The Effects of Blood Flow Restriction Therapy on Physical Performance in Adults as Compared to Standard Physical Exercise and Control Groups: Systematic Review

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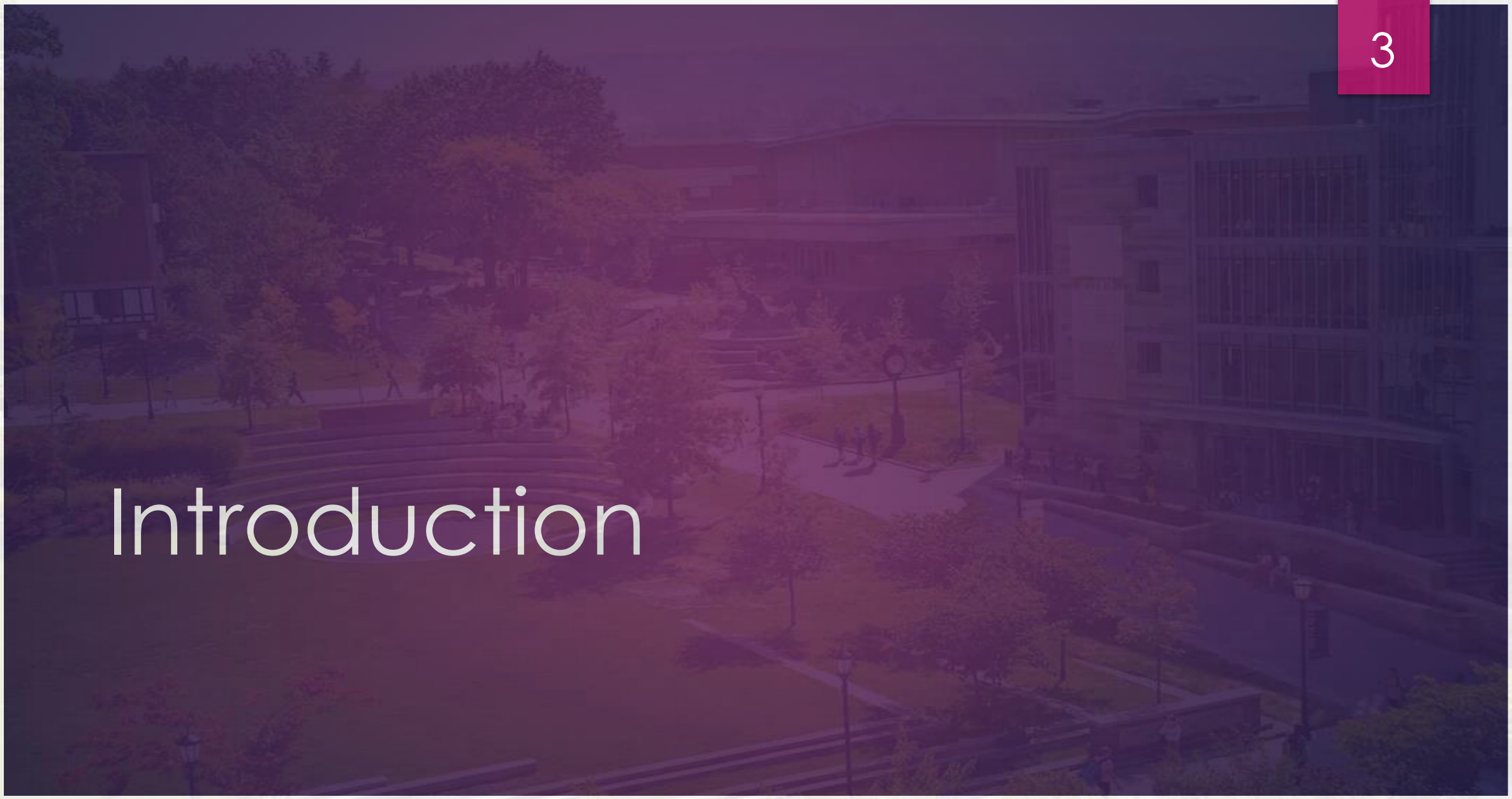

Introduction

What is blood flow restriction (BFR)?[1-3]

- Pressure applied via the tourniquet device is sufficient to limit arterial inflow while occluding venous outflow
- The goal is to enable patients to achieve greater strength gains while lifting lighter loads
- Muscle hypertrophy has been demonstrated to occur within two weeks VS the typical 9-12 weeks

How does BFR work?[1,2,4]

- BFR creates increased protein synthesis due to the hormonal responses the body has to BFR training
- Typical protocol is for - UE occlusion: 50% & LE occlusion: 80%* of arterial blood flow
- Electrical stimulation and/or biofeedback can be applied simultaneously

*Owens Recovery System with ***Delfi*** BRF unit

How does BFR work? (cont.)[1,2]

- Four sets of each selected exercise are performed:
  - 30 repetitions
  - 15 repetitions
  - 15 repetitions
  - 15 repetitions
- With a 30 second rest break between sets
- The occlusion is maintained throughout the entire process. One minute deflation between selected exercises

Contraindications to BFR[2]

- **Venous thromboembolism**
- **Open fracture**
- **Severe HTN**
- **Extremity infection**
- Cancer
- Sickle cell anemia
- Previous revascularization of the extremity
- Acidosis
- Severe crush injuries
- Open soft tissue injuries
- Vascular grafting
- Lymphectomies
- Extremities with dialysis access
- Tumor distal to tourniquet
- Medications that increase clotting risk
- Increased ICP

Precautions associated with BFR[2]

- **Diabetes**
- **Cardiopulmonary conditions**
- **Infection**
- **Patients who are taking: Anti-hypertensive medication or Creatine supplements**
- Hypotension
- Renal Compromise
- Sickle Cell Trait
- Abnormal clotting times
- Crush injury
- Tumor

Potential Side Effects/Risk of use of BFR[2]

Potential Side Effects

- Muscle soreness
- Tenderness
- Bruising at site of cuff
- Numbness
- Cold feeling
- Fainting/dizziness

Risks

- Bruising
- Nerve injury
- Skin injury
- Pain
- Arterial injury

Purpose

- The purpose of this systematic review was to determine the effects of blood flow restriction therapy (BFRT) on physical performance in adults as compared to standard exercise protocol or no exercise

Search Criteria

Search Terms

- (Blood Flow Restriction **OR** BFR **OR** Blood Flow Occlusion **OR** Blood Flow Restriction Therapy **OR** BFRT) **AND** (older adults **OR** elderly **OR** adults) **AND** (walking **OR** ambulating **OR** ambulation **OR** gait)

Databases

- ProQuest
- Google Scholar
- CINHAL
- Cochrane Library
- PubMed

Inclusion & Exclusion Criteria

Inclusion Criteria

- Peer Reviewed Journals
- In English language
- Human Subjects
- Randomized Controlled Trials (RCTs)
- Age of subjects ≥45[5]
- 2008 - 2018

Exclusion Criteria

- No outcome measures of functional performance, mobility, or strength
- Not RCTs

PRISMA

Identification

Screening

Eligibility

Inclusion

Records Identified through database searching (n=968)

Records after duplicates removed (n=928)

Records screened (n=928)

Records excluded with reasons (n=921)

- Subjects not ≥ 45 (n=19)
- Not human subjects (n=8)
- Not related to BFRT (n=795)
- Outcome measures not relevant (n=22)
- Subjects have comorbidities that could affect ability to obtain BFR (n=69)

Full-text articles assessed for eligibility (n=7)

Full-text articles excluded, with reasons:

- Outcome measures not relevant (n=2)

Studies Included (n=5)

PEDro Scoring[6-10]

Study	1	2	3	4	5	6	7	8	9	10	11	Total
Abe et al.	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6/10**
Araujo et al.	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6/10**
Clarkson et al.	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6/10**
Karabulut et al.	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6/10**
Ozaki et al.	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	**6/10**

Average: 6/10

Methods

- Total of 121 men and women between 5 studies[6-10]
  - Ages: 57-80
- Treatment parameters [6-10]
  - 6 to 8 weeks
  - 4 to 5 sessions per week

Methods cont.

- Treatments
  - Aquatics/water exercise, treadmill training, ambulation training, upper and lower body exercising[6-10]
- Limb occlusion parameters[6-10]
  - Combined limb pressure ranged between 96 ± 10 mmHg to 240 mmHg for UE and LE

Results

Results

- Four out of 5 studies used the TUG as an outcome measure[6-8,10]
- Three out of 5 studies used 30STS and 1 study utilized 5x STS [6-8,10]
- Two out of 5 studies also used maximum voluntary isokinetic and isometric strength of both knee flexors and extensors[6,10]
- One study examined 1 rep max (1RM)[9]

Results

- All 4 studies using TUG showed statistically significant improvement with BFR ($p<0.001$, $p=0.016$, $p<0.01$, $p<0.01$)[6-8,10]
- One study noted greater improvements in TUG for BFR vs control after 6 weeks ($p=0.14$)[8]
  - Both control and BFR groups showed statistically significant improvements at week 6 ($p<0.01$)[8]
  - Statistically significant improvement noted at week 3 for BFR ($p<0.001$)[8]

Results

- Both water exercise with BFR and water exercise groups increased in 5x STS ($p=0.0001$)[7]
- All 3 studies using 30STS showed improvements with BFR ($p<0.05$, $p<0.001$, $p<0.05$)[6,8,10]
- One study revealed statistically significant improvements in BFR and control groups at week 6 for 30STS ($p<0.005$)[8]
  - Statistically significant improvement in BFR group continued from weeks 3 to 6 ($p<0.001$), but not in the control group[8]
- One study noted higher percent change in BFR group vs control for repetition performed (20.5% vs. 7.8%)[10]

Results

- Two studies showed statistically significant improvements in maximal isokinetic knee flexion and extension ($p<0.05$, $p<0.01$)[6,10]
- Statistically significant improvement in maximal isometric knee extension strength in 1 study ($p<0.05$)[6]
- One rep max[9]
  - Significant improvements in lat pulldown, bicep curl, leg press, and knee extension strength with low intensity (20% 1 RM) BFR vs. high intensity (80% 1RM) resistance training[9]
  - Both groups increased in shoulder press with no difference noted between groups[9]

Discussion

Conclusion

- There is moderate to strong evidence in support of BFRT to improve physical performance and strength in adults
- Studies reviewed demonstrated improved physical performance with the following demonstrating efficacy of BFRT in reducing fall risk and improving ADL's
  - Reductions in TUG times
  - Increased reps in the 30STS

Clinical Relevance

- Clinicians should consider BFRT with selected adults to improve physical performance
- It is imperative that a thorough screening is conducted to ensure safety and appropriate use of device is conducted prior to BFRT, in the adult population
- Blood flow restriction walking is a low-load alternative to resistance training for improving physical performance in older adults who are contraindicated to high-load resistance training

Research Limitations

- Small samples sizes
- TUG distance variations
- Inability to blind subject, assessor, and therapists
- Differences in BFR parameters
- Unspecified parameters used for 30 seconds chair stand test
- Different protocols are used with different units

Future Research

- Future RCTs focusing on determining the optimal parameters (frequency, duration, intensity) and long-term effects of BFRT, would prove enlightening
- Future research is needed to identify the optimal protocol of BFR training to improve overall functional mobility and strength
- Future RCTs should include larger sample size

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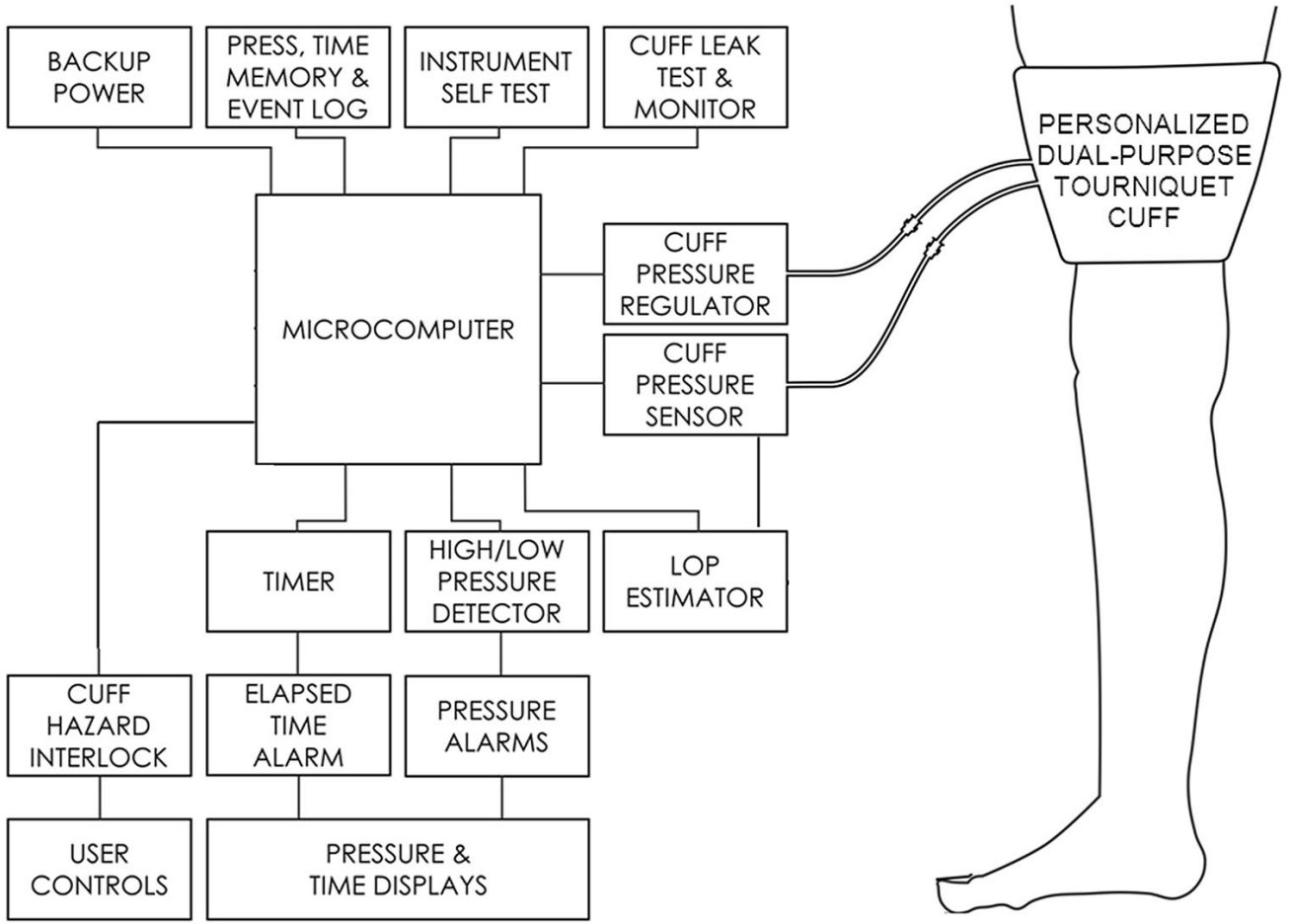
Thank you!
Questions?

Appendix

Modern surgical-grade tourniquet instrument[11]



Metabolite Theory[2]

- Lactate increases muscle activation (measured as iEMG activity).
- As lactate builds up in muscle, it inhibits the surrounding contraction of working muscle fibers and consequently additional motor units need to be recruited to maintain muscle force production.
- This essentially follows the size principle in that as work under heavy load is performed the muscle will recruit larger motor units (fast twitch) to complete the task.
- Utilizing BFR to produce lactate also forces the muscle to use larger motor units.
- The reduction in oxygen and subsequent metabolic accumulation during BFR increases fiber recruitment through stimulation of the group III and IV afferents, which may cause an inhibition of the alpha motor neuron, resulting in an increased fiber recruitment to maintain force and protect against conduction failure.

How Occlusion Was Determined

- Effects of Low-Intensity Walk Training with Restricted Leg Blood Flow on Muscle Strength and Aerobic Capacity in Older Adults[6]
  - 160-22 mmHg was selected for the restriction stimulus on the basis of a previous study in young men and clinical experience for older subjects
  - The restriction pressure of 160–230 mmHg was selected for the occlusive stimulus, as this pressure has been suggested to restrict venous blood flow and cause pooling of blood in capacitance vessels distal to the belt, as well as restricting arterial blood flow

How Occlusion Was Determined

- The Effects of Water-based Exercise in Combination with Blood Flow Restriction on Strength and Functional Capacity in Post-menopausal Women[7]
  - A vascular Doppler probe (DV-600; Marted, Ribeira˜o Preto, Sa˜o Paulo, Brazil) was placed over the tibial artery to capture its auscultatory pulse. For the determination of blood pressure (mm Hg) necessary for a complete vascular restriction (pulse elimination pressure), a standard blood pressure cuff was attached to the participant's thigh fold region) and then inflated up to the point in which the auscultatory pulse was interrupted
  - The pressure for exercise was set to 80 % of the arterial occlusion pressure (pressure needed to completely occlude blood flow out of water) to ensure that the participants were only under partial BFR

How Occlusion Was Determined

- Blood Flow Restriction Walking and Physical Function in Older Adults: A Randomized Control Trial[8]
  - Did not state
- The effects of low-intensity resistance training with vascular restriction on leg muscle strength in older men[9]
  - The pressure for vascular restriction pressure was decided based on the protocol used in the previous studies investigating the changed in lower body strength in young adults
  - Selected for the occlusive stimulus as this pressure has been suggested to restrict venous blood flow and cause pooling of blood in capacitance vessels distal to the belt, and ultimately restrict arterial blood flow

How Occlusion Was Determined

- Increases in Thigh Muscle Volume and Strength by Walk Training with Leg Blood Flow Reduction in Older Participants[10]
  - The air pressure of 140–200 mm Hg was selected for the BFR stimulus based on a review of the data in elderly participants
  - The restriction pressure of 160–230 mmHg was selected for the occlusive stimulus, as this pressure has been suggested to restrict venous blood flow and cause pooling of blood in capacitance vessels distal to the belt, as well as restricting arterial blood flow