What is BFR

By repeating the contraction of specific motor units, they “fatigue” and signals associated with “fatigue” induce both local and systemic responses that allow the motor units to improve their ability to sustain the exercise.

“Fatigue” is felt when “Homeostasis” in the working tissues is “Disturbed”.

In the case of BFR exercise, this Disturbance is caused by severe hypoxia and decrease in intracellular phosphate stores (ATP/PC).

Protein synthesis is up-regulated in all active tissues.

History summary

Yoshiaki Sato had an epiphany in 1966 that led to the development of Blood Flow Restriction Training.

Over the next ~30 years, Sato experimented with many different methods to achieve safe and effective BFR training leading to relatively narrow, elastic, pneumatic bands that are adjusted by air pressure.

The decade from 2000 to 2010 saw publication of various aspects of BFR training in Western scientific publications.

This decade also saw the spread of the concept to Europe and the Americas, but since Sato's equipment was either unavailable or too expensive, many different devices were tried in an attempt to reproduce Sato's, including wraps, straps, belts, BP cuffs, surgical tourniquets. Many of these devices were neither safe, nor effective.

From 2010 to the present BFR training has become increasingly popular in rehabilitation and training. More and more studies have been published with now over 300 peer reviewed publications in English.

Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans: Appl Physiol (1985). 2000 Jun, 88(6): 2097-106 Takarada Y, Takazawa H, Sato Y, Takebayashi S, Tanka Y, Ishii N.

Study Design: Before and after measures of elbow flexor strength and CSA of 11 BFR, 11 HIT, 8 low intensity, 5 CON 2x/week for 16 weeks

Type of testing: CSA (cross sectional area) by MRI and isokinetic dynamometer for strength and blood draw to measure vascular and hormonal changes

Type of Exercise- Low intensity group with and without occlusion (LIO, LI), normal resistance training (NR), and control 2x/week for 16 weeks. Low intensity group performed 3 set of 20 repetitions at 50% 1 RM and normal resistance performed 3 set of 10 repetitions at 80% with 1 min rest.

Results - significantly elevated blood plasma levels in occlusion group compared to other groups, Significant increase in CSA for LIO and Normal compared to LI and trend towards increased CSA for LIO compared to normal Significant increase in strength for LIO and normal compared to LI and control. Trend towards increased strength of normal over LIO.

Blood flow-restricted strength training displays high functional and biological efficacy in women: a within-subject comparison with high-load strength training.

Am J Physiol Regul Integr Comp Physiol. 2015 Oct;309(7):R767-79. doi: 10.1152/ajpregu.00497.2014. Epub 2015 Jul 22

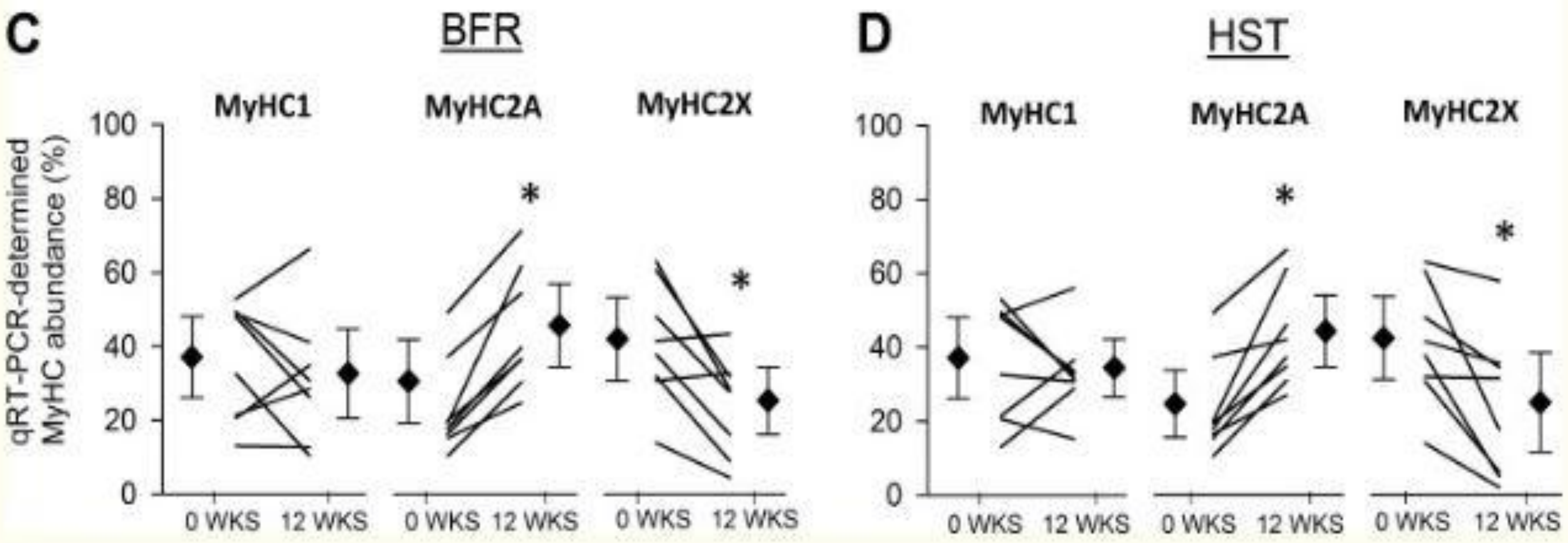
Ellefsen, Hammarström, Strand, Zacharoff, Whist J, Rauk, Nygaard, Vegge, Hanestadhaugen, Wernbom, Cumming, Rønning, Raastad, Rønnestad

Study Design - 9 untrained females crossover study knee extensor CSA and strength. 4x/week for 12 weeks, 2 times BFR (30% 1 RM to exhaustion, 5 sets, 45 seconds rest), 2 times HST (6-10 reps to failure, 3 sets, 90 seconds rest) on opposite leg.

Type of testing - CSA via MRI, 1 RM strength, and blood serum levels

Results - Similar blood serum levels, similar shift from type 2x (low oxidative capacity, highest force output, exclusive anaerobic) to type 2a fibers (higher oxidative capacity, high force output. Primarily anaerobic, some aerobic). "This particular adaptation suggests improvements in muscle functionality and is especially beneficial for individuals with elevated MyHC2X levels, such as is observed in many patient groups and as a consequence of aging."

CSA and 1 RM strength improved similarly across both groups except under cuff


C
BFR
MyHC1
MyHC2A
MyHC2X
D
HST
MyHC1
MyHC2A
MyHC2X
qRT-PCR-determined MyHC abundance (%)
100
80
60
40
20
0
0 WKS
12 WKS
*

Practical blood flow restriction training increases muscle hypertrophy during a periodized resistance training programme.
Clin Physiol Funct Imaging (2013)doi: 10.1111/cpf.12099
Ryan P. Lowery, Jordan M. Joy, Jeremy P. Loenneke, Eduardo O. de Souza, Marco Machado, Joshua E. Dudeck, and Jacob M. Wilson

Study Design: Randomized Cross Over study of elbow flexor strength and CSA of 20 college athletes with 1 year RT training. 2x/week for 8 weeks (4 weeks BFR, 4 week HIT). Knee wraps to 6-7 out of 10 for BFR, 0/10 for HIT

Type of testing: muscle thickness measured by ultrasound

Type of Exercise- bicep curl 3 sets of 30 at 30% 1 RM for BFR, 3 sets of 15 at 60% 1 RM for HIT. All groups performed traditional full body exercises in addition to BFR or non-BFR curls

Results - No significant difference between HIT and BFR for muscle thickness at 0, 4, or 8 weeks. There was significant increase in muscle thickness at both 4 and 8 weeks regardless of which group did BFR first.

INFLUENCE OF RELATIVE BLOOD FLOW RESTRICTION PRESSURE ON MUSCLE ACTIVATION AND MUSCLE ADAPTATION

BRITTANY R. COUNTS, BS,1 SCOTT J. DANKEL, BS,1 BRIAN E. BARNETT, BS,1 DAEYEOL KIM, MS,2
J. GRANT MOUSER, BS,2 KIRSTEN M. ALLEN, BS,2 ROBERT S. THIEBAUD, PhD,3 TAKASHI ABE, PhD,1
MICHAEL G. BEMBEN, PhD,2 and JEREMY P. LOENNEKE, PhD
MUSCLE & NERVE March 2016

Study Design: 7 relatively young (avg. age 23) active individuals. Experimental design within subject comparison- acute and chronic effects with variable pressures of BFR

Type of testing: CSA (cross sectional area) by ultrasound, strength measured by isokinetic torque, muscle activation measured by surface EMG

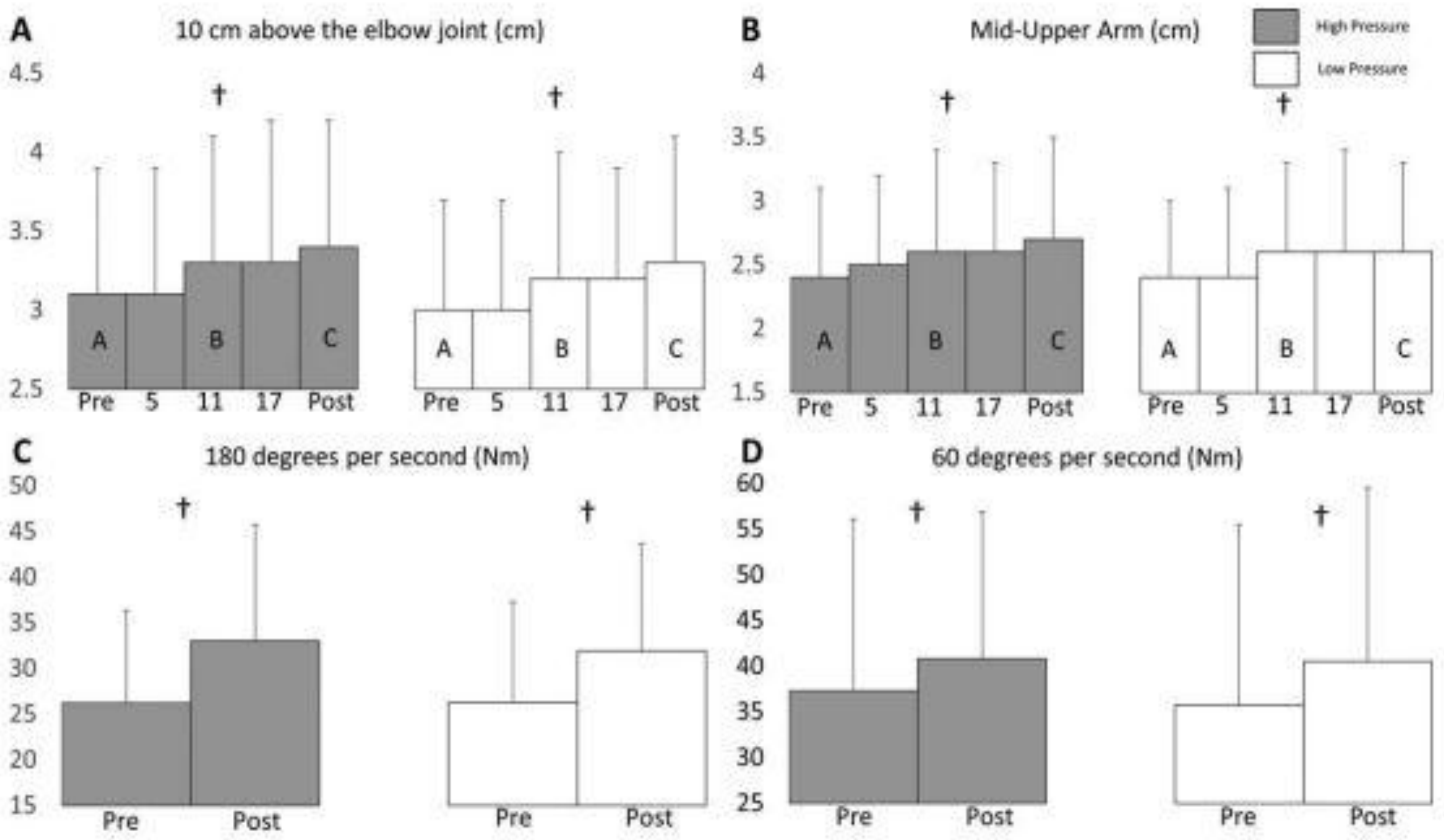
Type of Exercise- 3 sessions total spread out at least 48 hours for acute group 40% up to 90% occlusion. For chronic group 2x/week for 2 weeks followed by 3x/week for 6 weeks (one arm at 40%, the other at 90% occlusion). 1 set of 30 followed by 3x15 with 30 seconds rest at 30% 1 RM. Utilized hokanson cuff with doppler to determine occlusion.

Results - No significant difference in EMG activation for acute group across all pressures. Significant increase in strength in chronic occlusion group overall, no significant difference between pressures. Significant increase in discomfort in high pressure compared to low pressure.

Table 1. Muscle activation from experiment 1.

	EMG amplitude first 3 reps (%MVC)				Time
Arterial occlusion	Set 1	Set 2	Set 3	Set 4	1 vs. 2, 3, 4
40%	33 (9)	46 (19)	48 (18)	44 (14)	
50%	38 (13)	51 (17)	56 (21)	53 (23)	
60%	43 (31)	58 (32)	56 (30)	56 (28)	
70%	36 (20)	49 (26)	52 (26)	49 (23)	
80%	37 (13)	53 (23)	45 (15)	55 (31)	
90%	36 (20)	53 (37)	53 (39)	51 (33)	
	EMG amplitude last 3 reps (%MVC)				
Arterial occlusion	Set 1	Set 2	Set 3	Set 4	2 vs. 3, 4; 3 vs. 4
40%	53 (16)	61 (22)	56 (23)	49 (16)	
50%	62 (27)	74 (34)	64 (38)	63 (38)	
60%	71 (45)	71 (37)	65 (39)	60 (35)	
70%	62 (43)	65 (37)	59 (30)	55 (30)	
80%	61 (26)	68 (41)	66 (48)	61 (40)	
90%	57 (35)	64 (53)	58 (49)	56 (43)	

Variability represented as standard deviations. Main effects of time are noted in the "Time" column at far right. The different numbers represent significant differences between sets ($P \leq 0.05$).



A
10 cm above the elbow joint (cm)
B
Mid-Upper Arm (cm)
High Pressure
Low Pressure
C
180 degrees per second (Nm)
D
60 degrees per second (Nm)
Pre
5
11
17
Post

Table 1 Studies included in the analysis

Citation	Age (years)	Gender	Training status	Exercise mode	Exercise intensity	Frequency of training	Length of training	Protocol	Measure of hypertrophy
Abe et al. (2005c)	<25	M	Rec. active	Squat and knee flexion	20% 1RM	12× week	2 weeks	3 sets of 15 repetitions; 30 sec rest	MRI
Abe et al. (2005b)	<25	M	Athlete	Squat and knee flexion	20% 1RM	14× week	8 days	3 sets of 15 repetitions; 30 sec rest	Ultrasound
Abe et al. (2006)	<25	M	Rec. active	Treadmill walking	50 M/Min	12× week	3 weeks	52-min walking bouts; 1 min rest	MRI
Abe et al. (2009)	<25	M	Rec. active	Treadmill walking	50 M/Min	6× week	3 weeks	52-min walking bouts; 60 sec rest	MRI
Abe et al. (2010b)	>50	M/F	Rec. active	Treadmill walking	67 M/Min	5× week	6 weeks	20 minutes walking	Ultrasoun
Abe et al. (2010a)	<25	M	Rec. active	Cycling	40% VO_{2max}	3× week	8 weeks	15 minutes cycling	MRI
Beekley et al. (2005)	<25	M	Rec. Active	Treadmill walking	50 M/Min	12× week	3 weeks	52-min walking bouts; 60 sec rest	MRI
Fujita et al. (2008)	<25	M	Rec. Active	Knee extension	20% 1RM	12× week	6 days	30-15-15-15 repetitions; 30 sec rest	MRI
Kacin and Strazar (2011)	<25	M	Rec. Active	Unilateral knee extension	15% MVC	4× week	4 weeks	4 sets to volitional fatigue	MRI
Madarame et al. (2008)	<25	M	Untrained	Knee extension and knee flexion	30% 1RM	2× week	10 weeks	30,15,15 repetitions; 30 sec rest	MRI
Ozaki et al. (2011)	>50	M/F	Untrained	Treadmill walking	45% HRR	4× week	10 weeks	20 minutes walking	MRI

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.
	The role of blood flow restriction training for applied practitioners:	

Blood flow restriction training in clinical musculoskeletal rehabilitation: a systematic review and meta-analysis.

BJSM. 2017 Mar; 0(10): 1-11. Luke Hughes, Bruce Paton, Ben Rosenblatt, Conor Gissane, Stephen David Patterson

Study Design: Systematic Review and Meta Analysis. Only included randomised controlled trials comparing LL-BFR to either low-load or high-load protocol without BFR.

Type of testing: 20 studies included: 3 ACL reconstruction, 3 Knee OA, 13 older adult at risk for sarcopenia, 1 sporadic inclusion body myositis.

Results: Across the board improvements compared to low intensity training without BFR (strength, CSA, blood markers).

ACLR groups - (1) 5x5' occlusion first 2 weeks significant difference in CSA, (2) 16 weeks post op exercises one group with BFR, the other without. Significant increase in strength and CSA, (3) 5x5' with quad sets first 2 weeks showed no significant difference in CSA. **Knee OA group** - (1) 4 sets of leg press w/ or w/o BFR at 30% 1 RM for 4 weeks no significant changes in strength/KOOS (released between sets), (2) same as previous, but with women, did show significant increase in 1 RM, isokinetirc knee extensor strength, and stair climb power. (3) 6 weeks Regular stretching and hip strengthening exercises, knee extension w/ or w/o BFR. All improved function and strength, decreased pain during exercise for BFR group. **Elderly** - treadmill walking, lower and upper body exercises. Across the board increase in strength, CSA, arterial/venous compliance, and functional outcomes when assessed.

"The clinical relevance of this review is the demonstration that LL-BFR training can provide a more effective approach to low-load and more tolerable approach to heavy-load rehabilitation. Individualised LL-BFR training prescription may provide a comparable surrogate for heavyload training while minimising pain during training."

Blood Flow Restriction Therapy Preserves Whole Limb Bone and Muscle Following ACL Reconstruction
American Orthopaedic Society for Sports Medicine
March 16, 2019
Corbin A. Hedt, DPT, Robert A. Jack, MD, Michael Moreno, PhD, Domenica Delgado, BS, Joshua David Harris, MD, Patrick C. McCulloch, MD

Study Design: Randomized control study comparing BFR with ACL rehabilitation patellar tendon graft. Preliminary findings posted

Type of testing: 14 relatively young (avg. age 23: 6 Female, 8 male). 2x/week for 12 weeks starting 10 days post-op.

Type of Exercise- Same exercises performed, select exercises performed with BFR. (Quadriceps contractions wks1-3, bilateral leg press wk3-12, eccentric leg press wk4-12, hamstring curl wk4-6, eccentric hamstring curl wk7-12). 20% 1 RM estimated based on unaffected side. 30x15x15x15 30s rest b/w sets.

Results - Total lean mass in only the control group remaining diminished at wk12 ($p<0.05$). Whole leg LM in the injured limb was decreased in the control group, but not the BFR group, at both wk6 and wk12. The control group was observed to have a decrease in BMD at the distal femur and proximal tibia at wk12 as well as the proximal fibula at wk6 and wk12. Similar improvements in single leg squat distance, Y-balance, leg curl, and leg press from wk8 to wk12

Values = Means +/- SEM (Change from Pre-Surgery). Sig: #=diff from pre-surgery, $=diff between group				
GROUP:	BFR		CONTROL	
Independent Variable	**wk6**	**wk12**	**wk6**	**wk12**
Total Lean Mass (kg)	-1.07 ± 0.60 (-1.94 ± 1.22%) #	-0.01 ± 0.87 (-0.06 ± 1.77%)	-1.31 ± 0.80 (-2.39 ± 1.32%) #	-1.14 ± 0.59 (-2.23 ± 0.98%) #
Leg Lean Mass (kg)	-0.19 ± 0.09 (-2.31 ± 1.19%)	-0.11 ± 0.17 (-1.53 ± 1.65%)	-0.72 ± 0.31 (-7.69 ± 3.03%) #	-0.48 ± 0.21 (-5.5 ± 2.29%) #
Thigh Lean Mass (kg)	-0.13 ± 0.03 (-4.45± 1.31%) #	-0.03 ± 0.05 (-1.26 ± 1.72%)	-0.26 ± 0.10 (-7.72 ± 2.57%) #	-0.16 ± 0.05 (-5.21 ± 1.62%) #$
Leg Bone Mass (g)	-8.05 ± 3.40 (-1.29 ± 0.56%)	-11.97 ± 4.39 (-1.92 ± 0.72%) #	-13.40 ± 3.29 (-2.43 ± 0.52%) #	-16.26 ± 3.03 (-3.01 ± 0.52%) #
Distal Femur BMD (g/cm^2)	-0.06 ± 0.03 (-4.55 ± 2.22%)	-0.09 ± 0.03 (-7.41 ± 2.54%)	-0.09 ± 0.03 (-7.83 ± 1.95%)	-0.12 ± 0.02 (-10.35 ± 1.78%) #
Proximal Tibia BMD (g/cm^2)	-0.05 ± 0.02 (-3.55 ± 1.14%)	-0.03 ± 0.05 (-1.68 ± 3.61%)	-0.06 ± 0.07 (-3.42 ± 4.90%)	-0.15 ± 0.02 (-10.35 ± 1.57%) #$
Proximal Fibula BMD (g/cm^2)	-0.02 ± 0.02 (-4.35 ± 4.05%)	+0.01 ± 0.02 (+1.66 ± 5.81%)	-0.07 ± 0.03 (-13.49 ± 5.47%) #$	-0.08 ± 0.02 (-15.9% ± 3.14%) #$

THE EFFECTS OF BLOOD FLOW RESTRICTION TRAINING ON HEALTHY INDIVIDUALS USING (B)STRONG BRAND CUFFS: A RANDOMIZED CONTROLLED TRIAL

Kate Early, Ph.D, Joshua McGinty, PT, DPT, OCS, David Buuck, PT, DPT, OCS, Rachel Selman, PT, DPT, CSCS, Mallory Rockhill

Study Design: RCT comparing strength, hypertrophy, and pain. 31 healthy young adults (11 BFR, 10 HIT, 10 control).

Type of testing: 1 RM and grip strength, Bioelectric impedance, limb circumference, number of pusn-ups

Type of Exercise- Upper and lower extremity exercises 2-3x/week for 7 weeks for total of 20 sessions. HIT (3x8 at 60%) BFR (3x30 at 20%). bicep curl, tricep extension, push-up, hamstring curl, knee extension, calf raise

Results - No significant difference in BMI, increase in circumference in R/L forearm in HIT and BFR. Significant increase in strength for both BFR and HIT which had similar outcomes. Trend toward increase strength HIT with push ups, hamstring curl, tricep extension. Significant decreased DOMS in BFR vs HIT.

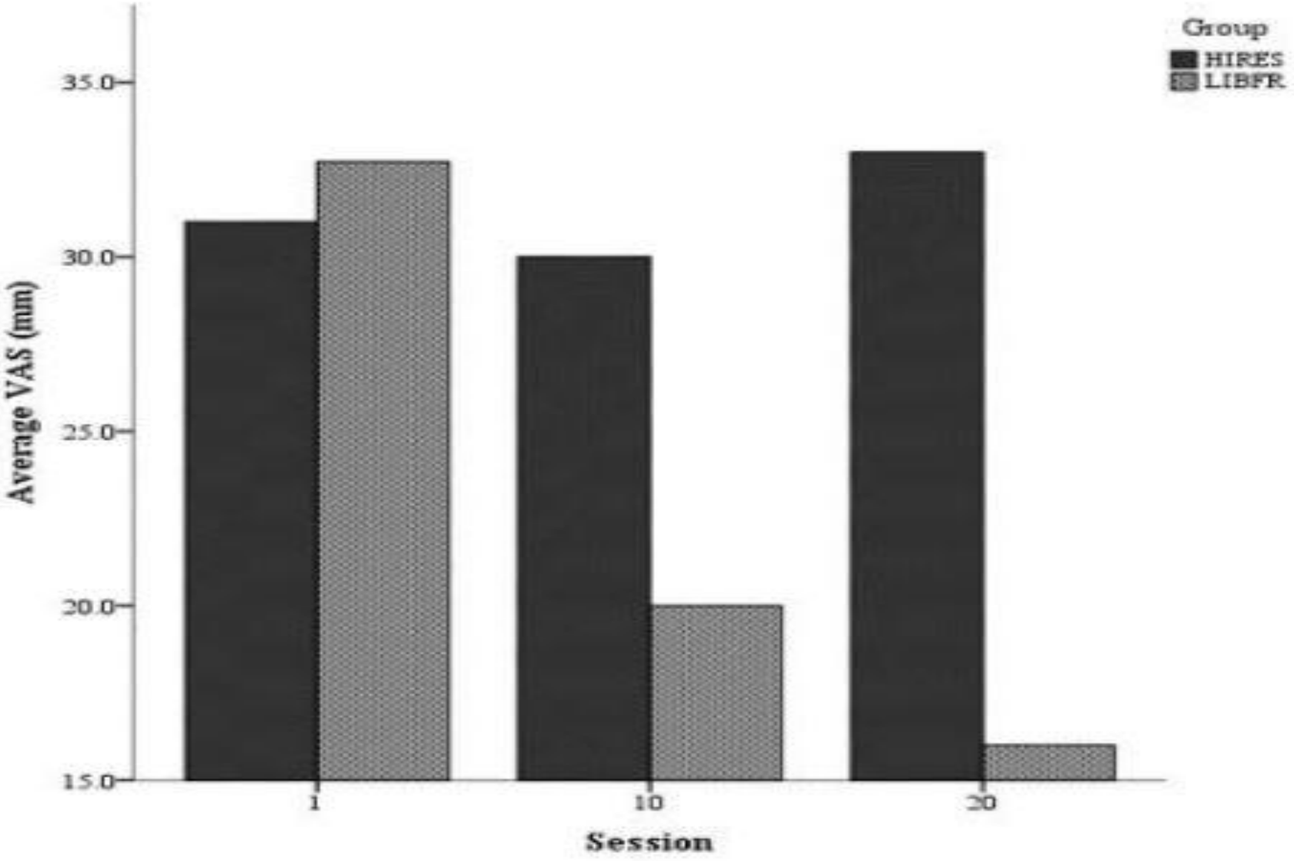


Figure 3. Results from the Visual Analog Scale (VAS) taken 24-hours post each exercise session. [a]Significant difference between groups (*p*<0.05).

Rapid Increase in Plasma Growth Hormone after low-intensity resistance exercise with vascular occlusion

nt. J. KAATSU Training Res. 2005; 1: 77-81

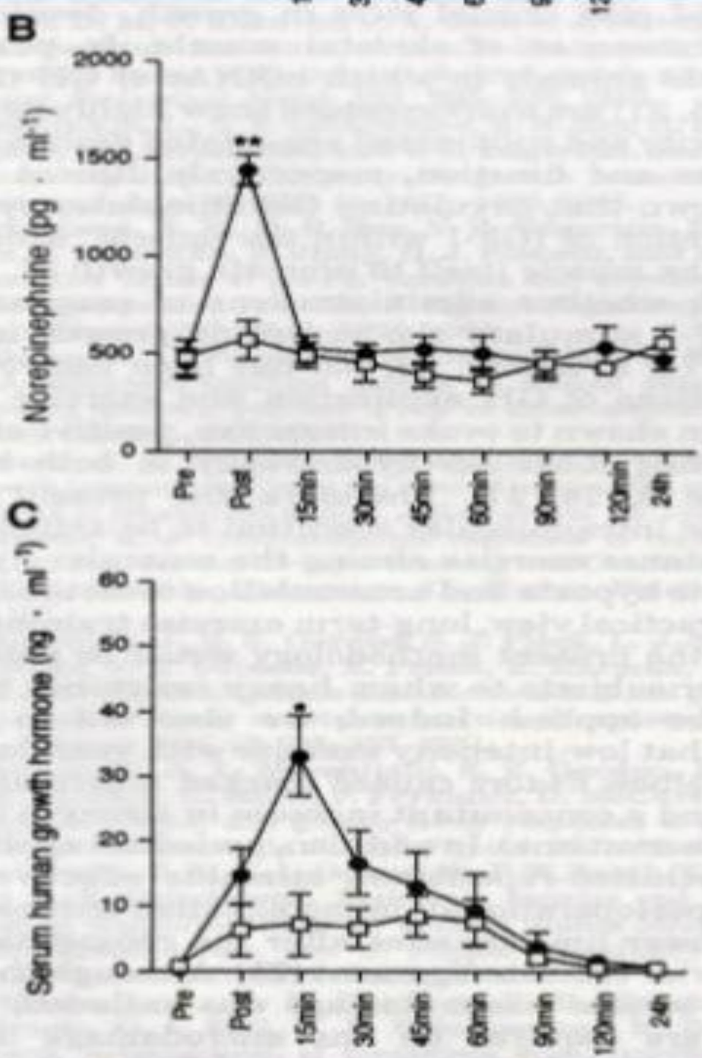
M.D. Beekley, Y. Sato, T. Abe

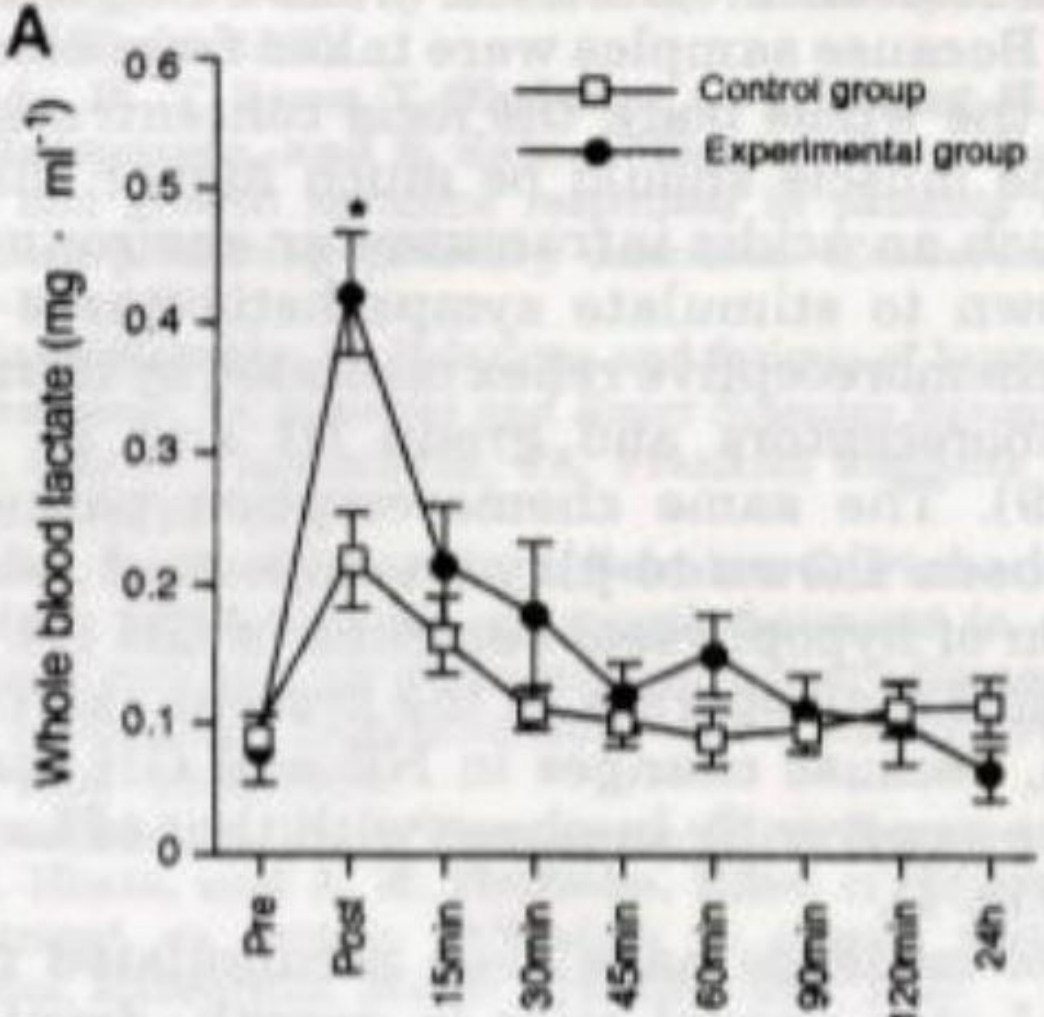
Study Design: 6 young (20-22) male athletes, proximal thigh compressed 214 mmHg ± 7, cuff width, 33 mm; length, 800 mm).

Type of testing: Blood sampling looking at Plasma concentrations of growth hormone (GH), norepinephrine (NE), lacate (La), lipid peroxide (LP), interleukin-6 (IL-6), and activity of creatine phosphokinase (CPX).

Type of Exercise- Bilateral Leg extension at 20% 1 RM 5 sets to exhaustion (mean of 14 repetitions) with 30 seconds rest. Same subjects performed same exercise 1 week later without occlusion. Blood draws taken at 0, 15, 45, 90, and 24 hours

Results - significant increase in blood plasma levels of all hormones, 290% increase in GH (1.7x higher than high intensity with < 1 min rest b/w sets). Greatest increase in LA and NE immediately after exercise, peak GH 15 min post exercise. Rapid decline thereafter, returning to baseline. Less than a quarter of CPx and IL-6 (which are inflammatory markers) compared to eccentric exercise.


B
Norepinephrine (pg · ml⁻¹)
2000
1500
1000
500
0
Pre
Post
15min
30min
45min
60min
90min
120min
24h
C
Serum human growth hormone (ng · ml⁻¹)
60
50
40
30
20
10
0
Pre
Post
15min
30min
45min
60min
90min
120min
24h



A
Control group
Experimental group
Whole blood lactate (mg · ml^-1)
0.6
0.5
0.4
0.3
0.2
0.1
0
*
Pre
Post
15min
30min
45min
60min
90min
120min
24h

Effects of low-intensity bench press training with restricted arm muscle blood flow on chest muscle hypertrophy: a pilot study
Clin Physiol Funct Imaging (2010) 30, pp338–343
Tomohiro Yasuda, Satoshi Fujita, Riki Ogasawara, Yoshiaki Sato and Takashi Abe

Study Design: Randomized control trial 10 subjects (5 BFR, 5 CON).

Type of testing: muscle thickness (measured by ultrasound), muscle strength, blood serum levels

Type of Exercise- bench press 2x/day 6x/week for 2 weeks. 30x15x15x15 in both groups, one with BFR, the other without

Results - 8% and 16% increase in muscle thickness (triceps and pec major), compared to no increase in control group. Significant increase in strength (6%) compared to control. No significant changes in blood markers (samples taken pre and 2 post exercise). No significant changes in inflammatories markers indicating muscle hypertrophy not due to swelling.

Electromyographic responses of arm and chest muscle during bench press exercise with and without KAATSU
Int. J. KAATSU Training Res. 2006; 2: 15-18
T. Yasuda, T. Fujita, Y. Miyagi, Y. Kubota, Y. Sato, T. Nakajima, M.G. Bemben, T. Abe

Study Design: Randomized control (6 BFR, 6 Con)

Type of testing: surface EMG for muscle activation

Type of Exercise- Bench press (30x15x15x15) at 30% max with and without BFR with 30 seconds rest between sets.

Results - Significantly elevated muscle activation in both triceps and pec major in BFR group in third set of bench press compared to control.

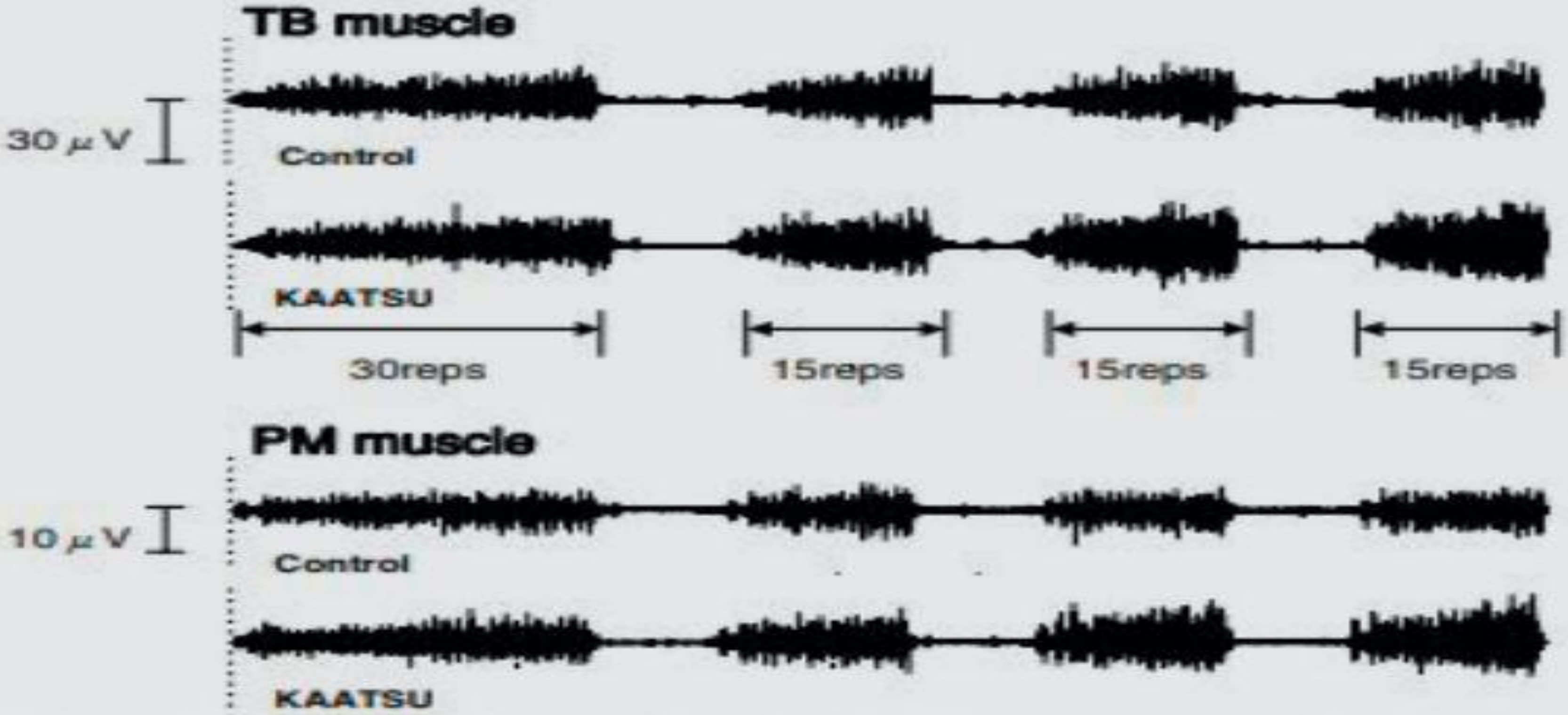


Figure 1. Typical examples of EMG signals recorded from triceps brachii (TB) and pectoralis major (PM) muscles during low-intensity flat bench press exercise with and without KAATSU.

KAATSU-walk training increases serum bone-specific alkaline phosphatase in young men: nt. J. KAATSU Training Res. 2005; 1: 77-81 M.D. Beekley, Y. Sato, T. Abe

Study Design: Case study of 18 young healthy men (no resistance training in past year)

Type of testing: CSA (cross sectional area) by MRI, strength measured by 1 RM, and blood serum levels via blood draw pre-exercise and 3 days post exercise

Type of Exercise- treadmill walking at 50m/min for 5x2' with 1' rest between sets 2x/day, 6days/week for 3 weeks with and without BFR

Results - significantly increase in CSA, 1 RM strength, BAP (10%), trend towards significant changes in IGF-1. BAP has a role in bone mineralization and has previously been elevated with high intensity training and not with low intensity training.

Disturbance of Homeostasis in Working Muscle

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

Mechanism summary

A local Disturbance of Homeostasis is created as working muscle does not receive enough blood flow to sustain contractions.

Release of Autonomic and Anabolic Hormones, that go throughout the body.

The systemic response amplifies the local responses that up-regulate protein synthesis.

Because little damage was done, increases in strength and fitness come quickly

All tissues involved in the exercise, proximal or distal to the BFR, enjoy the anabolic action

Safety

-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 undergoing ~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.

-it has been shown that DVT occurrence with BFR training is 0.06% (no higher than general population). No elevation in coagulation markers acutely or at 4 wks and increases tPA activity.

Effects of high-intensity and blood flow-restricted low-intensity resistance training on carotid arterial compliance: role of blood pressure during training sessions
Eur J Appl Physiol (2013) 113:167–174 DOI 10.1007/s00421-012-2422-9 Hayao Ozaki • Tomohiro Yasuda • Riki Ogasawara •Mikako Sakamaki-Sunaga • Hisashi Naito •Takashi Abe

Study Design - 19 healthy young males, Randomized trial, before and after measures of central arterial compliance, systolic blood pressure, CSA, 1 RM of bench press

Type of Testing - Ultrasound for arterial compliance, semi-automatic BP cuff, MRI for CSA, and 1 RM for bench press

Type of Exercise - 9 HIT (3 sets of 10, 2-3 min of rest at 75% 1 RM), 10 BFR (30x15x15x15 w/ 30 sec rest. Inflated to 160 mmgh, estimated 60% occlusion at rest, 30% occlusion during exercise) 3x/week for 6 weeks

Results - Significant increase in CSA and 1 RM in both groups (greater increase in 1 RM in HIT than BFR), significant decrease in arterial compliance in HIT, no significant difference in BFR (slight increase in compliance). No significant changes in resting BP in either group. Significant increase in SBP in HIT compared to BFR during final set of exercise.

Potential safety issues with blood flow restriction training:

Scand J Med Sci Sports 2011: 21: 510–518
doi: 10.1111/j.1600-0838.2010.01290.x

J. P. Loenneke,, J. M. Wilson,, G. J. Wilson,, T. J. Pujol,, M. G. Bemben

Study Design: Review of various safety concerns with BFR.

Peripheral and Central Cardiovascular changes - similar changes in peripheral resistance and ABI, less increase in SBP, DBP, HR, Mean Arterial Pressure compared to HIT.

Blood coagulation - No increase in D-dimer and fibrin degradation product (FDP) which are indicators of blood clot formation. No changes in prothrombin time, tPA increased.

Oxidative stress (increase in free radical stress or decrease in antioxidant defense)- No significant changes, although few studies available.

muscle damage/NCV - No significant changes (1.6% reported transient changes out of 30,000). Some longer lasting effects from prolonged occlusion with surgery (1-2 hours), but not with BFR. Less muscle inflammatory markers compared to HIT.

Contact info

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