Effects of Continuous and Intermittent Blood Flow Restriction on Physiological Responses during Aerobic Exercise

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Abstract

Blood flow restriction (BFR) during exercise improves cardiovascular fitness with lower work-rates compared to traditional exercise, but differences in continuous (CONT-BFR) or intermittent BFR (INT-BFR) are unknown. This study examines physiological responses to light intensity with no BFR (LIIE), INT-BFR, CONT-BFR, and high-intensity interval exercise (HIIE). Subjects will participate in four trials; BFR-INT, CONT-BFR, LIIE and HIIE. Trials consist of five two-minute intervals with a one-minute recovery interval. During CONT-BFR, cuffs will continuously be inflated at 60% of limb occlusion pressure; INT-BFR is similar except cuffs deflate during recovery intervals. Each trial blood pressure, cardiac output, oxygen uptake, and muscle oxygenation will be measured. Oxygen consumption and cardiac output should be similar across light-intensity trials regardless of BFR, but lower than HIIE. Blood pressure and decline in muscle oxygenation should be the greater in the CONT-BFR compared to INT-BFR; BFR trials will be greater than LIIE but less than HIIE.

Background Information

- Oxygen Consumption (VO_2) is the amount of oxygen that your body consumes during exercise to create aerobic energy to complete exercise. Cardiac output (CO) measures the amount of blood pumped by the heart per minute and represents oxygen delivered to the muscle. Stroke volume (SV) is defined as the volume of blood pumped each beat. These physiological measurements all increase with exercise intensity.
- Mean arterial pressure (MAP) describes the average pressure that blood exerts on the walls of the arteries and is the force that pushes blood to the muscles. These measurements are important to gather because if cardiovascular stress is too high, damage to the blood vessels is possible.
- Rate-pressure product (RPP) describes how hard the heart is working to deliver blood to the body. This is calculated by multiplying heart rate by systolic blood pressure. Again, if this number climbs too high, adverse effects may be seen.
- Muscle oxygenation (StO_2) is another important measurement to obtain. Especially with BFR, this is a measurement of peripheral stress and how the muscles are reacting to a decreased amount of blood flow.

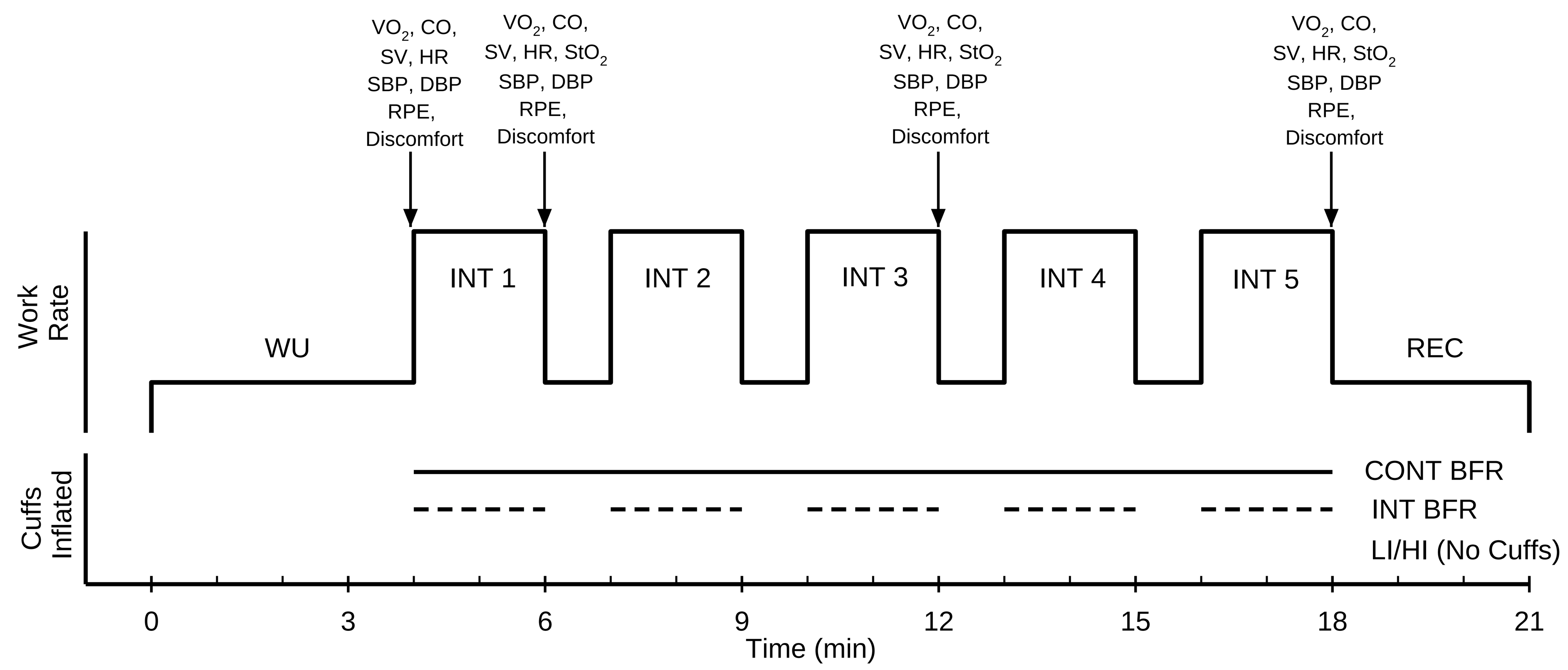
Introduction

- Blood flow restriction (BFR) is defined as limiting blood flow to an area of the body. This study focused on limiting blood flow bilaterally to the legs.
- BFR can benefit someone physiologically by improving the cardiovascular system by lowering cardiovascular stress and providing effects similar to high intensity at a lower exercise intensity compared to without BFR.
- The effects of continuous versus intermittent BFR need to be examined to determine if there are differences between the two when it comes to physiological response, or perceived exertion and discomfort.
- If there is a difference, then one can be shown to provide more benefits, and if there is not a difference, then perceived exertion and discomfort can better determine which is more suitable for the individual.

Purpose and Hypothesis

- The purpose of this study is to examine the physiological effects of continuous (CONT) blood flow restriction (BFR), intermittent BFR, low-intensity interval without BFR (LI), and high-intensity interval exercise without BFR (HI)
- It is hypothesized that MAP will be greater and the decrease in (StO_2) will be greater in CONT compared to the INT
- It is also hypothesized that VO_2 and CO should be similar across all trials, except HI, which it will be greater.

Experimental Trials



- Five subjects completed this study. The age of subjects was 26.7 ± 6.6 years, their height was 181.2 ± 8.1cm, and weight was 80.4 ± 7.8kg.

Exercise Protocol

- Exercise protocols consisted of a 5-min warm up at 20 W followed by five 2-min work intervals with a 1-minute rest between intervals. During the BFR trials and the low intensity trial, work intervals were 35% of peak power. For the high intensity trial, wattage was set at 70% of peak power. Peak power was the highest power output during a graded exercise test to maximal effort on the first visit.

Blood Flow Restriction

- Limb occlusion pressure was first determined by a Hokinson rapid inflation device, and a Hokinson Doppler ultrasound. While supine LOP is the pressure at which blood ceases in the anterior tibial arterial. BFR pressure during exercise was set at 60% of LOP.
- During CONT-BFR, BFR cuffs were initially inflated at the start of INT 1 and remained inflated through all intervals. At the end of INT5, they were deflated. During INT-BFR, cuffs were inflated only during INT 1 – 5 and deflated at the end of each INT during 1 minute of lowered exercise intensity.

Measurements

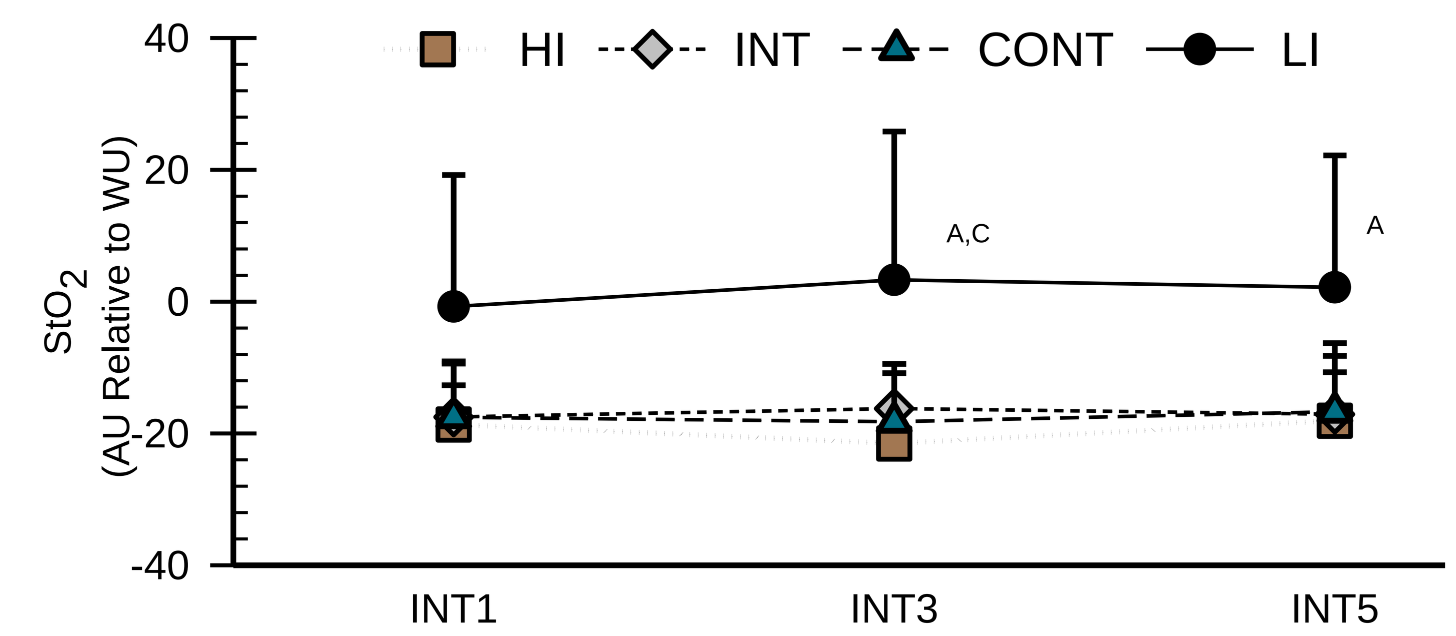
- VO_2 was continuously gathered with a COSMED Quark PFT breath-by-breath metabolic cart. CO, SV, and heart rate (HR) were measured by the Physioflow device. Systolic (SBP) and diastolic blood pressure (DBP) were obtained by manual auscultation on the right brachial artery. Muscle oxygen saturation was measured using the NIRs device placed on the right vastus lateralis. Data was collected continuously and averaged over the last 30 seconds of the warmup (WU), INT 1 , INT 3, and INT 5.
- MAP calculated from SBP, DBP and HR using methods developed by Moran et al (J Physiol Anthr, 1995). RPP was calculated by multiplying SBP and HR (RPP = SBP * HR)
- Rating of perceived exertion and discomfort were measured using the Borg RPE scale (6-20) and Borg discomfort scale (CR-10+), respectively. Subjects were asked to provide these ratings during the last 30 seconds of WU, INT 1, INT 3, and INT 5.

Physiological Responses

	WU				INT 1				INT 3				INT 5			
	LI	HI	INT	CONT	LI	HI	INT	CONT	LI	HI	INT	CONT	LI	HI	INT	CONT
VO2	0.75	0.85	0.86	0.81	1.21	2.05^{B,C,D}	1.30	1.30	1.38	2.23^{B,C,D}	1.37	1.44	1.36	2.33^{B,C,D}	1.39	1.44
(L/min)	± 0.05	± 0.04	± 0.08	± 0.06	± 0.18	± 0.35	± 0.30	± 0.21	± 0.20	± 0.25	± 0.20	± 0.20	± 0.24	± 0.25	± 0.15	± 0.23
CO	8.1	9.8	8.8	8.1	10.8	15.8^{C,D}	11.6	10.8	11.5	18.6^{B,C,D}	12.8	11.8	12.6	20.8^{B,C,D}	13.0	12.4
(L/min)	± 1.4	± 1.8	± 0.9	± 0.6	± 2.0	± 3.2	± 0.6	± 1.3	± 1.8	± 5.2	± 0.7	± 1.9	± 1.2	± 5.1	± 1.2	± 1.4
SV	91.5	102.3	95.3	96.7	104.1	117.3	99.8	100.6	107.6	116.9	104.0	101.2	109.6	123.0	102.0	100.7
(ml/beat)	± 16.6	± 21.1	± 16.2	± 20.3	± 19.6	± 30.0	± 15.2	± 18.5	± 21.9	± 38.6	± 17.7	± 23.8	± 22.6	± 35.6	± 21.6	± 18.5
HR	90	98	94	86	106	137^{B,C,D}	118	109	111	161^{B,C,D}	126	118	110	163^{B,C,D}	131	125
(bpm)	± 14	± 18	± 16	± 11	± 20	± 7	± 16	± 14	± 22	± 7	± 16	± 15	± 23	± 36	± 16	± 15
MAP	97.7	103.4	99.1	97.4	103.5	119.4^{C,D}	113.0	109.0	105.6	123.2^{D}	114.4	115.8	107.7	124.9^{C,D}	115.1	114.5
(mmHg)	± 9.3	± 6.5	± 7.7	± 5.6	± 6.2	± 4.1	± 9.4	± 5.1	± 6.1	± 4.3	± 10.5	± 4.3	± 8.2	± 4.6	± 11.4	± 5.1

Data presented as means ± standard deviation. A = different from HI; B = different from INT; C = different from CONT; D = different from LI

Muscle Oxygenation



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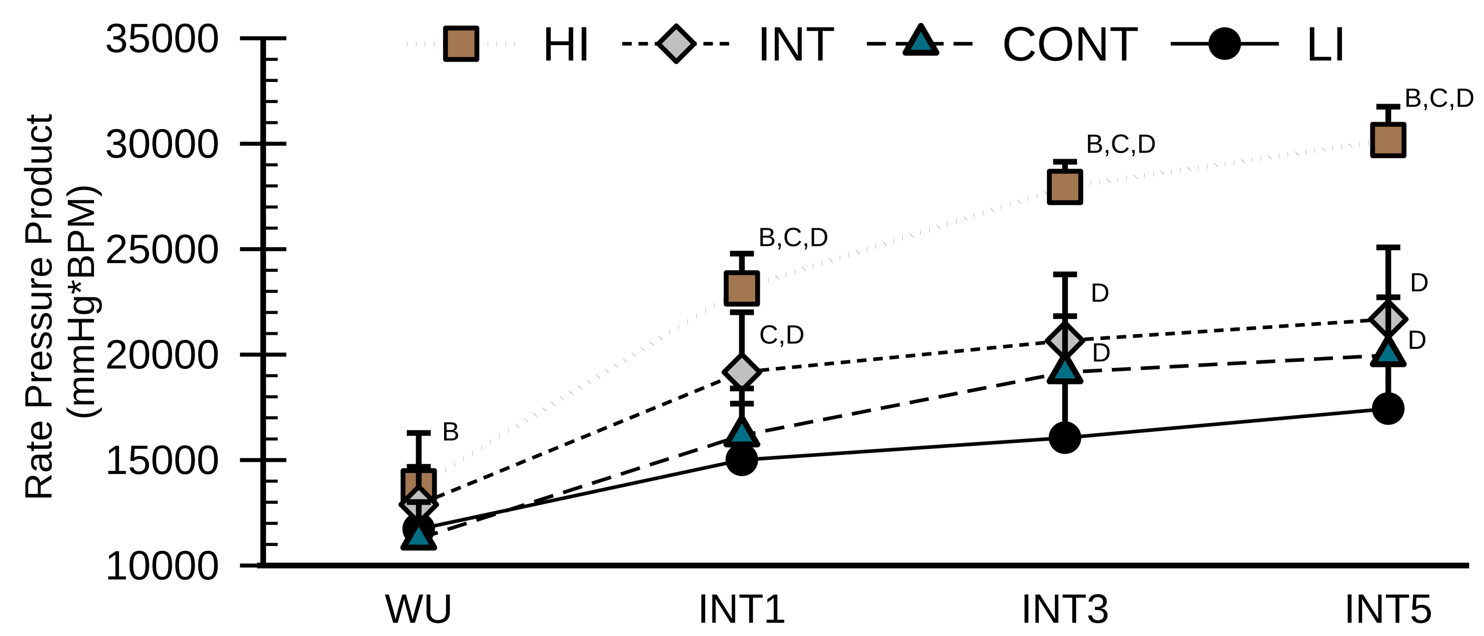
Rate Pressure Product



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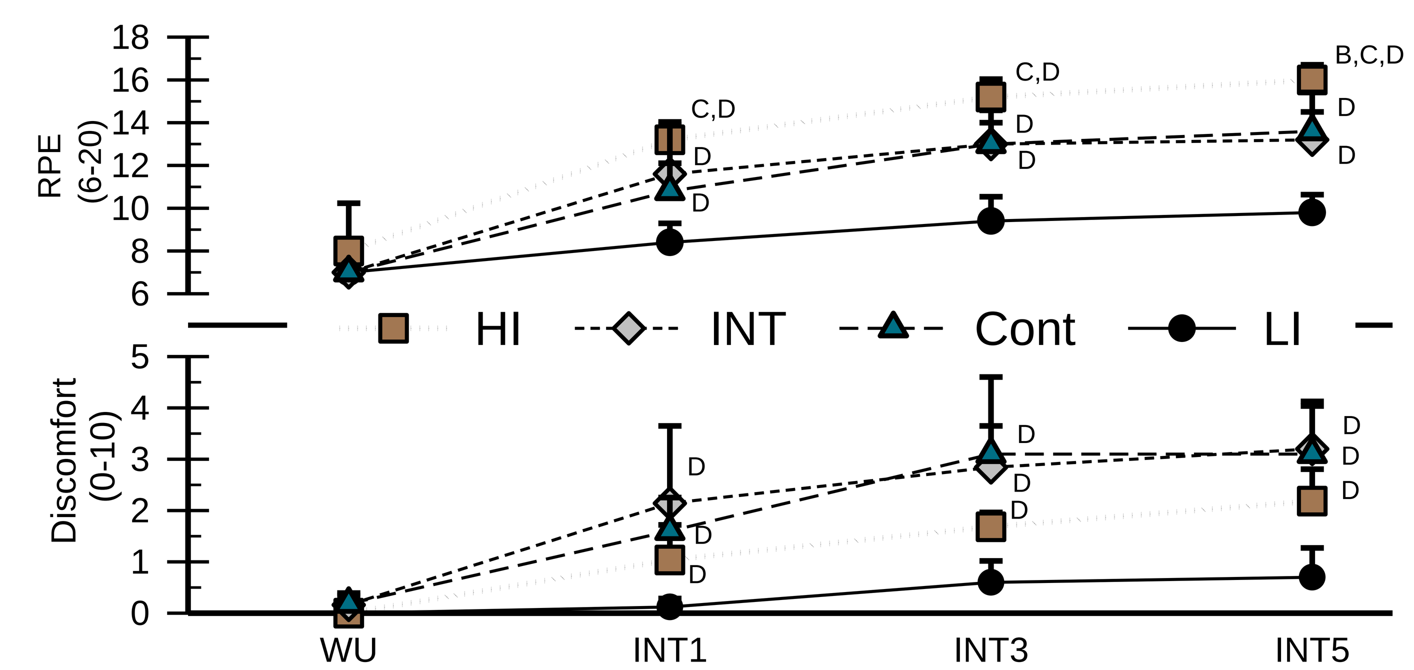
Perceptual Responses



Data presented as means ± standard deviation. A = different from HI; B = different from INT; C = different from CONT; D = different from LI

Conclusion/ Practical Applications

- There were no differences between CONT-BFR and INT-BFR.
- Both BFR trials has lower cardiovascular stress with similar peripheral stress as the HI. This means BFR could provide similar muscular adaptations while decreasing the risk of acute cardiovascular events.
- BFR provides an alternative form of exercise to individuals that can not reach a high intensity of exercise due to increases cardiovascular work, but still need peripheral adaptations.