Physiological Effects of Interval Duration during Aerobic Exercise with Blood Flow Restriction

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Abstract

BACKGROUND: Aerobic exercise with blood flow restriction (BFR) has been shown to elicit positive physiological adaptions. A mechanism of adaptation with BFR is increased local metabolic stress, however, BFR can also increase cardiac work. Metabolic stress and cardiac work could be affected by the work interval duration during BFR but the acute physiological effects of interval duration with BFR are unexplored. This study will examine the effect of work interval duration on the local metabolic stress and cardiac work during low-intensity aerobic exercise with BFR. METHODS: Healthy males (18-25 yrs) will complete a graded exercise test to determine WR for experimental conditions. On separate days, participants will complete three experimental interval (INT) exercise protocols with intermittent BFR, in a random order. All protocols will consist of a 4-min warm-up ([20 W] WU), work INTs (35% peak power), and 1-min recovery INTs (20 W) between work INTs. The work INTs in the three protocols will be: 1) six 2-min INTs (2-min INT), 2) twelve 1-min INTs (1-min INT), and 3) three 4-min INTs (4-min INT). During work INTs, BFR cuffs will rapidly inflate to 60% of limb occlusion pressure (LOP) and deflate during recovery INTs. LOP will be the pressure at which the posterior tibial artery pulse ceases by Doppler auscultation. In each protocol, the duration of work INTs and BFR will be 12 mins. Gas exchange, heart rate (HR), and tissue oxygen saturation (StO_2) of the vastus lateralis, via near-infrared spectroscopy, will be collected throughout exercise. To quantify local metabolic stress, StO_2 will be averaged over the last 30 sec of the WU and expressed as change from WU. Blood pressure (BP) will be taken manually and rate pressure product (RPP) will be calculated to assess cardiac work. Due to the different protocol durations, data will be compared at 0% (end of WU), 33%, 67%, and 100% of each protocol duration. Differences between protocols will be determined by a 2-way (trial x time) repeated measures ANOVA. Significance will be established if $p \leq 0.05$. ANTICIPATED RESULTS: It is hypothesized StO_2 will have a greater decrease from WU and RPP will be greater, suggesting greater local metabolic stress and cardiac work in 4-min INT compared to 1-min INT and 2-min INT. If the hypothesis is confirmed, training with longer intervals could elicit greater local adaptations, but cardiac work will be increased during training.

Background

- Exercise with blood flow restriction (BFR) is a form of exercise known for partially restricting arterial blood flow and for restricting venous outflow. It is performed by 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. Some studies found similar metabolic stresses as vigorous-intensity exercise, despite a lower work rate.
- Near-infrared spectroscopy (NIRS) measures the muscle oxygenation status and indirectly metabolic stress. The addition of BFR decreases muscle oxygenation by creating a mismatch between oxygen demand and delivery.
- 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.
- There are many variables that 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 will alter metabolic stress and cardiovascular work.
- One area less explored is the effect of work interval duration on BFR training. It is known that BFR increases both metabolic stress and cardiac work, but it could be important to find an optimal work interval duration to utilize BFR at the highest efficiency.

Purpose

This purpose of this study is to examine the effect of work interval duration on the local metabolic stress and cardiac work during low-intensity aerobic exercise with BFR.

Experimental Conditions

- The order of the experimental conditions will be randomized and performed on separate days.
- Work rates for exercise protocols will be determined by a graded exercise test (GXT) that will take place prior to experimental conditions. The GXT will be performed on a cycle ergometer to obtain each individual's peak power (PP). Each exercise protocol workload will be 35% of participant's peak power (PP).
- Each exercise protocol will be structured to match total work interval duration and total restriction duration, but protocol duration and total recovery interval duration will be different between trials.

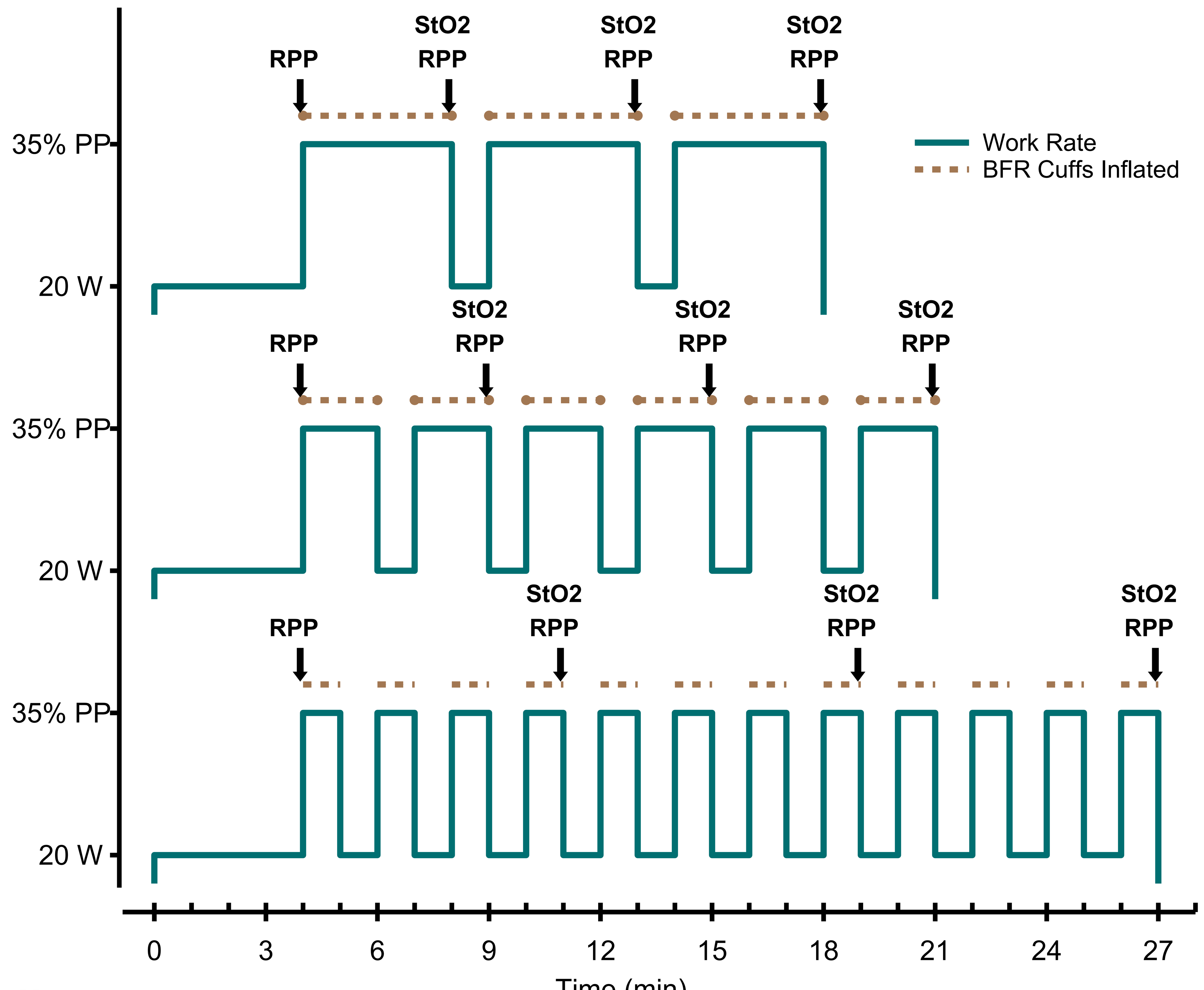
Exercise Protocols

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

Prior to all protocols, limb occlusion pressure (LOP) will be determined. Cuffs will be inflated to 60% of LOP during the work intervals and deflated during recovery.

LOP

- The participants will assume a supine position with the cuffs on the proximal portion of their thigh.
- Once the pulse of the posterior tibial artery is identified via doppler ultrasound pressure in the cuffs will be progressively increased until the pulse is unable to be heard. The pressure that leads to the cessation of the pulse will be identified as the participants LOP.



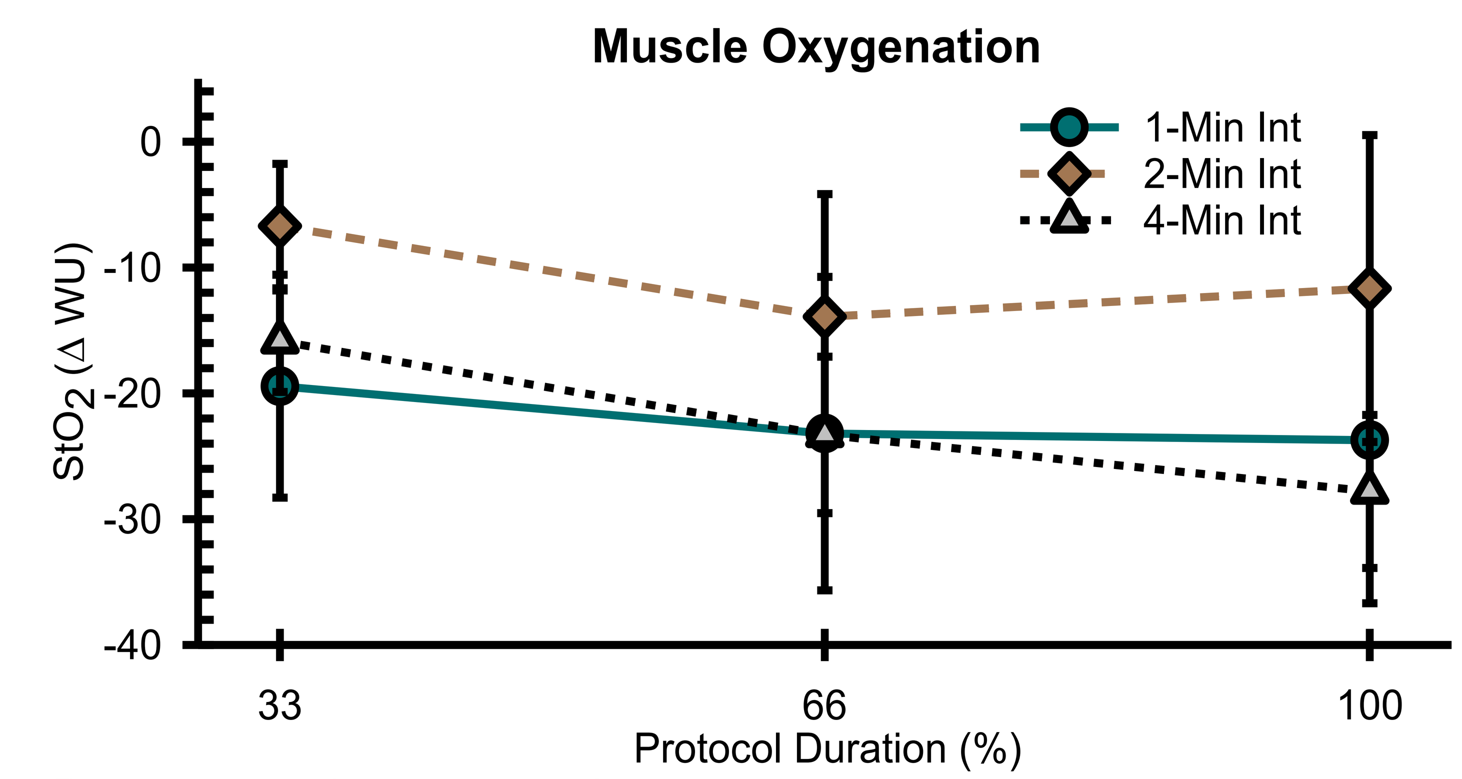
Measurements

- A near-infrared spectroscopy (NIRS) sensor will be placed on the right vastus lateralis to measure muscle oxygenation throughout each session. Tissue oxygen saturation (StO_2) will be normalized to the final 30-seconds of the warm up and presented as a change from warm up (Δ WU).
- Rate-pressure-product (RPP) will be calculated from heart rate and blood pressure.
- Due to the differences in protocol duration, all measurements will be averaged over the final 30 seconds of the 0% (warm up), 33%, 67%, and 100% of the protocol duration.

Pilot Data (n = 3)

1-Min Int BFR Pressure (mmHg)	2-Min Int BFR Pressure (mmHg)	4-Min Int BFR Pressure (mmHg)
87.0 ± 5.7	87.3 ± 9.9	80.3 ± 4.0

BFR pressure will be 60% of limb occlusion pressure. Data presented as mean ± sd.



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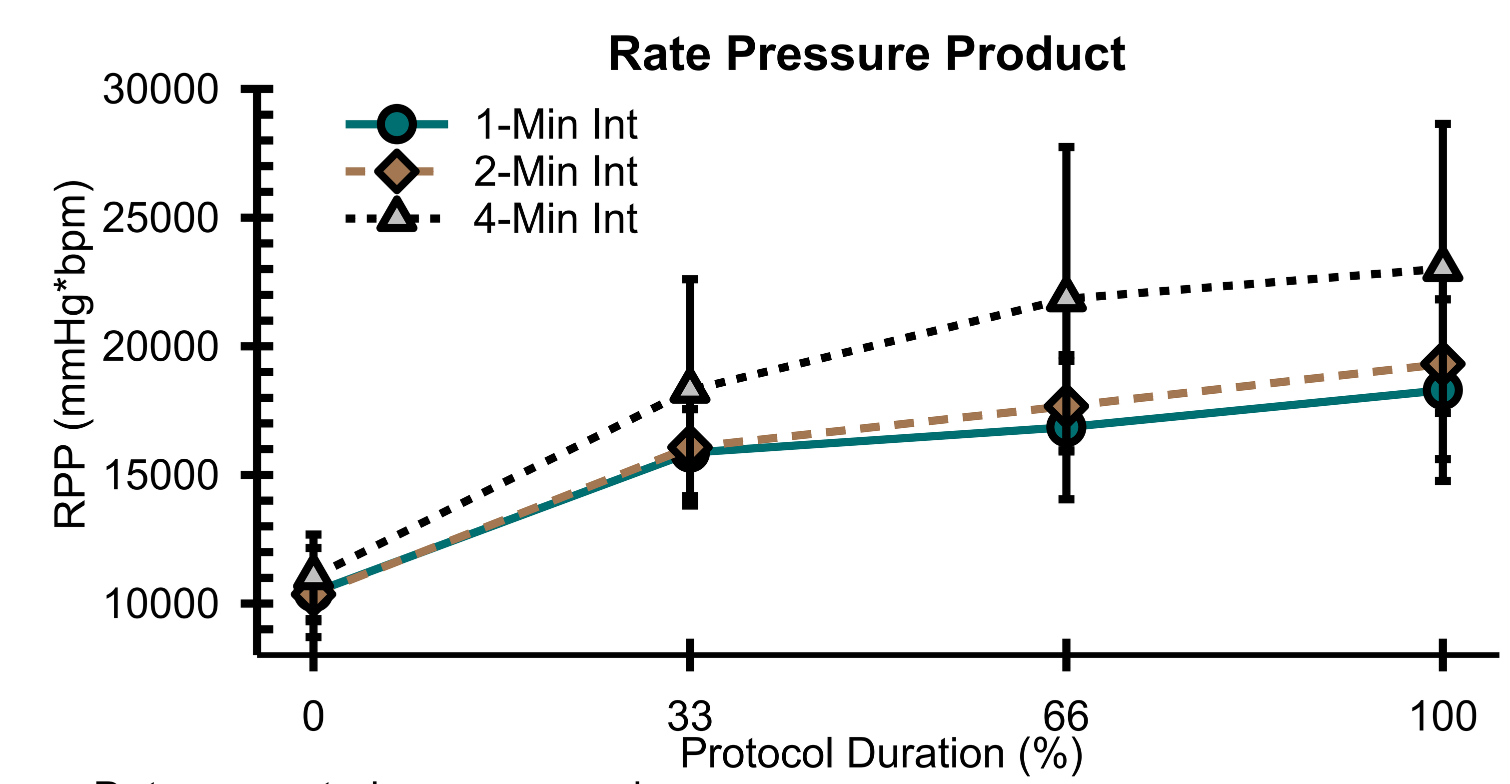

Data presented as mean ± sd.

Anticipated Results

- It is hypothesized that metabolic stress, as measured by StO_2, and cardiac work, as measured by RPP will be greater in the 4-min INT protocols compared to 2-min INT and 1-min INT protocols.
- In all protocols, StO_2 is expected to decrease from warm up. However, there will be a greater decrease in the 4 min INT because of the reduced recovery duration and reperfusion periods.
- In all protocols, RPP is expected to increase from warm up. However, there will be a greater increase in the 4 min INT compared to the other protocols due to greater heart rate response and greater systolic blood pressure response.