Effect of 4 Weeks of Low-Intensity Training with Blood Flow Restriction on Aerobic Fitness, Muscle Strength and Power, and Muscle Oxidative Capacity

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Introduction

- Muscle oxidative capacity (MOC) is critical for recovery from resistance training and repeated sprints. Traditionally assessed via muscle biopsy, this method is invasive and impractical for many athletes.
- Near-infrared spectroscopy (NIRS) offers a non-invasive alternative by measuring muscle oxygen consumption (mVO_2) through changes in deoxyhemoglobin (HHb) during short arterial occlusions. Faster mVO_2 recovery indicates higher MOC.
- Blood Flow Restriction (BFR) training, which partially restricts blood flow during low-intensity exercise, creates a mismatch between oxygen supply and demand. This stimulates adaptations such as increased mitochondrial density and improved MOC.
- Research shows that BFR training can improve muscle mass, strength, aerobic capacity, and power, even at lower intensities.
- BFR combined with aerobic exercise induces greater metabolic stress compared to similiar free-flow exercise, potenially matching the effects of vigorous-intensity training.
- However, the impact of different restriction pressures during BFR on aerobic adaptations remains unclear and warrants further investigation.

Purpose and Hypothesis

The purpose of this study was to examine the effect of low-intensity aerobic training with (BFR) and without (CONT) blood flow restriction (BFR) on aerobic fitness, muscle strength, muscle power, and muscle oxidative capacity (MOC)

Experimental Design

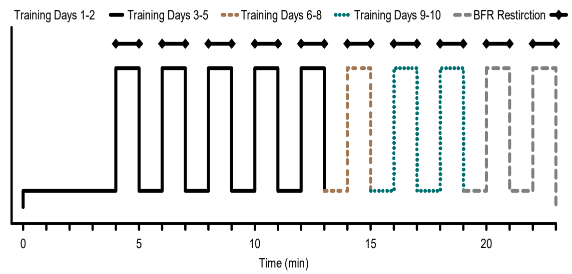
Blood Flow Restriction Application

- The BFR group was the only group with cuffs applied to the upper thigh.
- Once a week, participants assumed a supine position with the BFR cuffs placed on the proximal portion of their thigh.
- A Doppler ultrasound device was used to identify the posterior tibial artery, and pressure in the cuffs was increased until the pulse could not be heard. The pressure that leads to the cessation of the pulse was considered the limb occlusion pressure (LOP).
- Restriction pressure during training was 80% of LOP; only inflated during work intervals.

Participant Characteristics

Group	Age (yrs)	Height (cm)	Weight (kg)	Work Interval (W)	Total Training Work (W)	LOP (mmHg)	Restriction Pressure (mmHg)
No-BFR	26.3 ± 6.0	171.5 ± 4.6	79.0 ± 17.3	51.3 ± 11.8	8393.0 ± 1800.8	0 ± 0.0	0 ± 0.0
BFR	25.1 ± 6.6	168.0 ± 4.1	70.4 ± 10.8	49.0 ± 20.9	7942.0 ± 3245.3	141.7 ± 9.2	113.6 ± 8.0

Cycle Training



In all training days:

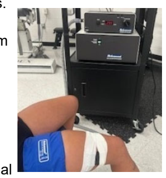
- Warm up: 4 minutes at 20 Watts
- Intensity: 70% of gas exchange threshold
- Work Interval Time: 2 minutes
- Rest duration: 1 minute at 20 watt
- For BFR, cuffs were inflated work and deflated during rest.
- Control group did not have BFR.

Work intervals per training day:

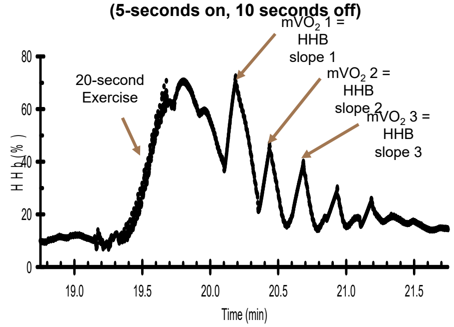
- Training day 1 – 2: 5 work intervals
- Training day 3 – 5: 6 work intervals
- Training day 6 – 8: 8 work intervals
- Training day 9 – 10: 10 work intervals

Muscle Oxidative Capacity

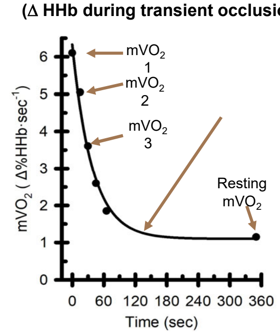
- Muscle oxidative capacity (MOC) was assessed using a NIRS device secured on the vastus lateralis. A blood pressure cuff was placed above the quadriceps and inflated to 300 mmHg.
- Deoxygenated hemoglobin (HHb) was recorded continuously at 10 Hz using the 30-, 35-, and 40-mm channels via Oxysoft software. HHb values were normalized through physiological calibration and corrected for blood volume changes using the method by Ryan et al. (2012).
- Resting mVO_2 was calculated from three 10-second occlusions performed at rest, without exercise.
- Participants performed a 20-second exercise bout, followed by eight 5-second occlusions with 10 seconds of rest in a seated position. This protocol was repeated four times.
- In each channel, the slope of HHb increase during the first 3 seconds of each occlusion was used to calculate mVO_2. The four values at each time point were averaged and plotted over time, with the final point representing resting mVO_2.
- A mono-exponential curve was fitted to the data using the equation: y(t)=End−Δ·e−k·; where k is the time constant.



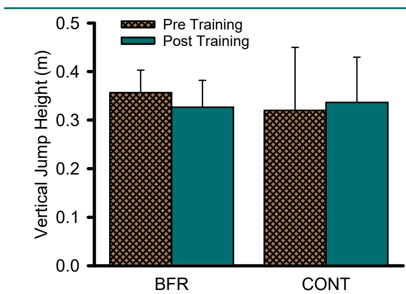
Deoxygenated hemoglobin during transient occlusions (5-seconds on, 10 seconds off)

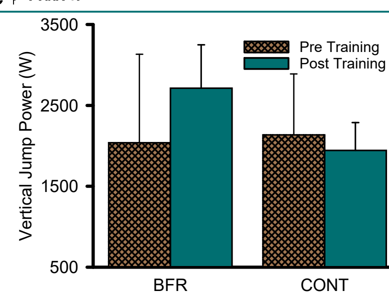


mVO2 (Δ HHb during transient occlusions)



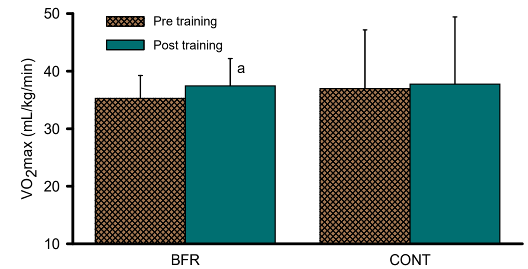
Muscle Power





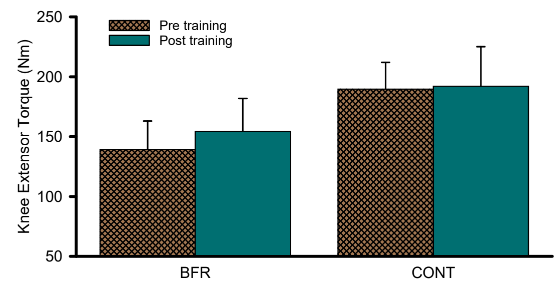
Data are mean ± SD

Aerobic Fitness



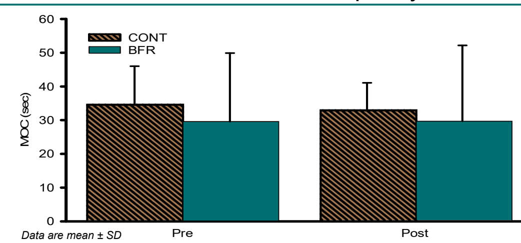
Data are mean ± SD. a = significantly different from Pre training

Muscle Strength



Data are mean ± SD

Muscle Oxidative Capacity



Data are mean ± SD

Conclusion

- Adding blood flow restriction (BFR) to aerobic training can enhance aerobic fitness, even without changes in strength and poser.
- The current protocol was not sufficient to induce mitochondrial adaptations, suggesting that longer duration, higher intensity, or varied occlusion pressures may be necessary for more comprehensive physiological improvements.

Practical Applications

- Use BFR to boost aerobic fitness in populations unable to perform high-intensity training.
- Do not expect short-term changes in strength, power, or mitochondrial capacity without adjusting training variables. Future training programs should explore manipulating frequency, intensity, and limb occlusion pressure (LOP) to promote broader adaptations.
- Ideal for rehabilitation or low-impact settings, where aerobic gains are desired without high mechanical load.