# Concepts and Applications of Blood Flow Restricted Exercise

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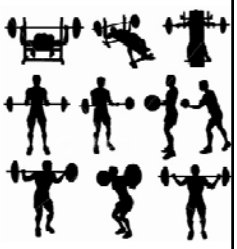
## Lecture Objectives

- ✓ Describe blood flow restricted (BFR) exercise
- ✓ Summarize the training adaptations following BFR exercise
- ✓ Recognize the limitations and benefits of BFR exercise

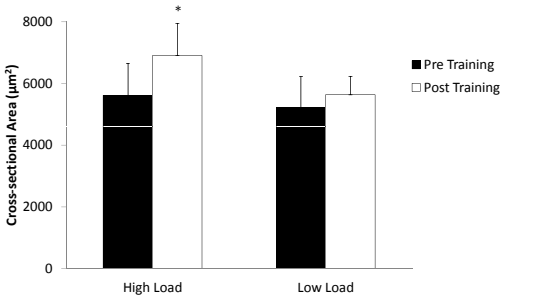
## Resistance Training

- Leads to increases in muscle strength and size
- Loads >70% maximal strength to induce hypertrophy
- 6-12 repetitions for hypertrophy, 3-5 for strength



ACSM. *Medicine and Science in Sports and Exercise, 2011*

## Hypertrophy following High-load vs Low-load Exercise



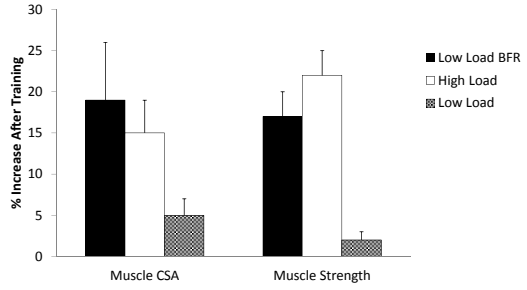

Campos et al. *European Journal of Applied Physiology, 2002*

## BFR Resistance Training

- Low-load exercise
  - ~20-30% maximum strength
- Compressive cuff inflated to suprasystolic pressure
- Perform 20-50 repetitions until muscular failure

*Commercially referred to as *KAATSU*

## Training Adaptations




Takarada et al. *Journal of Applied Physiology, 2000*

## Mechanisms of Adaptation

- UNKNOWN!
- High motor unit recruitment/muscle activation (Takarada 2000)
  - But not as high as traditional high-load exercise (Cook 2012)
- Stimulates protein synthesis
  - mTor pathway (Fujita 2007, Fry 2010, Gundermann 2012)
- Suppresses mRNA expression of genes related to protein degradation
  - MURF-1, atrogin, and myostatin (Manini 2011, Laurentino 2012)
- Myogenic stem cell (satellite cells) activation (Nielson 2012)

## Clinical Uses of BFR Exercise



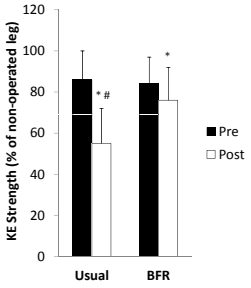
Injury Rehabilitation | Spaceflight | Elderly

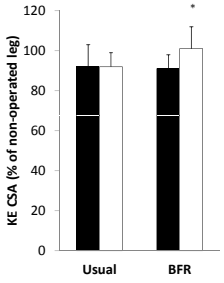
## BFR exercise after ACL reconstruction

- 44 patients
  - 18-52 years old (mean=29 years)
  - Males and females
- Randomly selected to do:
  - Usual rehabilitation
  - Usual rehabilitation with BFR
- Torque and cross-sectional area were assessed before and after 16-weeks of training


Ohta et al. *Acta Orthopaedica Scandinavica*, 2003

## BFR exercise after ACL reconstruction




Ohta et al. *Acta Orthopaedica Scandinavica*, 2003

## BFR exercise after ACL reconstruction

- It is effective at attenuating muscle weakness due to disuse
- It can increase muscle size

Potential limitations:

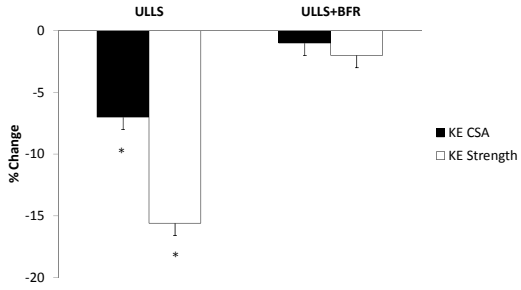
- Subject discomfort
- Risk of thrombosis or edema

## BFR exercise during Simulated Spaceflight

- 16 Subjects
  - 18-50 years old (mean=22 years)
  - Males and females
- Randomly selected to do:
  - ULLS
  - ULLS with BFR
- Strength and cross-sectional area were assessed before and after 30 days of ULLS

Cook et al. *Journal of Applied Physiology*, 2009

## BFR Exercise during Simulated Spaceflight



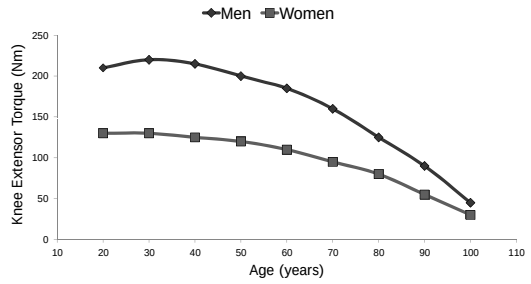

## BFR Exercise during Simulated Spaceflight

- BFR resistance exercise on the knee extensors attenuates atrophy and strength losses following prolonged unloading

Potential limitations:

- Ground-based analog of microgravity
- Exercising non-restricted musculature
- Risk of thrombosis or edema

## BFR Exercise for Older Adults?



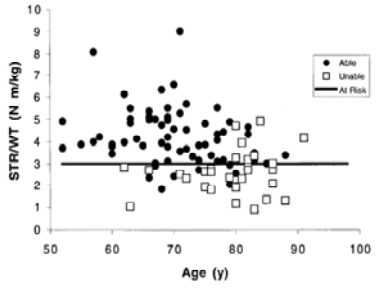

Lindle RS, et al. *Journal of Applied Physiology* 1997

## Lower Extremity Weakness

- Impairments in physical functioning
  - chair rise, gait speed, stair ascent and descent
- Disability
- At risk for falls
- Increased risk for nursing home admission
- Greater risk of mortality

Clark et al. *Nutrition*, 2012, Ploutz-Snyder et al. *Journals of Gerontology,* 2002, *American Geriatrics Society,* 2001

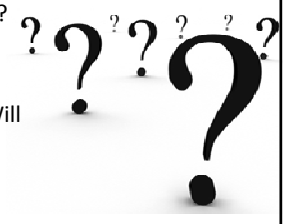
## Strength and Physical Function




Ploutz-Snyder et al. *Journals of Gerontology* 2002

## BFR Exercise in Older Adults?

- Will improvements in muscle strength and size transfer into improvements in daily physical functioning in older adults?
- Is BFR resistance exercise feasible in older adults? Will they tolerate it?



## BFREE Trial

**B**lood **F**low **R**estricted **E**xercise **E**fficacy

## Purposes of the BFREE Trial

1. To compare lower body strength and muscle size after 12-weeks of traditional or BFR resistance training.
2. To evaluate compliance and overall exercise experience following acute and chronic traditional or BFR resistance training.
3. To compare functional capacity and quality of life in older adults following 12-weeks of traditional or BFR resistance training.

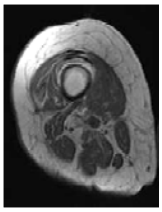
## Methods of the BFREE Trial

- 45 males and females aged ≥65 years
- Classified as ***"at risk of mobility limitations"***
  - Strength-to-weight ratio
    - <1.71 Nm·kg$^{-1}$ for males
    - <1.34 Nm·kg$^{-1}$ for females
- Randomized by sex and age to:
  - Traditional resistance training (n=12)
  - BFR resistance training (n=12)
  - Upper body stretching control (n=12)

Manini et al. *Journal of the American Geriatrics Society,* 2007

## Measurements in the BFREE Trial

- Muscle strength of knee extensors and flexors
- Muscle size via MRI
- Physical Functioning
  - Short Physical Performance Battery
  - 400-m walk
  - Stair Ascent Descent
- Quality of Life



## Very Preliminary Results of BFREE Trial

| | Control | | | High-Load | | | Blood Flow Restricted | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 males | | | 3 females | | | 2 females, 1 male | | |
| | Pre | Post | % Change | Pre | Post | % Change | Pre | Post | % Change |
| **Strength-to-weight ratio (Nm·kg)** | 1.48±0.28 | 1.61± 0.46 | 8 | 1.01±0.3 | 1.22±0.3 | 5 | 1.2±0.2 | 1.3±0.1 | 8 |
| **400-m walk speed (m·s$^{-1}$)** | 1.44± 0.2 | 1.53±0.2 | 6 | 1.19±0.4 | 1.18±0.5 | 0 | 1.3±0.1 | 1.3±0.1 | 5 |
| **1 Repetition Maximum (kg)** | | | | | | | | | |
| Knee extension | 65±20 | 61± 25 | -6 | 24±6 | 41±12 | 70 | 33±19 | 43±18 | 32 |
| Leg Curl | 43±18 | 45±18 | 5 | 18±2 | 28±5 | 57 | 25±9 | 35±17 | 37 |
| Leg Press | 161±64 | 160±31 | 1 | 60±11 | 82±18 | 36 | 65±12 | 92±24 | 41 |

## Summary

- BFR resistance exercise may be a therapeutic modality in cases of disuse and aging
  - It attenuates atrophy and weakness
  - It results in hypertrophy and strength gains
  - Does this transfer into enhanced physical functioning?
- BFR resistance exercise has limitations
  - One can only restrict blood flow to the arms and legs
  - Some perceive this exercise to be uncomfortable
  - Long-term safety?

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**Study Participants**

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