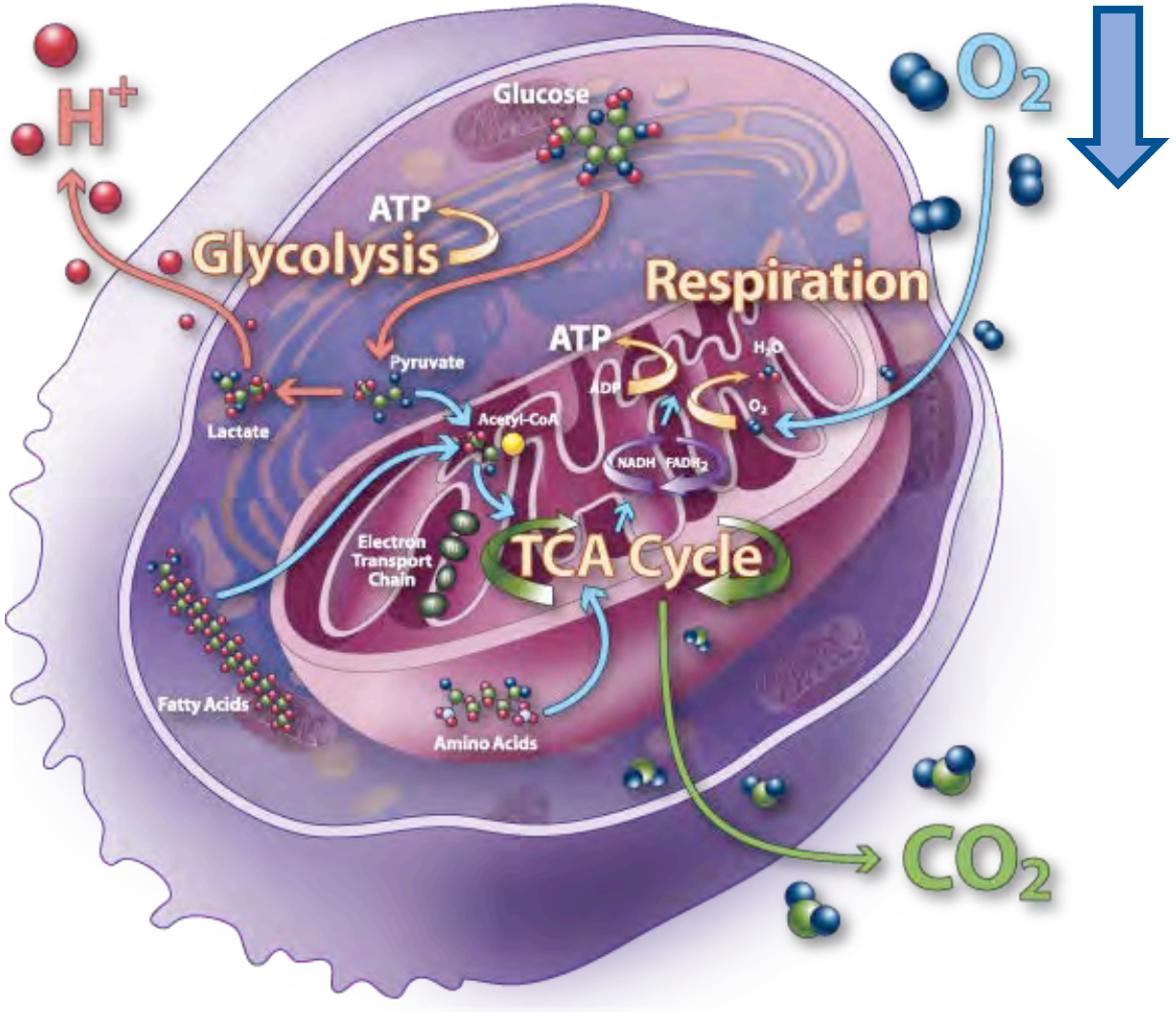
1. Afferent nerve traffic to CNS to release neuro-immuno-humeral systemic response

mTOR Pathway



Disturbance of Homeostasis in Working Muscle

- Reduction in pO_2
- Reduction in pH
- Increase in [Lactate]
- Increase in $[P_i]$
- Decrease in [Phospho Creatine (PC)]
- Decrease in [ATP]
- Altering Electrolyte (K^+, Na^+, Ca^{2+}) gradients



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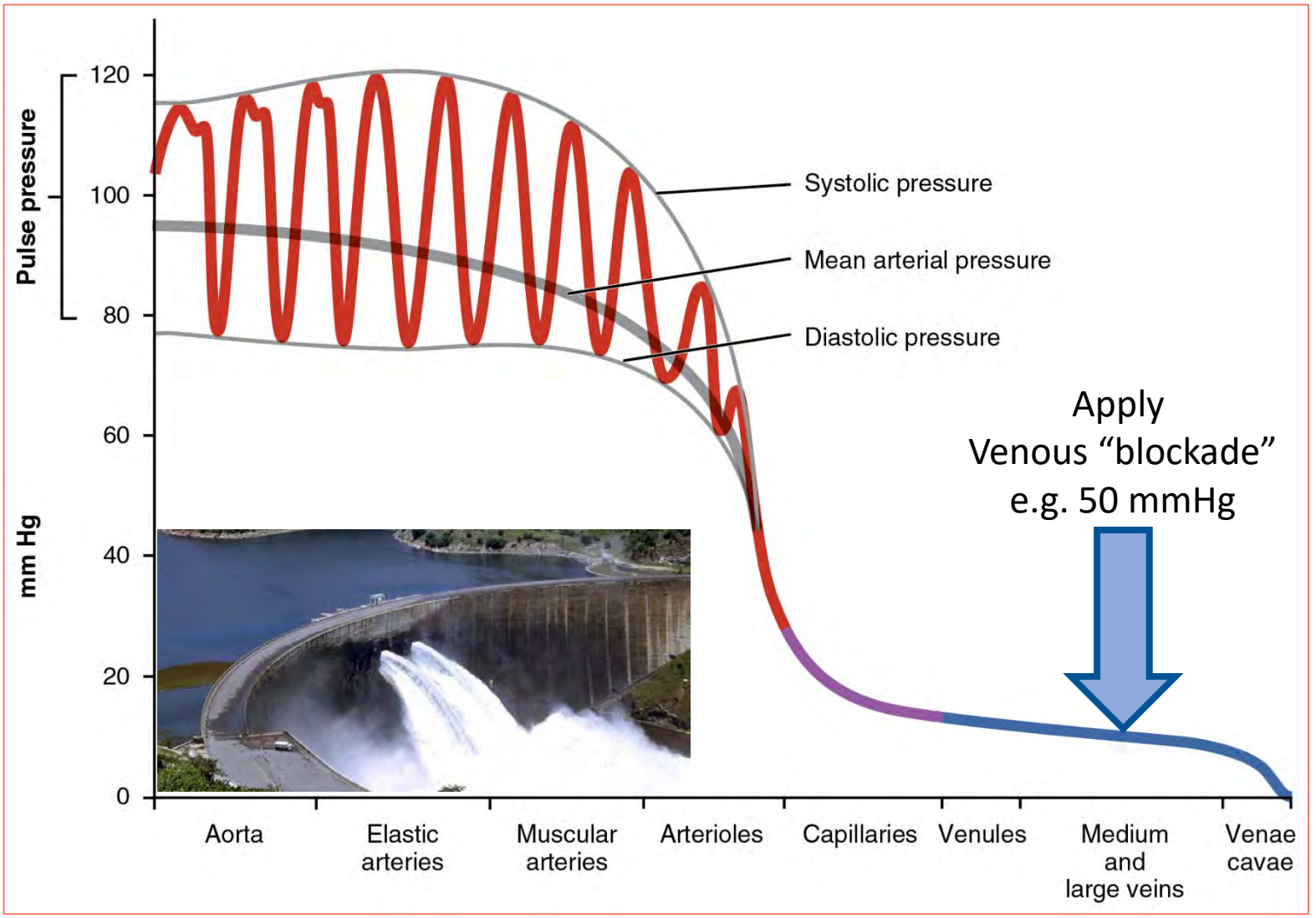
Equilibrium



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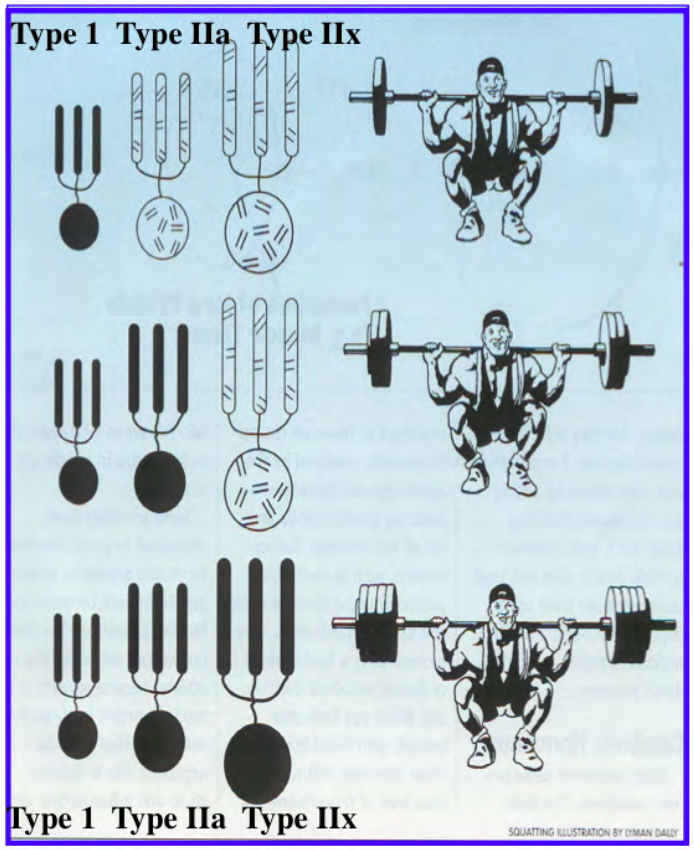
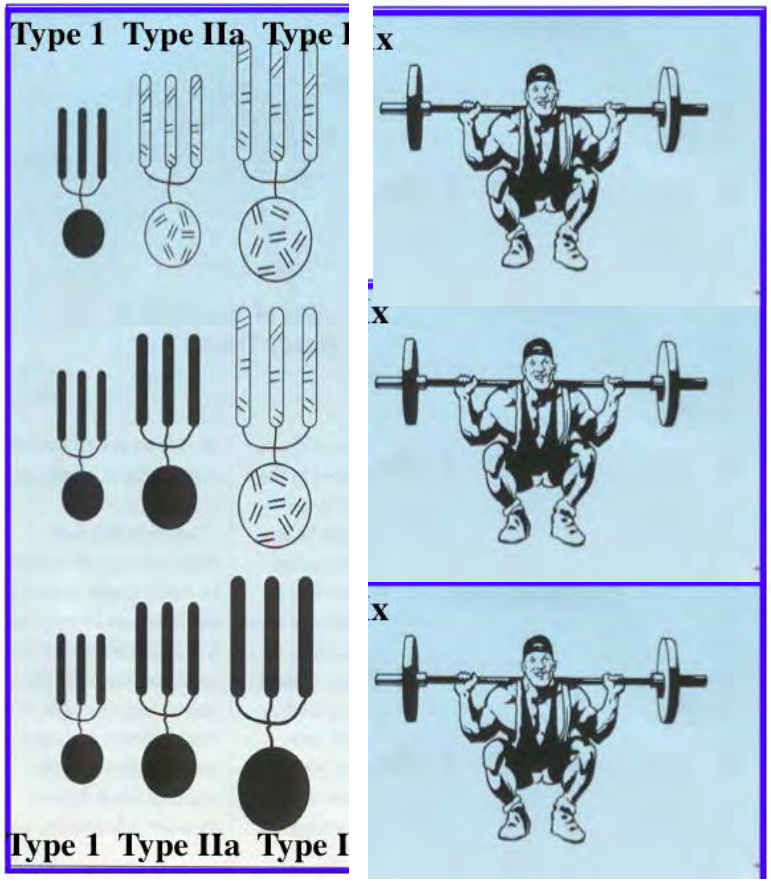
Recruitment and Fatigue

Normal Recruitment and Fatigue Pattern



BFR Recruitment and Fatigue Pattern



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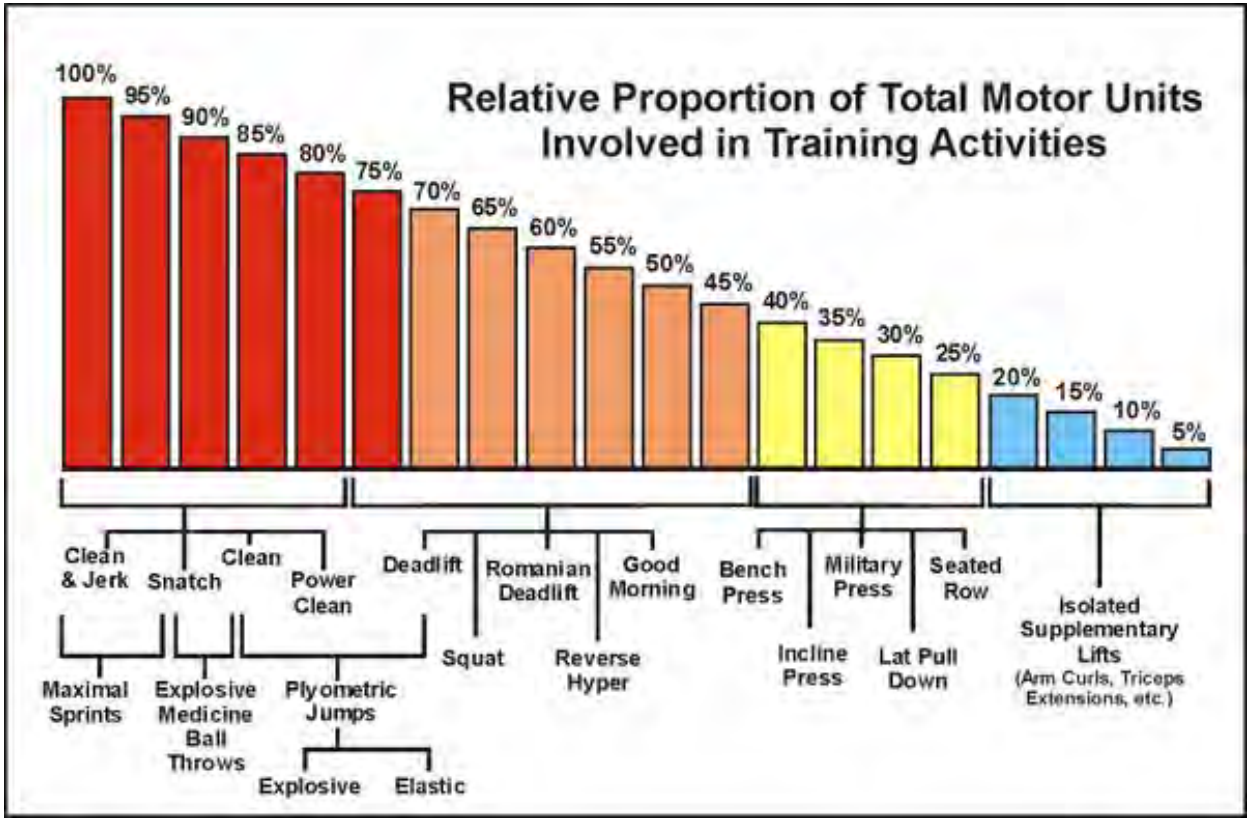
Sequential Recruitment of Motor Units for different exercises



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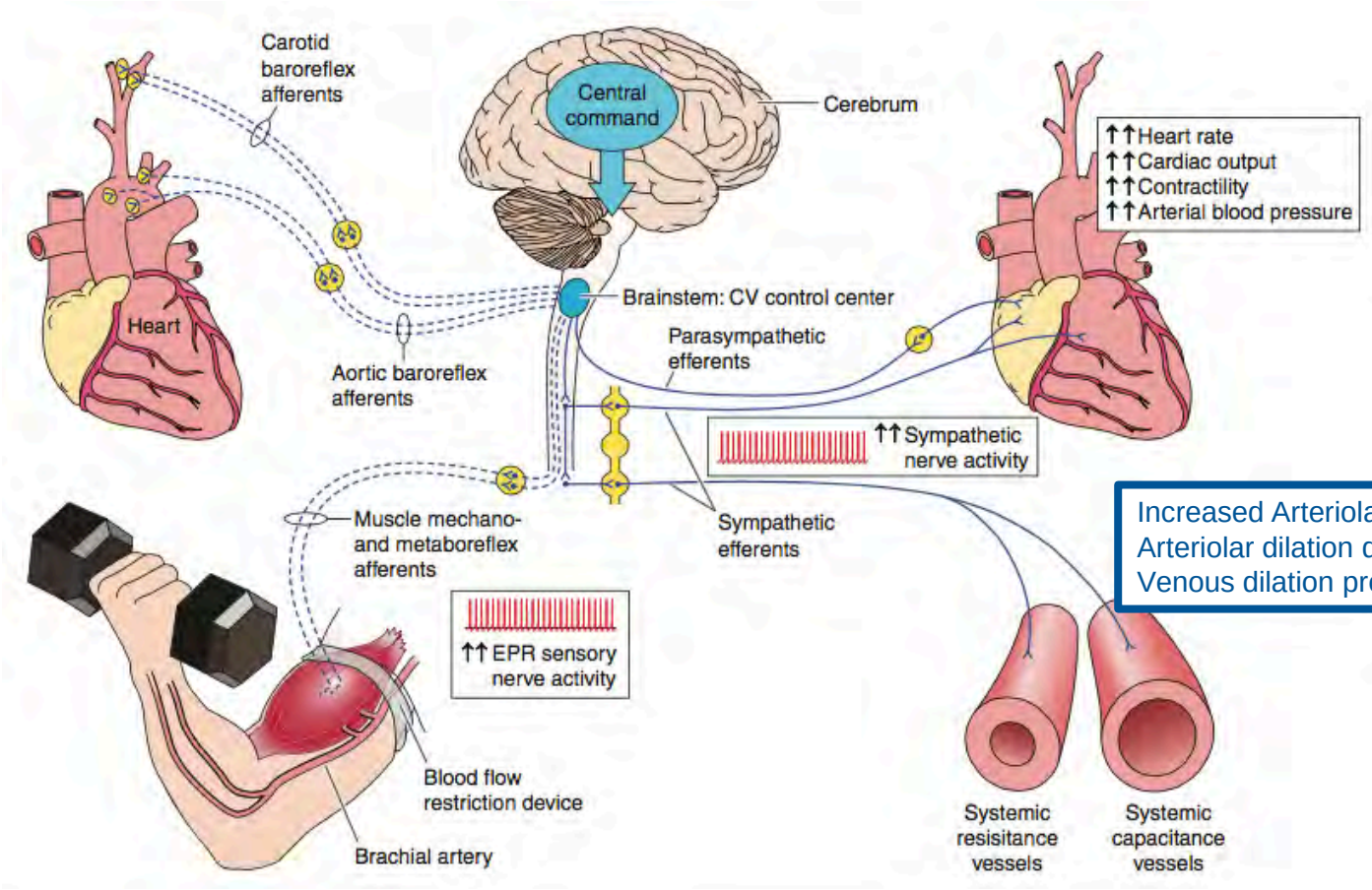
Neural afferent and efferent pathways



Increased Arteriolar resistance proximally
Arteriolar dilation distally
Venous dilation proximally and distally

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Disuse Atrophy

- 2 weeks of microgravity results in 20% reduction in skeletal muscle mass
- 2 weeks of bedrest results in substantial atrophy
- 2 weeks of immobilization in a brace or cast results in substantial atrophy

Top Diagnoses / Who Benefits

- ACL Reconstruction
- Knee Arthroscopy (especially meniscus repairs)
- Total Joint Replacements
- Shoulder Surgeries
  - Rotator Cuff Repair
  - Stabilization Procedures
  - Arthroscopies
- Most Tendon Repairs
  - Achilles
  - Patellar
  - Quad
- Hip Arthroscopy
- Any surgery/diagnosis requiring periods of immobilization or restricted weight-bearing
- Arthritic Joints
- Any athlete/injured worker

BFR Safety

- Contraindications – depends on the device!
  - Limb with Lymphedema
  - Sickle cell
  - Limb with vascular access or indwelling catheter
  - Across a fresh wound
- Indications
- FDA Concerns?

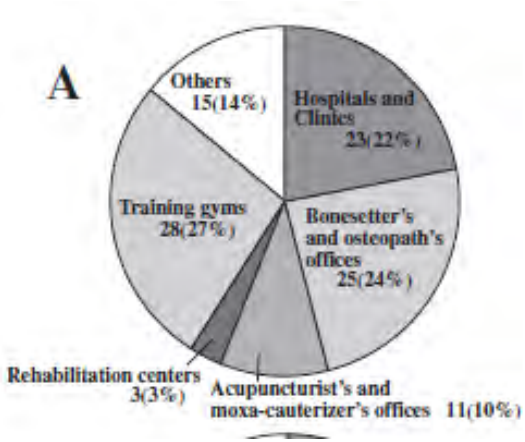
Is BFR Training Safe?

Approximately, 300,000 KAATSU sessions performed per day for years in Japan. No reports of complications.

National Survey 2005

a) 6 cases of DVT in 12,642 people or ~32,000 KAATSU sessions.

- ~1/2,000 in National Survey
- 1/100,000 in general population
- 1/100 in hospitalized population



b) 1 case pulmonary embolism

c) 1 case of rhabdomyolysis in ~32,000 KAATSU sessions.

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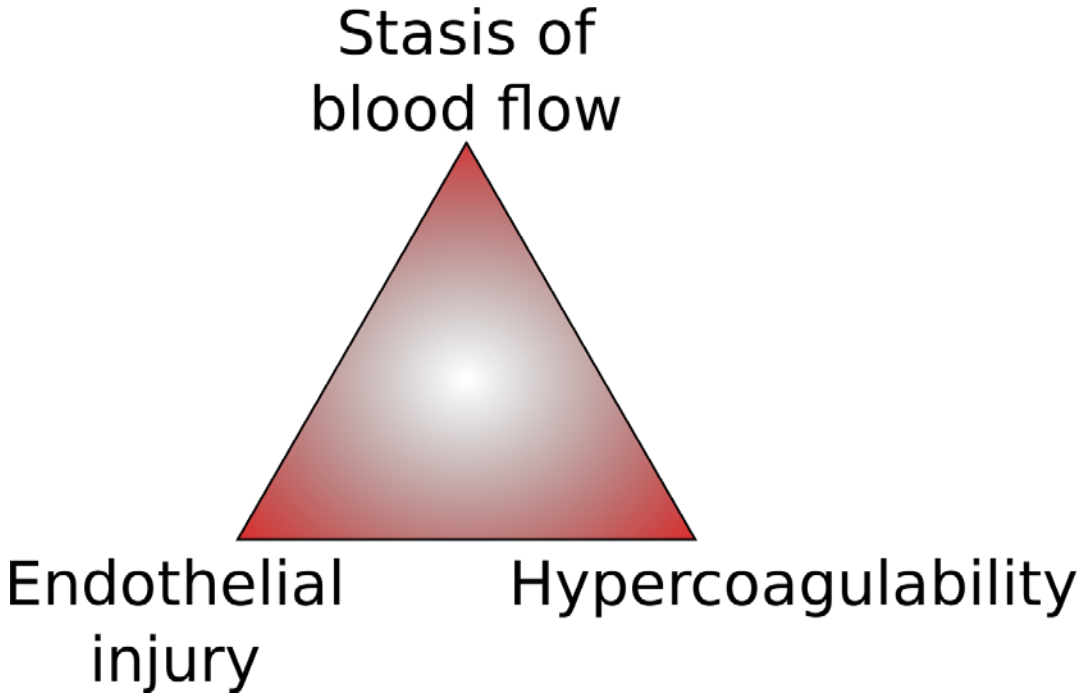
DVTs

If no occlusion of arterial inflow and exercise, one does not have stasis.

Unlike surgery, there is little to no endothelial injury with BFR

Virchow's Triad for Deep Venous Thrombosis (DVT's)



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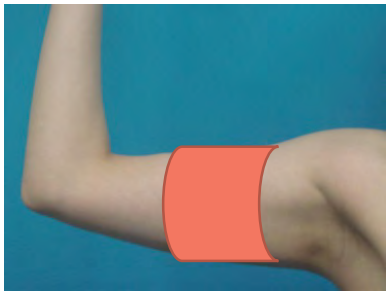
A Tale of Two Bands

Pneumatic Cuffs

- Inelastic
- Wide
- Designed to cut off blood flow / occlude
- Go to LOP and back off recommendation and monitor fatigue
- Painful



Pneumatic Belts/bands

- Elastic
- Narrow
- Designed to restrict/impede
- Use pressure
- Comfortable

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Wide, rigid cuff

Start at 0 mmHg showing both arterial and venous flow, then cuff up to 150 mmHg with total occlusion of both arterial and venous flow, then return to 0 mmHg and resumption of arterial and venous flow

Narrow, Elastic Band

Start at 0 mmHg showing both arterial and venous flow, then belt to 150 mmHg with continued arterial and venous flow, then up to 500 mmHg with absent venous flow and diminished but present arterial flow, then hand squeeze reestablishing both arterial and venous flow, then back to 0 mmHg and vigorous arterial and venous flow

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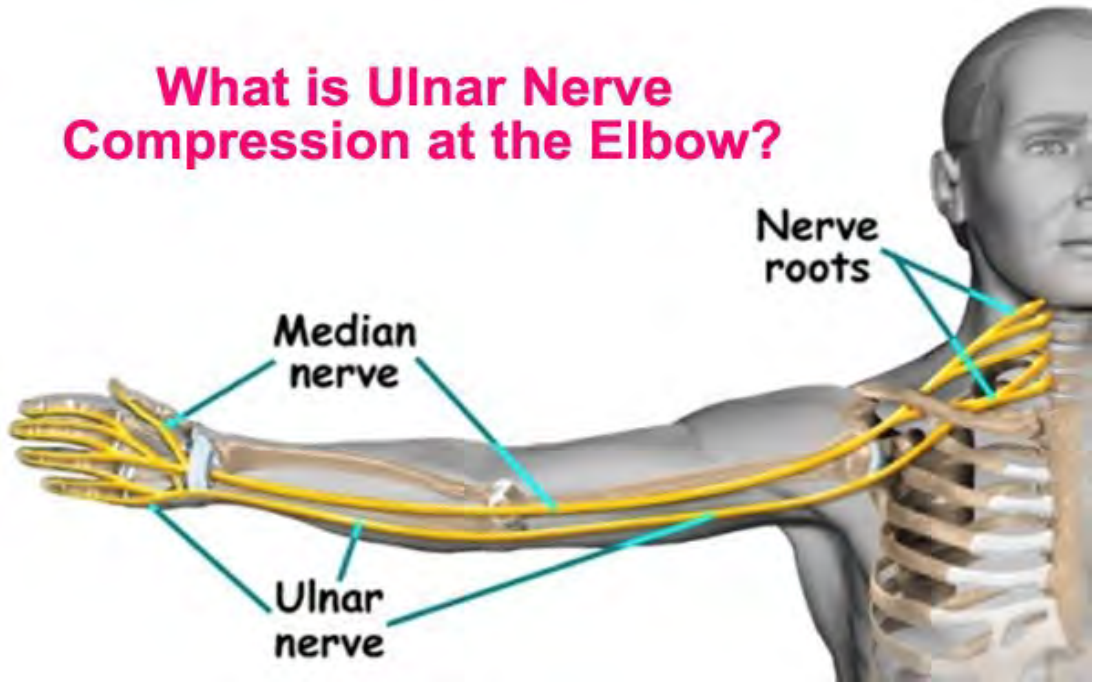
Peripheral Neuropathy from BFR Training?

1. Very narrow, non-elastic, non-pneumatic, rigid belts, placed tightly, can pin the ulnar or median nerve against the humerus and cause damage by direct mechanical compression.
2. Any cuff or band, if pressure is high enough (occlusive) can cause ischemic damage to the small vessels in the peripheral nerves resulting in a neuropathy.



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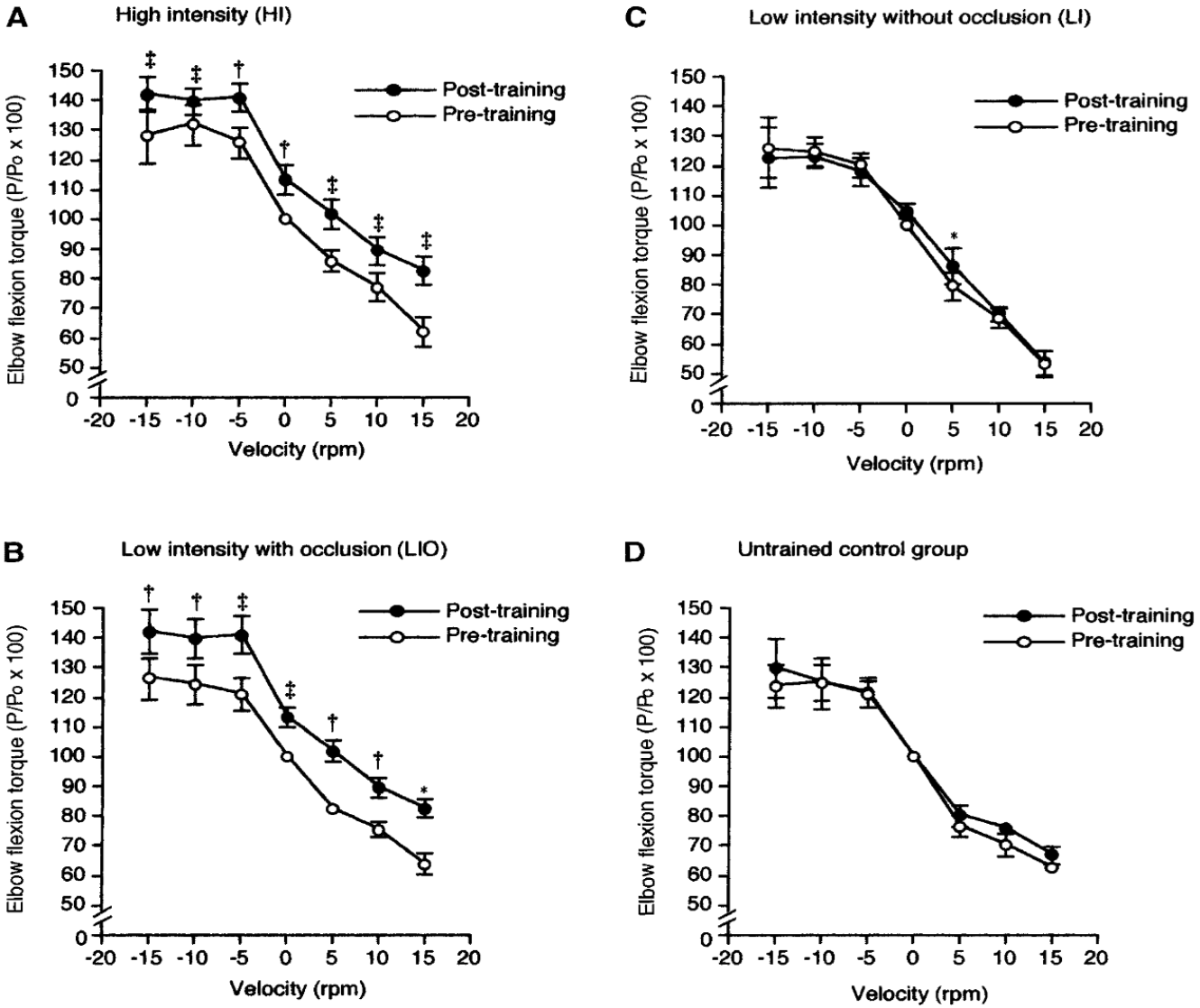
BFR Efficacy

Takarada et. al.
J. Appl. Physiology
88: 2097-2106, 2000



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Increase in muscle CSA from KAATSU

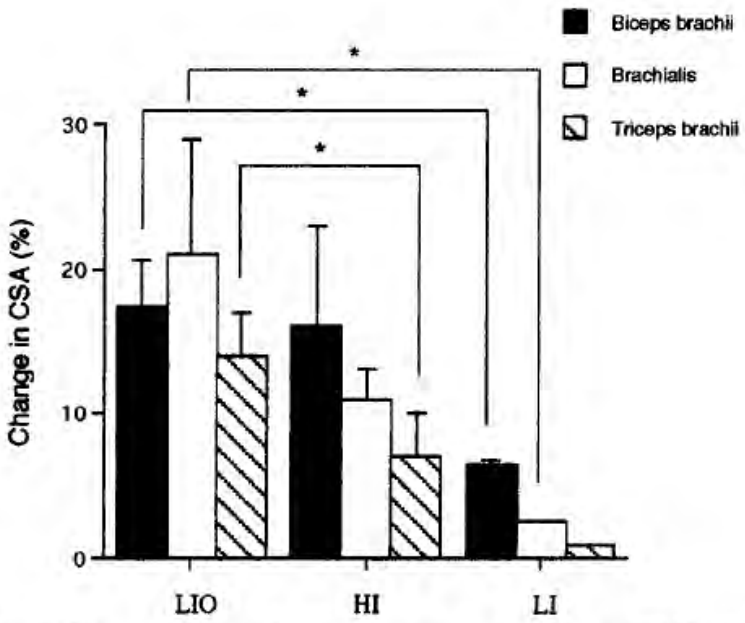

Fig. 6. Percent changes in muscle cross-sectional area (CSA) after exercise training at low intensity with occlusion (LIO), low intensity without occlusion (LI), and high intensity (HI), shown as means ± SE ($n = 19$). *Statistically significant differences ($P < 0.05$).

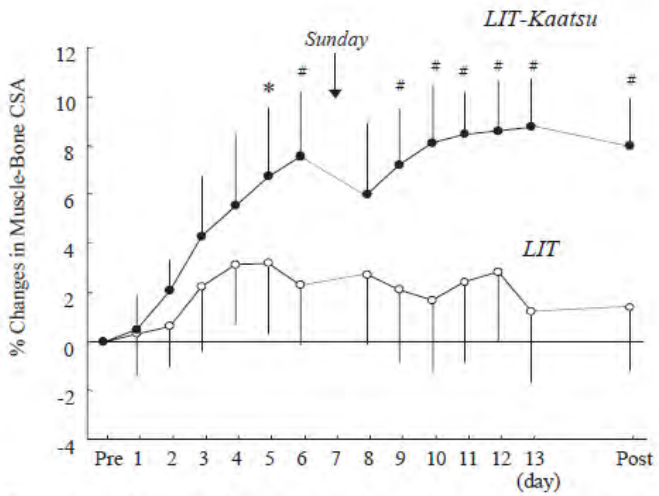

Figure 1. Percent change in estimated muscle-bone cross-sectional area (CSA) for the low-intensity resistance training combined with restriction of muscular blood flow (LIT-Kaatsu, filled symbols) and low-intensity resistance training alone (LIT, unfilled symbols) groups measured before, during (every morning prior to the training session), and after the training period. Values are mean ± SD. *P < 0.05 and #P < 0.01 between LIT-Kaatsu and LIT.

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Hypertrophy distal AND proximal!

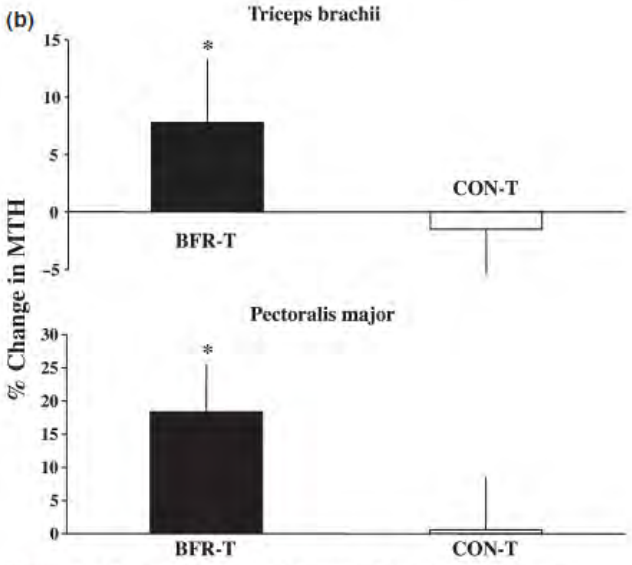

Figure 3 Changes in muscle thickness of the triceps brachii and pectoralis major muscles following the training period. Data are means ± SD. BFR-T is blood flow restriction group (filled symbols), and CON-T is non-blood flow restriction group (unfilled symbols). *Different from CON-T, $P<0.05$.

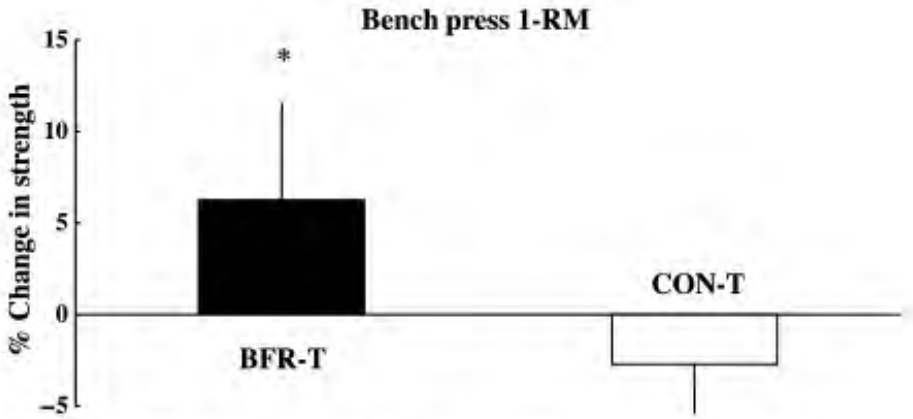

Figure 4 Per cent changes in one repetition maximal bench press strength following the training period. Data are means ± SD. BFR-T is blood flow restriction group (filled symbols), and CON-T is non-blood flow restriction group (unfilled symbols). *Different from CON-T, $P<0.05$.

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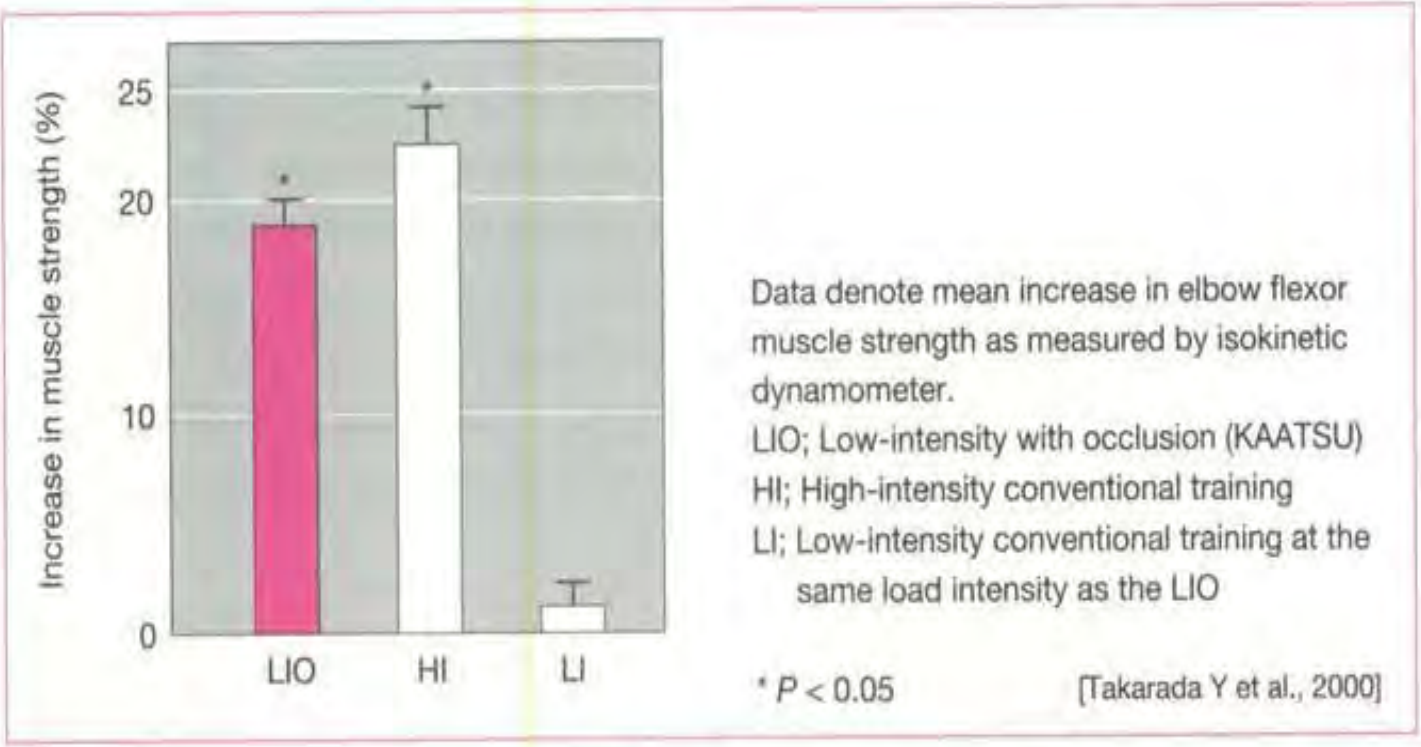
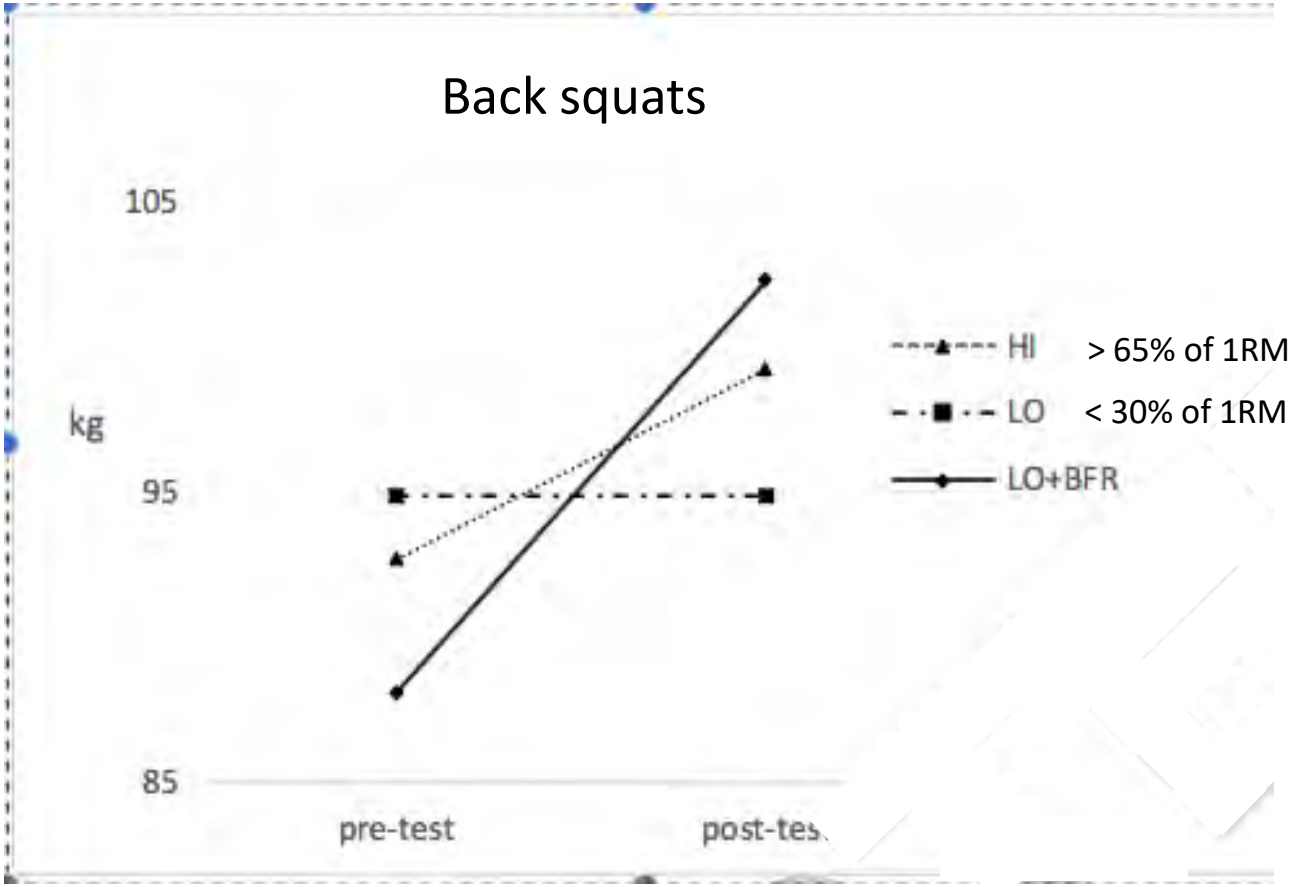


Fig. 4.3 Increase in muscle strength after KAATSU TRAINING on the elbow flexor muscle at 30 - 50% 1RM.

Comparison of efficacy of 12 sessions of strength training in high school students

Light weight plus BFR is more effective than either standard heavy lifting or light lifting alone at improving strength



Luebbers et. al.
J. Strength and Conditioning
Publ. ahead of print 11/2017

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Evidence of BFR Training Effect on Bone

Table 1. Percent changes in strength, muscle CSA and blood parameters following 3 weeks of walk training combined with (KAATSU) and without (Control) restriction of leg muscle blood flow.

	Leg press 1-RM	Thigh muscle CSA	Bone-specific ALP	IGF-1
Control	1.3 ± 3.8	-0.6 ± 2.9	0.3 ± 8.9	-0.2 ± 14.7
KAATSU	7.5 ± 6.2 *	5.8 ± 3.8 †	10.8 ± 0.6 *	3.5 ± 15.0

CSA, cross-sectional area; ALP, alkaline phosphatase; IGF-1, insulin-like growth factor-1
*P<0.05, †P<0.01 Control vs. KAATSU

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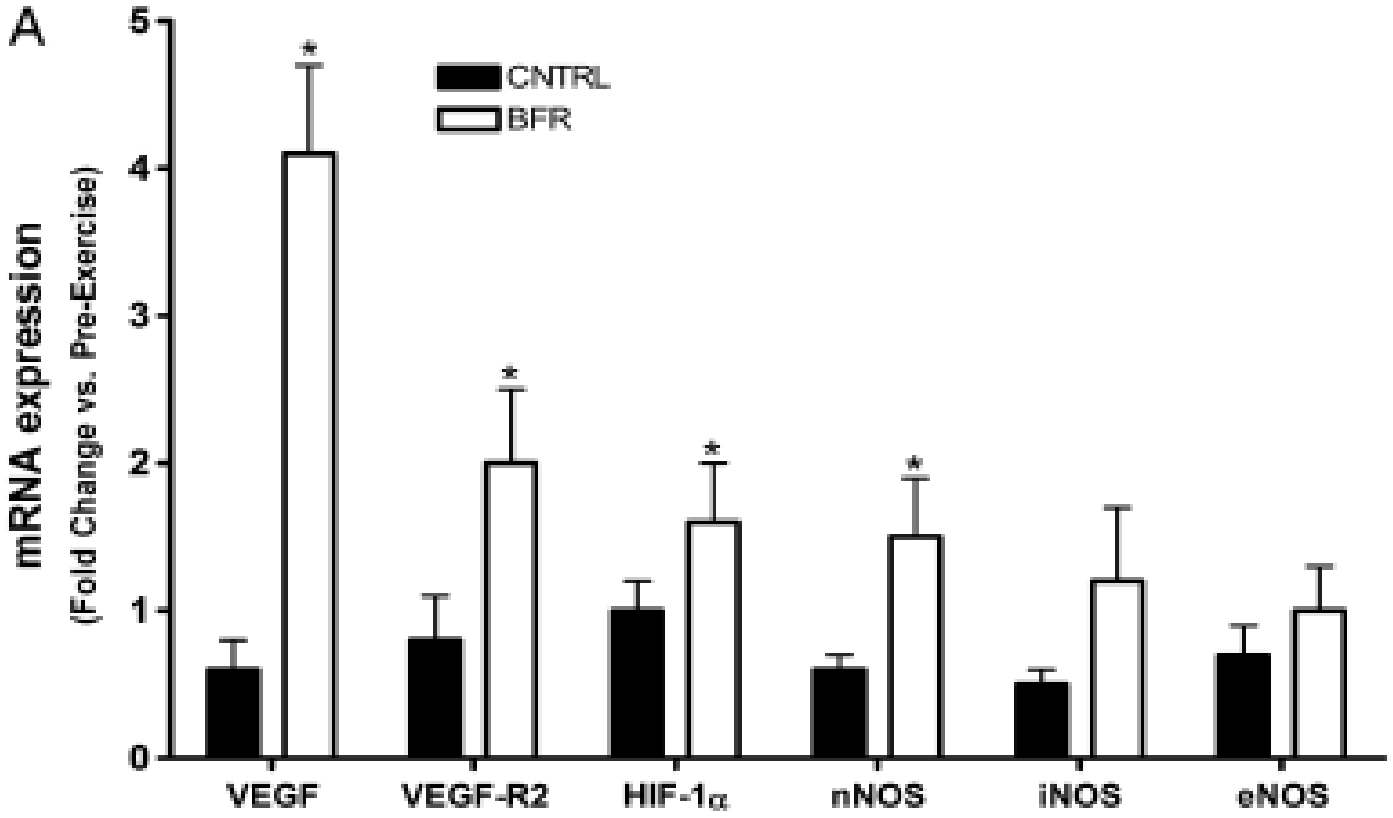
Evidence of angiogenic stimulation from BFR



Larkin et. al.
Blood Flow Restriction Enhances Post-Resistance Exercise Angiogenic Gene Expression
Med Sci Sports Exer Vol 44, No 11, pg 2077-2083, 2012

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Summary – Efficacy of BFR

- Nerve—myelination, size
- Muscle
  - Strength
  - Size
    - Hypertrophy
    - Hyperplasia
- Vasculature
  - Arteries—adventia, smooth muscle, endothelium
  - Capillaries– endothelium
  - Veins—smooth muscle, endothelium
- Tendon
  - Tensile strength
- Bone
  - Bone density

Professional Space

B Strong

DELFI

KAATSU

Smart Cuffs

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Consumer Space

B Strong

BFR Bands

Occlusion Cuff

OptiFit

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LAB!

- Band Placement
- Recommended Pressures
- Work distal to proximal
- Disturbance of Homeostasis
- 20 minute maximum inflation time (can deflate, wait a few minutes and re-inflate)
- Depending on feedback, can increase/decrease pressure by 25-50 mmHg each session or can also vary exercise/resistance

Band Placement

- There is no right or left side (belts are identical)
- Inflation valve should be on front of body facing inward
- Place Velcro tail strap through metal buckle around limb
  - Upper Extremity: Sits above belly of biceps muscle and below deltoid insertion
  - Lower Extremity: as high as possible on thigh
- Insufficient initial tension on belt can lead to an ineffective B-Strong session
- To remove, first deflate by pressing valve with finger/nail, then release Velcro tail strap and pull belt off.

Recommended Pressures

If not using app, general starting pressures:

- Green UE – 150mmHg
- Red UE – 200mmHg
- Blue LE – 250mmHg
- Yellow LE – 300mmHg

Patient Responses

APPROPRIATE

Tissue color

Pittichae

Fatigue

Disturbance of Homeostasis

Pre/Post Exercise

- Hydration
- Nutrition

INAPPROPRIATE

Numbness/tingling

Pain

Breakdown of technique

Vasovagal response

- Start with LE
- Bands in place but not inflated / lightly inflated

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Adjusting Pressures

- If no fatigue, increase 50mmHg
- If only mild fatigue, increase 25mmHg
- If appropriate response, no change
- If mildly too fatigued, decrease 25mmHg
- If severe DOMS, decrease 50mmHg

Care of Bands

- Wipe dry (wet towel or Sanizide)
- Can use stockinette underneath
- Can use in washing machine – gentle cycle (no dryer)
- Do not leave in sun
- Put away neatly in bag

UE Band Lab

- Using concept of distal to proximal:
  - Putty squeeze
  - Gripper squeeze
  - Biceps curls with dumbbell
  - Triceps isolation with cable column
  - Push-up matrix on wall vs prone
  - Static plank vs plank matrix in prone

LE Band Lab

- Using concept of distal to proximal:
  - Foot intrinsic strengthening
  - Toe/heel raises in sitting vs standing calf raises
  - Sit to stand (eccentric control, butt taps)
  - Total Gym double leg vs single leg squats
  - Forward Step up with TKE
  - Lateral/Forward Step Down
  - RDLs
  - Double vs single leg bridges
  - Ball Bridges with/without curl

Cardio / Plyometric Band Lab

- Squat Jumps
- Depth Jump to Vertical Jump
- Interval Training
- Skater Jumps
- Plyo Box Explosions
- Juggling with soccer ball

Documentation/Coding

Code for exercises that were performed and for patient education

SOAP note documentation:

- Subjective: any immediate effect of BFR or response from last treatment
- Objective: Document band size and pressure, time with bands on
- Assessment: patient response to treatment
- Plan: increase/decrease band pressure; what exercises to progress to with bands

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