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Cardiovascular Responses to Woodsmoke Inhalation During Exercise

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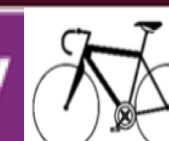
ABSTRACT

Summers in the Rocky Mountain West are notorious for wildfires. By virtue of event frequency, inhalation of woodsmoke particulate matter (PM) may potentially impact cardiovascular health. While field based studies have provided some insights, well controlled lab studies that quantify cardiovascular function before and after smoke inhalation are the next step. In order to better understand the physiological effects, we examined autonomic-sensitive cardiovascular responses to exogenous particulate during exercise using lab simulated exposure to filtered woodsmoke (Western Larch dried to 15% water content). High heart rate variability (time difference between cardiac cycles in an ECG) and low pulse wave velocity (“PWV”, the speed at which a cardiac impulse is transmitted through arteries) are two metrics of cardiovascular autonomic control that are indicative of good health. Two exercise trials at 70% VO_{2max} cycling for 45-minutes, with smoke (PM 2.5 μm , “WS” at 250 $\mu g/m^3$) or without smoke (PM 2.5 μm , “CON” at 0 $\mu g/m^3$) were performed with a randomized, cross-over design ($n=5$). WS and CON trials were separated by one week with significance occurring at $p<0.05$, *a priori*. Exercise bouts were confirmed identical for each trial (Watts, HR, and RPE). Key dependent outcomes measured pre-exercise (“PE”), immediately post exercise (“IP”), and 90-min post-exercise (“90-P”) include Heart Rate Variability (low/high frequency, “L/F”), and PWV. We found an increase in L/F (IP CON=2.42 \pm 0.855, IP WS=5.26 \pm 1.67; $p=0.030$), and increased PWV (IP CON=5.51 \pm 0.70m/s, IP WS=7.45 \pm 2.26m/s; $p=0.030$). These findings demonstrate that smoke exposure influences autonomic tone to alter HRV and PWV measures. Study outcomes suggest implications for long term cardiovascular health, but further examination is required. Funded by USDA Forest Service 18-CR-11138100-023 (JQ).

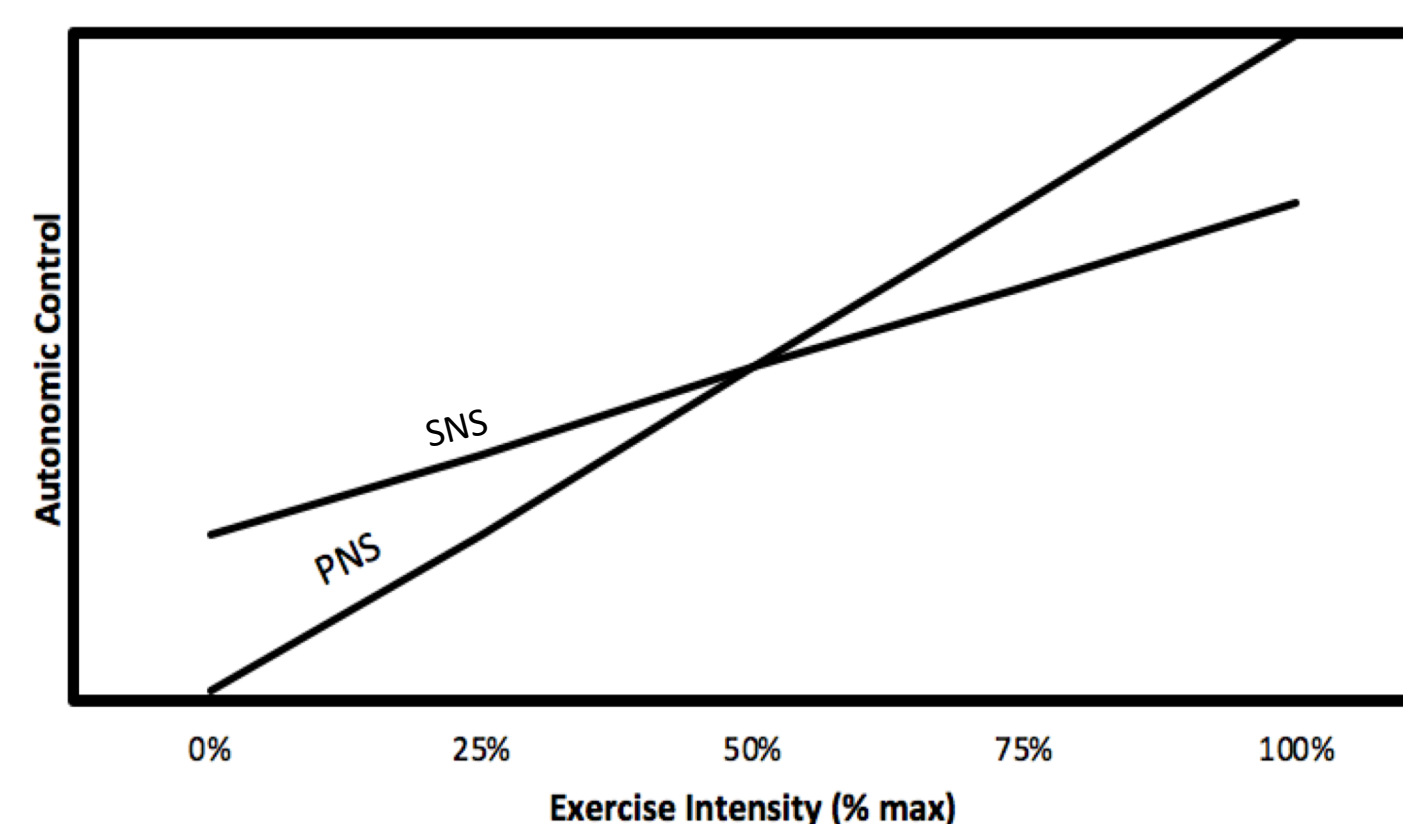
INTRODUCTION

- While detrimental health effects from inhaling particulate matter (PM) are widely accepted by the general public, determining central nervous system (CNS) responses to PM exposure is a necessary step to understand the cardiovascular effects of physical activity in smoky environments.
- This study quantified acute cardiovascular responses to moderate/intense exercise with PM exposure that The Air Quality Index (AQI) categorizes as “Very Unhealthy”*.

Air Quality Index - Particulate Matter

301-500	Hazardous
201-300	Very Unhealthy 
151-200	Unhealthy
101-150	Unhealthy for Sensitive Groups
51-100	Moderate
0-50	Good

Parasympathetic vs. Sympathetic Control in Exercise



*Sacramento Metropolitan Air Quality Management District

PURPOSE

Project our data for the general audience given the relationship between 45 mins of 70% VO_2 max: 90-min moderate physical activity: 4-5 hrs low intensity physical activity.

METHODS

Experimental Design

- Five participants’ characteristics shown in **Table 1**. Subjects visited lab three times during the morning hours.
 - Prior all visits, participants abstained from exercise and alcohol for 24-hours, caffeine for 12-hours and completed an overnight fast. A standardized diet was consumed for one day prior to visits two and three. Participants consumed water *ad libitum*.

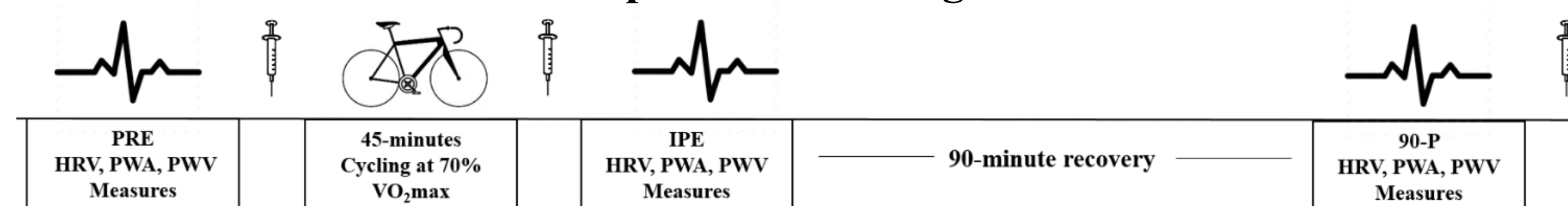
Visit One

- Subjects performed VO_{2max} tests on a cycle ergometer.
- Body composition was measured with underwater weighing.

Visit Two and Three

- Randomized, cross-over, controlled, double-blind design.
- Two exercise trials: 70% VO_{2max} on a cycle ergometer with smoke exposure and without smoke exposure. Trials for each subject were separated with a one week washout period.
- Measurements of pulmonary function, Heart Rate Variability (HRV), Pulse Wave Velocity (PWV), and vital signs (blood pressure and heart rate) were taken at rest before the trial, immediately post-exercise and 90 minutes post-exercise. Venous blood samples were collected at all time points for subsequent biomarker analyses. Cardiovascular measurements were obtained in a dark, quiet room to standardize autonomic responses. Cycle resistance and cadence were identical for both exercise trials.
- Smoke delivery was monitored during the smoke exercise trials.

Experimental Design:



Statistical Analysis

- Repeated measures ANOVA were used to determine main effects (time and trial), and interaction (time x trial) effect. Where appropriate, a Tukey post hoc test was performed. Statistical significance was set at $p<0.05$, *a priori*.

RESULTS

Table 1: Participant Characteristics

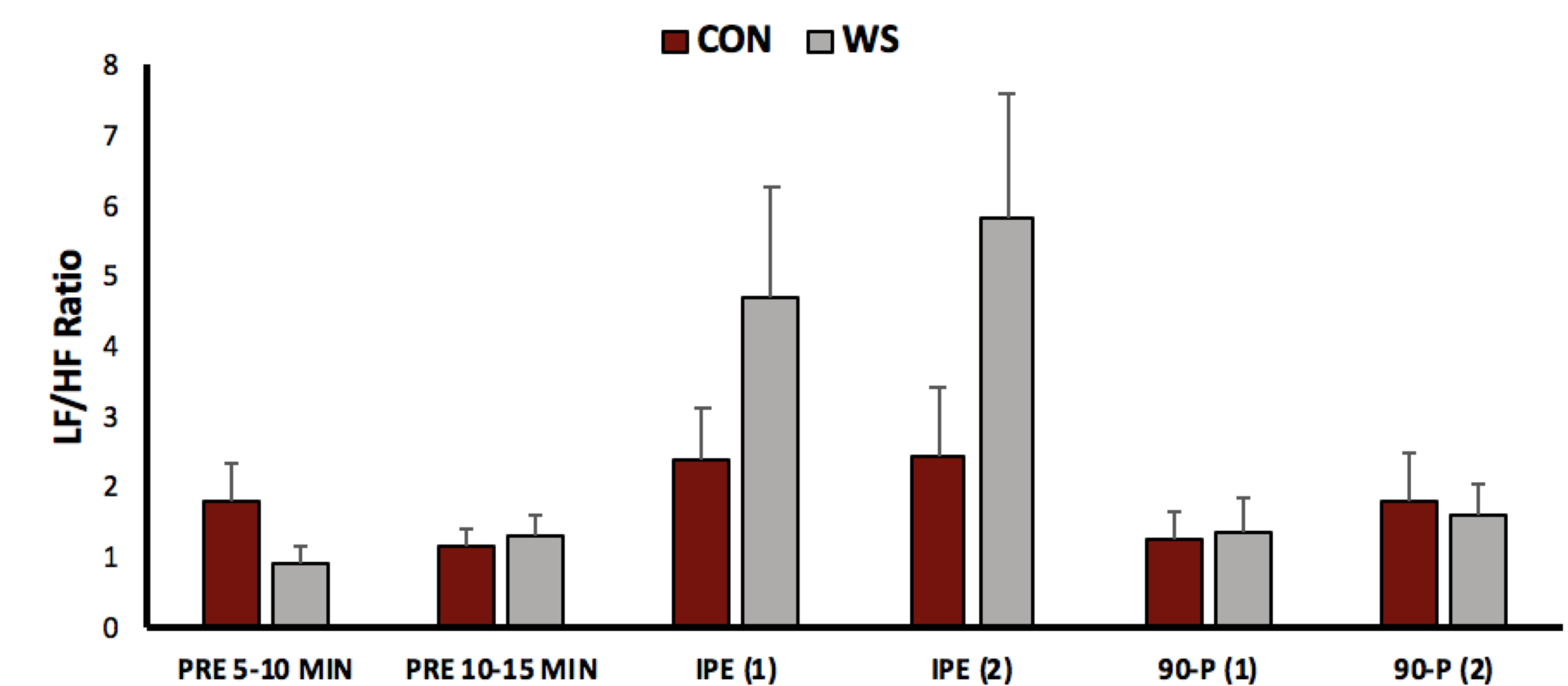
Height (cm)	176.8 \pm 4.59
Weight (kg)	74.44 \pm 6.38
% Body Fat	13.48 \pm 2.98
Lean Mass (kg)	67.25 \pm 5.49
Fat Mass (kg)	10 \pm 2.49
VO_2 max (ml/kg/min)	45.4 \pm 2.24



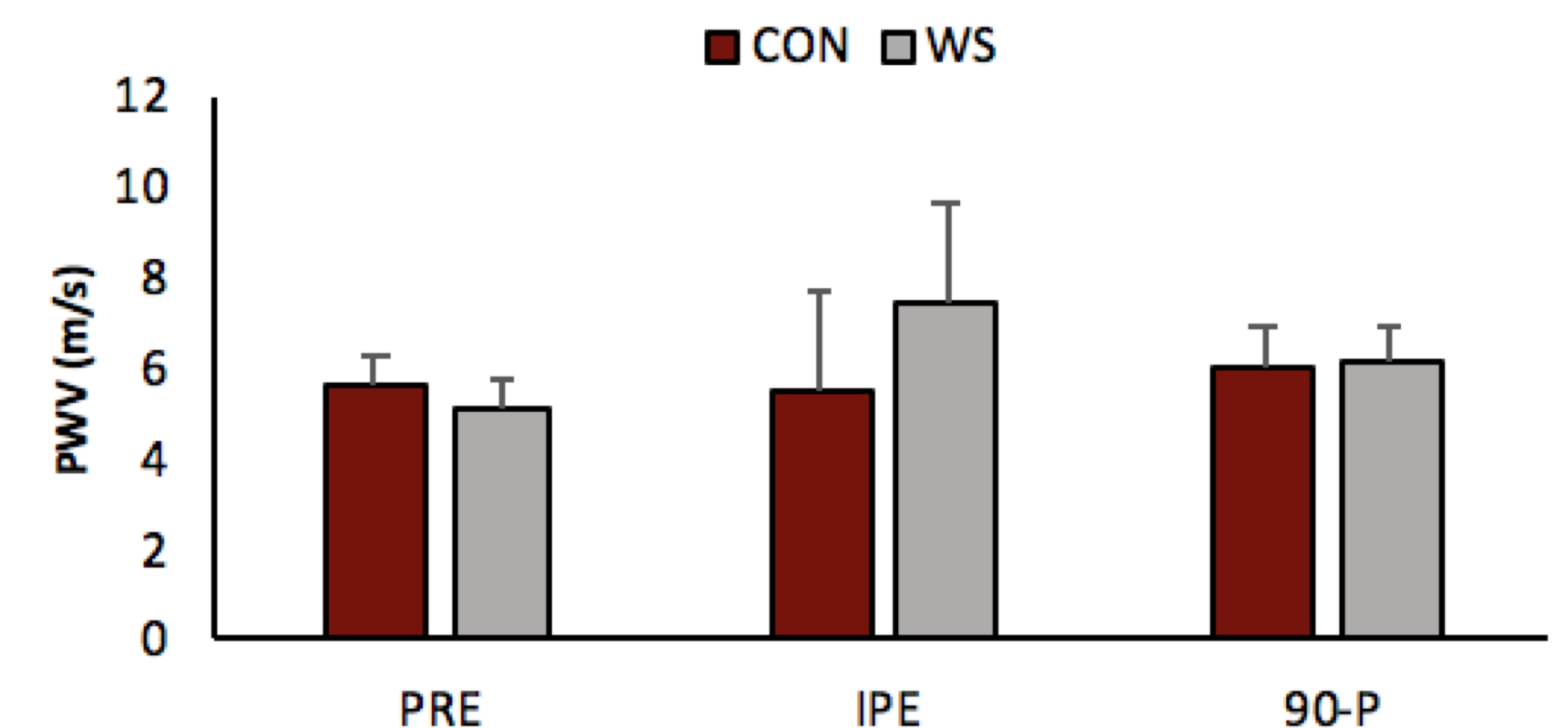
RESULTS

Autonomic Nervous System Measurements of Cardiovascular Function

Heart Rate Variability (LF/HF)



Pulse Wave Velocity



CONCLUSION

- Non-significant numerical increases in PWV and HRV were observed immediately post exercise.
- Power analyses indicate that similar responses, performed in 10 subjects, would achieve statistical significance
- Given that this investigation will be performed on 10-12 participants, additional observations may yield significant outcomes, although these conclusions are not supported statistically by the current data.

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- Peters B, Ballmann C, Quindry T, Zehner EG, McCroskey J, Ferguson M, Ward T, Dumke C, Quindry JC. Experimental Woodsmoke Exposure During Exercise and Blood Oxidative Stress. *J Occup Environ Med* 2018;60:1073-1081.