Practical/Clinical Applications

OBJECTIVE #5

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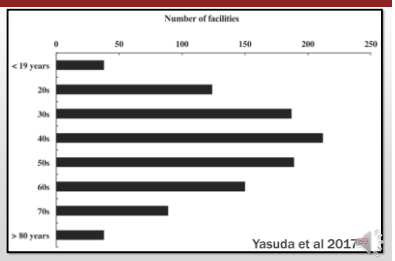
Practical/Clinical Application – Age Demographic

- Survey Japan KAATSU Training Society Survey
- Nov – Dec 2016
- 232 Facilities
- 12,827 persons
- M:F – 30:70



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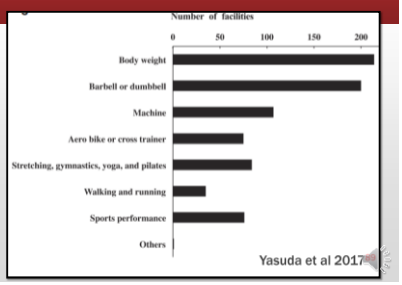
Practical/Clinical Application – Exercise Mode

- Occlusion pressure, intensity of training, number of sets and duration of a training unit remain unclear[83]



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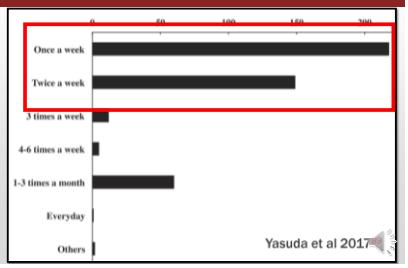
Practical/Clinical Application – Exercise Frequency

- Occlusion pressure, intensity of training, number of sets and duration of a training unit remain unclear[83]



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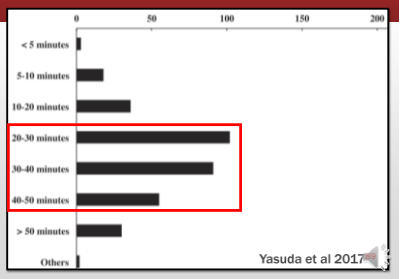
Practical/Clinical Application – Exercise Duration

- Occlusion pressure, intensity of training, number of sets and duration of a training unit remain unclear[83]



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Practical/Clinical Application – Intensity & Volume

Citation	Exercise intensity	Protocol
Abe et al. (2005c)	20% 1RM	3 sets of 15 repetitions; 30 sec rest
Abe et al. (2005b)	20% 1RM	3 sets of 15 repetitions; 30 sec rest
Abe et al. (2006)	50 M/Min	52-min walking bouts; 1 min rest
Abe et al. (2009)	50 M/Min	52-min walking bouts; 60 sec rest
Abe et al. (2010b)	67 M/Min	20 minutes walking
Abe et al. (2010a)	40% VO_{2max}	15 minutes cycling
Beekley et al. (2005)	50 M/Min	52-min walking bouts; 60 sec rest
Fujita et al. (2008)	20% 1RM	30-15-15-15 repetitions; 30 sec rest
Kacin and Strazar (2011)	15% MVC	4 sets to volitional fatigue
Madarame et al. (2008)	30% 1RM	30,15,15 repetitions; 30 sec rest
Ozaki et al. (2011)	45% HRR	20 minutes walking

Loenneke 2014[84]

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Practical/Clinical Application – Cuff Specifications

	Recommendation	Factors to consider
Cuff Application	Proximally around the limb to be trained	Trunk muscles can also benefit from BFR during multi-joint exercises
Cuff Type	Wide cuffs (~ 6–13.5 cm) for the legs, and narrow cuffs (3–6 cm) for the arms	Inflatable cuffs and elastic knee wraps may be most practical
Occlusion Pressure	Inflatable cuffs: 50–80 % of pressure to occlude arterial flow at rest Elastic wraps: should feel snug but not substantially restrict completion of desired repetition scheme	Limb circumference: Larger limbs require higher pressure Cuff width: Wider cuffs achieve occlusion at lower pressures
Occlusion Pressure	BFR alone: Attenuated ↓ in muscle mass and strength BFR + walking/cycling: Moderate ↑ or maintenance of muscle mass and strength Low-load resistance exercise + BFR: substantial ↑ in muscle mass and strength	The type of exercise that can be tolerated should be considered before deciding on an appropriate BFR strategy (Fig. 1). The progressive model proposed by Loenneke et al. [67] should be followed for clinical populations

Scott et al 2014[87]

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Practical/Clinical Application – Cuff Specifications

Type of Exercise	Both single- and multi-joint exercises can provide benefit	Hypertrophy between limb and trunk muscles following multi-joint BFR training may be disproportionate
Exercise Load	Low-load exercise (~ 20–40 % 1RM or MVC)	Multiple sets of low-load BFR exercise provides similar metabolic stimulus to high-load training, but may not replicate neural demands
Volume	50–80 repetitions per exercise (sets do not need to be performed to muscular failure)	Standard scheme of 30–15–15–15 repetitions equates to 75 total repetitions
Rest Intervals	30–45 s	To ensure sufficient venous pooling, occlusion should be maintained during inter-set rest periods
Frequency	Clinical populations: 2–3 training sessions per week is sufficient Athletic populations: 2–4 sessions per week, in addition to normal high-load resistance training	May be possible to train twice per day with BFR

Rest: [20]
- 30-60 sec (Anabolic Hormones, GH, Testosterone)
- 90 sec (IL-6 concentrations ↑)
- Between training sets BFR should be continued[83]

Duration:
- ≥ 6-10 weeks [84, 85]

Scott et al 2014[87]

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Practical/Clinical Applications – Cuff Pressures

- standardize restrictive pressures relative to brachial systolic blood pressure[11, 45]
  - NO evidence to suggest that this provides a good estimate of BFR to the lower limbs[87]
  - bSBP NOT able to explain additional variance in estimation of Lower Body Arterial occlusion pressures[90]
- Lower Extremities
  - **80% total arterial restriction** → hypertrophic & Strength responses similar to traditional high load training[11]
  - **50% total arterial restriction** → maximize EMG & ↑ acute decrements in torque during & following knee extension exercise (comparable (50% = 60% occlusion)[92]
    - Maximize acute muscle swelling & blood lactate responses[87]
  - VAS: 7/10 (pressure with no pain) = occluded venous return without stopping arterial inflow[83]
    - Limited difference in ratings of discomfort during exercise across a variety of pressures (perception may NOT be best estimate of actual restriction[87]

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Practical/Clinical Applications – Cuff Pressures

- **~60%** Complete Arterial Occlusion Pressure can be achieved in LE with correlating pressure with thigh circumference[90]
- **Anatomical Location:** 33% distance from inguinal crease to superior border of patella

Circumference	Pressure
≤50 cm	120 mmHg
51-55 cm	150 mmHg
56-59 cm	180 mmHg
≥ 60 cm	210 mmHg

Most Important Factors to consider for optimal pressure during BFR
1. Width of Cuff
2. Circumference of Limb
3. Arterial Occlusion Pressure of Limb

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Practical/Clinical Applications – Types of Cuff

- **Types:** tourniquet, inflatable cuffs, elastic knee wraps[87]
- **Narrow nylon cuffs** = 5 cm Elastic cuffs @ 50 mmHg (rest[94] & exercise[95])
- **Width:** Legs (4.5-18.5 cm), Arms (3-12 cm)[87]
  - wider cuffs (13.5 cm) restrict blood at lower pressures vs narrow cuffs (5 cm)[90]
- **Arms = narrow cuffs →** may limit normal/required ROM & muscle hypertrophy stimulus may be attenuated directly below the cuff[96]
- **Legs = wider cuffs →** some individuals did NOT reach arterial occlusion using narrow cuffs on Legs at pressure up to 300 mmHg[90]

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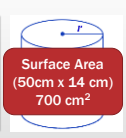
Practical/Clinical Application – BFR & Theraband

Resistance in Pounds

Percent Elongation	Black
25%	3.6
50%	6.3
75%	8.1
100%	9.7
150%	12.3
175%	13.5
200%	14.8
225%	15.2
250%	17.6



Circumference	Pressure
≤50 cm	120 mmHg (0.163141 kg/cm²)

Loenneke 2012[90]

TheraBand Tension	/	TheraBand Surface Area	=	TheraBand Pressure/REV
5.579186 kg		700 cm²		0.007970265... kg/cm²

Target Pressure	/	TheraBand Pressure/REV	=	# of revolutions (REV)
0.163141 kg/cm²		0.007970265... kg/cm²		20

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Practical Implications – Legislation

- **BFR Training Scope of Practice**
  - APTA: "BFRT is part of the professional scope of practice for physical therapists."
- **State Legislation**
  1. Check State's Practice Act
     - May be silent in regards to BFRT
  2. Check State's Laws for Confirmation
- **CAPTA Practice Act Silent on BFR & No laws prohibiting use of BFRT**

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Practical Implications – Legislation & Billing

FDA Regulation

- **Pneumatic Tourniquets are Class 1 - FDA regulated products**
- **Ensure that product is registered and approved by the FDA when practicing in the United States**

Billing

- **Billed under the standard physical therapy codes depending on the activity that the patient is performing**

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Practical/Clinical Application – RPE Adaptation

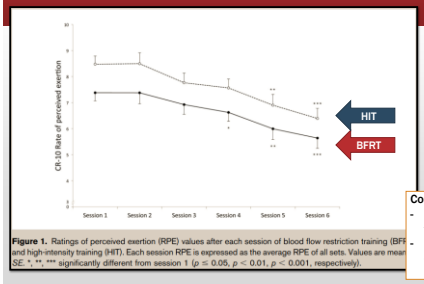

Figure 1. Ratings of perceived exertion (RPE) values after each session of blood flow restriction training (BFR and high-intensity training (HIT). Each session RPE is expressed as the average RPE of all sets. Values are mean SE. *, **, *** significantly different from session 1 ($p \leq 0.05$, $p < 0.01$, $p < 0.001$, respectively).

High Intensity Training:
- Sets: 3
- Reps: 8
- Intensity: 85% 1RM
- Leg Extension

BFR Training (BFRT):
- Sets: 4
- Reps: 30/15/15/15
- Intensity: 20% 1RM
- Leg Extension

Conclusion:
- BFRT induces a marked RPE to training, vs HIT
- may not limit the application of BFRT to highly motivated individuals

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Practical/Clinical Application – Cardiovascular Response

Table 1. Cardiovascular and respiratory responses at rest and during exercise at 10 min combined with (BFR) and without (CON) blood flow reduction.

	Resting		Exercise at 10 min	
	CON	BFR	CON	BFR
Heart rate (beats/min)	68 (13)	81 (16)	112 (13)	140 (16)†
Stroke volume (ml)	78 (17)	59 (12)*	100 (22)	74 (19)†
Cardiac output (l/min)	5.3 (1.7)	4.7 (1.1)	11.2 (2.8)	10.3 (2.9)
VO_2 (l/min)	0.28 (.05)	0.28 (.05)	1.29 (.09)	1.35 (.11)
V_E (l/min)	7.3 (1.9)	8.6 (3.0)*	24.7 (3.9)	34.5 (7.7)†
a-v O_2 difference	57 (18)	64 (24)	121 (29)	140 (35)
Total peripheral resistance	17.2 (5.4)	20.8 (5.4)	9.9 (2.7)	13.7 (3.6)†
Systolic arterial pressure (mmHg)	119 (14)	125 (11)	146 (16)	170 (20)†
Diastolic arterial pressure (mmHg)	67 (10)	77 (8)	63 (11)	95 (8)†
Mean arterial pressure (mmHg)	84 (10)	93 (7)	105 (9)	132 (13)†
Blood lactate (mmol/l)	1.6 (.4)	1.8 (.6)	2.1 (.5)	3.7 (.8)†
Rating of perceived exertion			10.4 (.7)	13.5 (1.2)†

Significant difference between CON and BFR *$p < 0.05$, †$p < 0.01$.
Values are represented as means and standard deviations (SD)

Subjects: n = 8 males
Mode: Upright Stationary Cycle
Duration: 30 min
Intensity: 40% VO2max

BFR: 200 mmHg
(50 mm wide; KAATSU Master, Sato Sports Plaza, Tokyo, Japan)

CON: no BFR

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Practical/Clinical Application – Cardiovascular Response

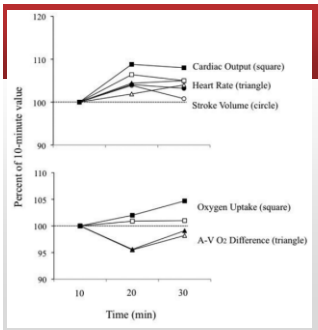

Fig. 1. % changes during 30 min of exercise.
Open symbols = normal blood flow
Solid symbols = blood flow restriction.
Values are represented as means (n=8)

NO statistical significant difference in CON vs BFR in:
- CO
- Stroke Volume
- HR
- VO2
- A-VO2 difference

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Practical/Clinical Application – Cardiovascular Response

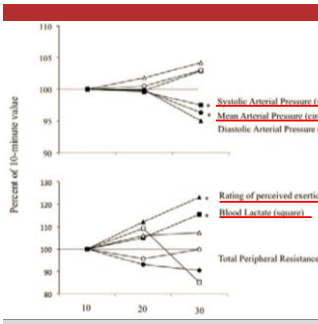

Fig. 2. % Δ during 30 min of exercise
Open symbols = normal blood flow (CON)
Solid symbols = blood flow restriction (BFR).
* = Stat Sig Difference BFR vs CON, p<0.05.
Values are represented as means (n=8)

NO statistical significant difference:
- Diastolic Arterial Pressure
- Total Peripheral Resistance

Statistical significant difference (p<0.05)
- Systolic Arterial Pressure (↓ BFR)
- Mean Arterial Pressure (↓ BFR)
- RPE (↑ BFR)
- Blood Lactate (↑ BFR)

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Practical/Clinical Application – Cardiovascular Response

Conclusion:

1. **BFR: SV & HR**
   - 0-10 min: SV↓ & HR↑ (CO no difference)
   - 10-30 min: No difference in % change of SV & HR
2. **BFR: Blood Pressure**
   - 0-10 min: ↑ SBP, ↑DBP, ↑MAP
   - 10-30 min: gradual ↓SBP & ↓MAP (due to ↓ in Total Peripheral Resistance
3. **BFR: blood lactate & RPE ↑ gradually during exercise**

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Practical/Clinical Application – Cardiovascular Response

Subjects: n = 18 healthy males (Age: 23±3 yr)
Mode: Velotron cycle ergometer
Warm Up: 7 min, 30% V02max (96± 3W)
Intervals: 3 rounds, 2 min work : 2 min rest (10 W)
Cool Down: 5 min, 30% V02max (96± 3W)
Low Intensity: 40% V02max

Low Intensity Group: 40% V02 Max (128±4 W)

BFR Low Intensity Group: 40% V02 Max (128±4 W)
- proximal thighs (10 cm wide) (only intervals)
- 80% arterial occlusion pressure (143±19 mmHg)

High Intensity Group: 85% V02 Max (272±9 W)

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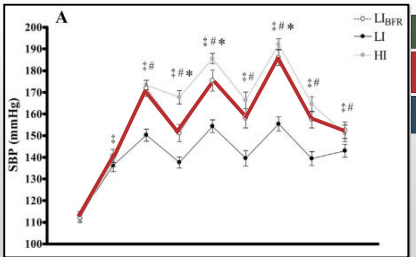
Practical/Clinical Application – Cardiovascular Response



Low Intensity Group
40% V02 Max

BFR Low Intensity Group
40% V02 Max

High Intensity Group
85% V02 Max

Thomas et al 2018

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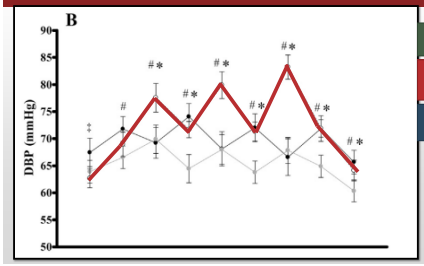
Practical/Clinical Application – Cardiovascular Response



Low Intensity Group
40% VO2 Max

BFR Low Intensity Group
40% VO2 Max

High Intensity Group
85% VO2 Max

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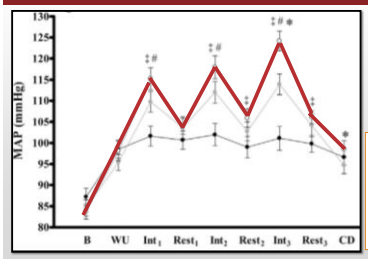
Practical/Clinical Application – Cardiovascular Response



Low Intensity Group
40% VO2 Max

BFR Low Intensity Group
40% VO2 Max

High Intensity Group
85% VO2 Max

Conclusion

- LIBFR interval cycling can ↑ metabolic & CV demands compared to low-intensity cycling alone
- ↑MAP w. LIBFR trials → ↑ myocardial workload (> HI session)
- use caution within a vascular compromised population.

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Conclusion & Summary

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Effectiveness of Blood Flow Restriction - Summary

1. LI-BFR: may ↑ in muscle size & strength effects; used when traditional high-load training may be inappropriate or unattainable.
2. Quantifiable muscular adaptations present quickly; Training >6 weeks seem to offer greater returns in strength adaptation.
3. BFR training has applicability to a range of populations who may seek to progress strength while reducing loads on the associated tissues including muscular, tendinous, connective, and bony.
4. Early studies indicate that BFR may have positive effects on bone remodeling

Slyzs et al.[85]

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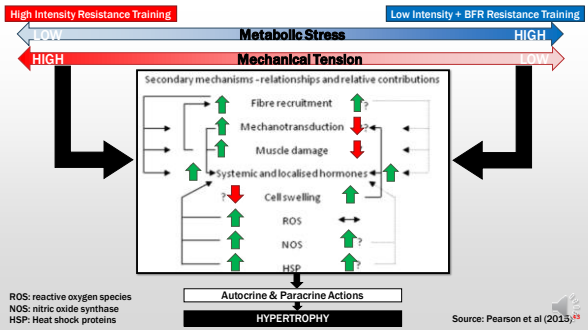

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Safety & Side Effects – Follow Basic Principles

1. **Confirm No Contraindications**
2. **Hemodynamically Unstable Patients** (slide 62, 63) shoulder NOT partake
3. **Thrombotic Diseased Patients** are Contraindicated
4. Explain **Petechial Hemorrhage Risk**
5. Individualize training
6. **Build Relationship & Trust** with Patient
7. **Pay Attention to** faintness, dizziness, or light-headedness
8. **Caution:** Older (>65), Bedridden, Postoperative Patients (DVT risk)
9. **AED Available**
10. **SHORT Term and LOW Intensity Loads**
11. **CONTRAINDICATION:** Patient is sick
12. **If unsure about medical condition seek specialist consult**

Nakajima 2011[88]

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Practical/Clinical Application – Summary

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Cuff Application	Proximally around the limb to be trained	Trunk muscles can also benefit from BFR during multi-joint exercises
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Scott et al 2014[87]

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Rest Intervals	30–45 s	To ensure sufficient venous pooling, occlusion should be maintained during inter-set rest periods
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- Between training sets BFR should be continued[83]

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Scott et al 2014[87]

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Questions, Comments, Feedback, Discussion…

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