Eur J Appl Physiol
DOI 10.1007/s00421-015-3203-z

ORIGINAL ARTICLE

# Effect of moderate exercise-induced heat stress on carotid wave intensity

**Denise L. Smith[1] · Jacob P. DeBlois[1] · Margaret Wharton[2] · Patricia C. Fehling[1] · Sushant M. Ranadive[3]**

Received: 7 November 2014 / Accepted: 6 June 2015


**Abstract**
*Introduction* Exercise disrupts the interaction between the left ventricle and the vasculature, as measured by wave intensity (WI) analysis. However, the effect of exercise-induced heat stress on WI amplitude is unknown. WI measures are calibrated using brachial or carotid artery blood pressure, but the influence of calibration method on WI outcomes is unknown.
*Purpose* (1) To compare WI analysis during low and moderate exercise-induced heat stress; (2) to examine differences in carotid WI analysis based on calibration method.
*Methods* Eleven healthy, young men (22 ± 3 years) performed intermittent exercise in moderate- and low-heat stress conditions. WI was assessed pre- and post-exercise on the right carotid artery, and calibrated with brachial and carotid blood pressures.
*Results* A main effect of time was found for W1 when calibrated by brachial, but not carotid pressure. A time-by-condition interaction was observed for late systolic/early diastolic function (W2) in both brachial ($p = 0.047$) and carotid calibration methods ($p = 0.042$), where W2 increased following exercise-induced moderate-heat stress but decreased following low-heat stress. The elastic modulus exhibited a significant time-by-condition interaction (brachial $p = 0.039$; carotid $p = 0.044$), increasing following moderate-heat stress but decreasing following low-heat stress. Calibrations using carotid blood pressure significantly reduced WI amplitudes compared with brachial calibrations ($p < 0.001$).
*Conclusions* Arterial–ventricular coupling is affected in different ways following moderate and low exercise-induced heat stress. Wave amplitudes were lower (~13 %) following carotid calibration compared with brachial.

**Keywords** Thermal strain · Arterial–ventricular coupling · Firefighting · Cardiovascular health

**Abbreviations**

| | |
|---|---|
| BP | Blood pressure |
| CS | Cooling shirt |
| Ep | Elastic modulus |
| NA | Negative area |
| PPE | Personal protective equipment |
| SCBA | Self-contained breathing apparatus |
| $T_{co}$ | Core temperature |
| USG | Urine specific gravity |
| $VO_{2max}$ | Maximal aerobic capacity |
| WI | Wave intensity |

## Introduction

Wave intensity (WI) is a hemodynamic index that describes the interaction between the heart and vasculature (Parker and Jones 1990). It is often used to describe left ventricular performance and the state of circulation at a specific location within the body (Hughes et al.

Communicated by Narihiko Kondo.

✉ Denise L. Smith
dsmith@skidmore.edu

[1] First Responder Health and Safety Laboratory, Department of Health and Exercise Sciences, Skidmore College, 815 N Broadway, Saratoga Springs, NY 12866, USA

[2] Saratoga Hospital, 211 Church Street, Saratoga Springs, NY 12866, USA

[3] Department of Anesthesiology, Mayo Clinic, Rochester, MN 55905, USA

Published online: 26 June 2015