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THERMOREGULATION BY SEX: A CARDIOVASCULAR MRI STUDY

Abstract

Core temperature impacts human performance and health. Humans maintain core temperature via the process of thermoregulation. Thermoregulation is affected by changes in: convective heat transfer from skin to environment, autonomic nervous system and metabolic processes, and cardiovascular (CV) system. The CV system plays a vital role in thermoregulation because of the influence of convection and regulation of regional blood flow. For long space flights, altered thermoregulation could compromise astronaut performance; however, little is known about the impact of sex on CV system responses to core temperature changes.

Purpose: To determine sex differences in the cardiovascular system's response to core temperature changes, eventually quantifying tissue thermal properties. A better understanding of the physiological contributors to thermoregulation will aid in astronaut selection, training, and performance.

Methodology: Male and female mice were anesthetized and imaged at 7T. Anatomical and functional data included the periphery (femoral, saphenous, popliteal arteries), central nervous system (Circle of Willis, CoW), infrarenal aorta, and heart. Data was acquired at 35, 36, 37, and 38 C. Cross-sectional area of the peripheral and cerebral arteries was calculated using thresholding methods. Infrarenal area and endocardial area across the cardiac cycle were quantified, with the latter used to calculate stroke volume and cardiac output. MR thermometry was implemented to determine temperature changes in the musculature non-invasively.

Results and Discussion: Changes due to temperature were largest in the peripheral vessels. Peripheral vessel area in males was statistically larger than females; however, females had a larger percent increase in vessel area. The tracking length increased by 290% in males and 768% in females from 35 to 38C. The CoW area remained the same for each temperature with differences between sexes at 36 and 38C. Infrarenal area increased with increasing temperature. Cardiac output and ejection fraction did not change. However, sex differences occur at all temperatures for both heart and infrarenal aorta. Maps from MR thermometry appear promising, showing relative differences in tissue temperatures.

Conclusion: This work is a novel approach to studying thermoregulation by using imaging techniques to quantify functional changes due to altered core temperature. The sex difference between CV responses cannot be attributed to body size difference alone. Future work includes: validating MR thermometry using temperature probes placed in specific tissue compartments (central blood vessel, muscle, skin); quantifying changes in the venous system; and, determining the contribution of body composition, athletic training, age, and the influence of different physiological states, e.g. exercise.