PHYSIOLOGICAL EFFECTS OF WORK:RECOVERY RATIO DURING AEROBIC INTERVAL EXERCISE WITH BLOOD FLOW RESTRICTION

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Introduction

- Exercise with blood flow restriction (BFR) is a form of exercise that partially restricts arterial blood flow and restricts venous outflow. It is performed by a pressurized cuff or tourniquet placed at the most proximal end of the exercising muscle.
- The addition of BFR to low-intensity aerobic exercise elicits greater metabolic stress compared to a similar intensity under free-flow conditions. Despite a lower work rate, some studies found similar metabolic stresses to vigorous-intensity exercise.
- Metabolic stress is thought to be responsible for the physiological adaptation to low-intensity exercise with BFR, such as mitochondrial biogenesis, angiogenesis, and improvements in aerobic fitness.
- Despite muscular benefits, the addition of BFR also increases cardiac work, as measured by rate pressure product. The addition of BFR increases both SBP and HR during exercise.
- Variables can be adjusted in aerobic interval training and BFR protocols, including exercise intensity, BFR duration, BFR pressure, etc. Previous studies have shown that adjusting any of these variables alters metabolic stress and cardiovascular work.
- One area less explored is the effect of work:recovery ratio (W:R) on BFR training. It is known that BFR increases both metabolic stress and cardiac work. It is important to under the effect of different W:R to utilize BFR at the highest efficiency.

Purpose

This study examined the effects of the work:recovery ratio (W:R) on metabolic stress and cardiac work during low-intensity aerobic exercise with BFR.

Subject Characteristics

- Nine participants (M = 4; F = 5) completed the study (21.1 ± 1.0 yrs, 168.2 ± 8.0 cm; 64.8 ± 7.0 kg).

VO_2peak ($L{\cdot}min^{-1}$)	VO_2peak ($ml{\cdot}kg^{-1}{\cdot}min^{-1}$)	VO_2 at GET* ($L{\cdot}min^{-1}$)	WR at GET (W)	Interval WR** (W)
2.37 ± 0.59	36.3 ± 6.3	1.42 ± 0.25	72.4 ± 26.1	50.7 ± 19.4

Data presented as mean ± SD. * = Gas exchange threshold (GET) found by visual inspection using the V-slope method. ** = interval work rates (WR) were 70% of the estimated work rate at the GET.

Blood Flow Restriction Application

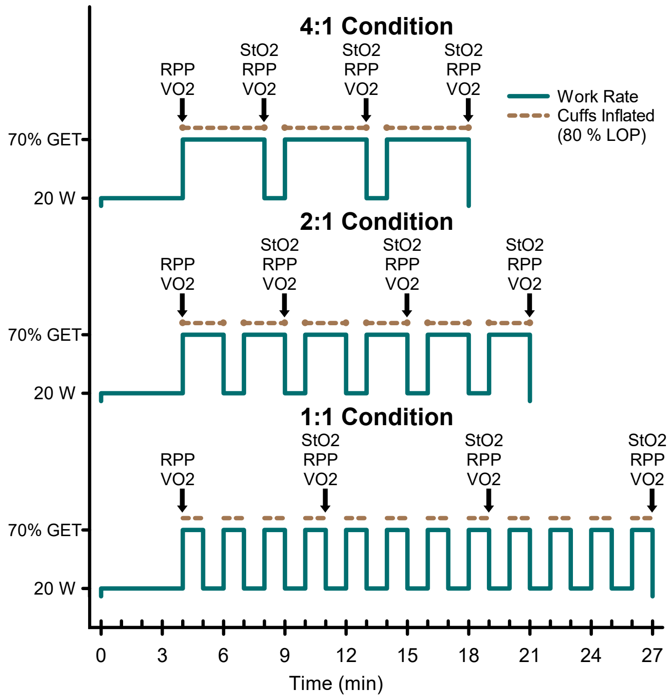
- Before exercise, participants assumed a supine position with the BFR cuffs placed on the proximal portion of their thigh.
- A Doppler ultrasound device was used to identify the posterior tibial artery and pressure in the cuffs was increased until the pulse could not be heard.
- The pressure that leads to the cessation of the pulse was considered the LOP. Restriction pressure during experimental trials was 80% of LOP.

	1:1	2:1	4:1
Limb Occlusion Pressure (mmHg)	146.9 ± 18.5	151.7 ± 17.7	149.8 ± 19.8
Restriction Pressure (mmHg)	117.7 ± 14.7	121.2 ± 14.4	119.7 ± 15.9

Data presented as mean ± SD.

Experimental Conditions

Three experimental visits were completed in a random order. Exercise protocols are shown below. Protocols are matched work interval and restriction duration (12 mins).



1:1 Condition – 12 one-min work intervals interspersed with 1-min recovery intervals (total duration = 18 mins; work duration = 12 min)
2:1 Condition – 6 two-min work intervals, interspersed with 1-min recovery intervals (total duration = 21 mins; work duration = 12 min)
4:1 Condition – 3 four-min work intervals, interspersed with 1-min recovery intervals (total duration = 27 mins; work duration = 12 min)

Measurements

- Oxygen consumption was collected continuously using a breath-by-breath metabolic cart.
- Rate-pressure-product (RPP) was calculated from heart rate and systolic blood pressure (taken by manual osculation).
- A near-infrared spectroscopy (NIRS) sensor was placed on the right vastus lateralis to measure muscle oxygenation throughout each session. Tissue oxygen saturation (StO_2) was normalized to the final 30 seconds of the warm-up and presented as a change from warm-up (Δ WU).
- Due to the differences in protocol duration, all measurements were averaged over the final 30 seconds of the warm-up (WU), 33%, 67%, and 100% of the protocol duration.

Acknowledgments

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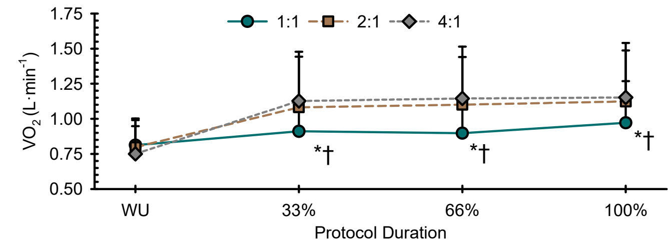
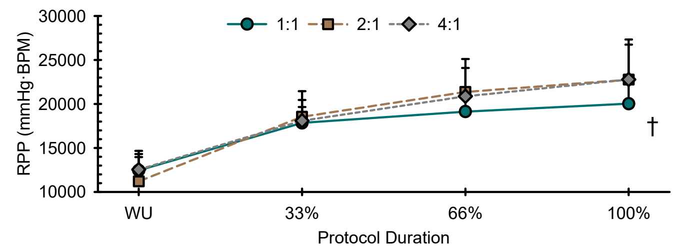
Oxygen Consumption



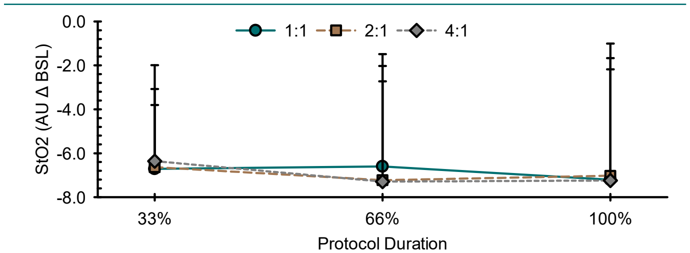
Data presented as mean ± SD; * = significantly different from 2:1; † = significantly different from 4:1 ($p<0.05$).

Rate Pressure Product



Data presented as mean ± SD. † = significantly different from 4:1 ($p<0.05$).

Muscle Oxygenation



Data presented as mean ± SD.

Conclusion/ Practical Applications

- There were no differences in muscle oxygenation between conditions, suggesting W:R did not affect metabolic stress in the working muscle.
- A 1:1 work/recovery ratio resulted in lower oxygen consumption than 2:1 and 4:1, suggesting longer work intervals could result in greater cardiopulmonary stress.
- Cardiovascular work in 4:1 was greater than 1:1 at the end of the protocol, but similar to 2:1. Cardiovascular work may increase to a greater extent in protocols with longer intervals, but only as the protocol progresses.
- When prescribing aerobic interval exercise with BFR, W:R should be considered. A 2:1 W:R could provide greater physiological stress while limiting the work on the cardiovascular system.