Analysis of arterial mechanics during head down tilt bed rest

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Introduction

- Hometown: Chattanooga, TN
- Career Goals:
  - Ph.D. in Biomedical Engineering, specializing in Tissue Engineering
  - Product oriented research in industry or government
- Why NASA? Mission and deliverables oriented
- Internship Objectives:
  - Data Analysis
  - Poster presentation at BMES Annual Meeting
  - Publication
Background

Cardiovascular Lab

- Investigate how weightlessness affects the cardiovascular system to aid in the improvement of astronaut health, develop countermeasures, and potentially benefit other populations on Earth

- Tests: head-down tilt bed rest (HDTBR), parabolic flight, hypovolemia models, and spaceflight

My Role

- Project 1: Define the frequency and pattern of mid-ventricular obstruction in the heart during high intensity exercise in a hypovolemic state

- Project 2: Analysis of arterial mechanics during HDTBR
Arterial Mechanics

- HDTBR

Physiological deconditioning similar to space

-6° head down

Ground based

Days analyzed: BR-5, BR60, BR+3

CARDIOVASCULAR DECONDITIONING IN WEIGHTLESSNESS

Earth’s Gravity (1G)
Normal Volume

Microgravity
Volume Shifts to Chest and Head

Adaptation to Microgravity
Volume is Low and Still Shifted to Chest and Head

Return to Earth’s Gravity
Volume is Low and Now Shifts from Head to Legs
Possibility of Fainting!

Adaptation to Microgravity
Arterial Mechanics

- 3 arteries analyzed

Carotid Artery – 13 subjects (7M, 6F, mean age 35±8, weight 71±10 kg, and height 168±9 cm)

Brachial and Tibial Arteries – 11 different subjects (8M, 3F, mean age 34±9, weight 74±16 kg, and height 170±9 cm)
Arterial Mechanics Cont.

- Intima-Media Thickness (IMT)

- Mechanical Properties

  Strain  \[
  \frac{(SD-DD)}{DD}
  \]

  Distensibility Coefficient (DC)  \[
  \frac{2}{PP} \frac{SD-DD}{*DD}
  \]

  Stiffness (\(\beta\))  \[
  \ln \left( \frac{SBP}{DBP} \right) \frac{DD}{(SD-DD)}
  \]

  Pressure-Strain Elastic Modulus (PSE)  \[
  0.1333 \times PP \times \frac{DD}{(SD-DD)}
  \]
Arterial Mechanics Results

Figure 1. Carotid IMT margins were significantly thicker than the brachial and tibial IMT ($p < 0.001$). The tibial IMT decreased relative to the brachial response from BR -5 to BR 60 and BR+3 ($p < 0.05$). The tibial IMT was thinner on BR60 ($p < 0.001$) and did not recover by BR+3 ($p = 0.02$). Error bars represent 95% confidence intervals.
Figure 2. The tibial artery trended towards increased DC (p = 0.1) from BR-5 to BR+3. Error bars represent 95% confidence intervals.

Figure 3. The tibial artery trended towards decreased stiffness (p = 0.06) from BR-5 to BR+3. Error bars represent 95% confidence intervals.
Figure 4. The tibial artery trended towards smaller moduli (p = 0.1) from BR-5 to BR+3. Error bars represent 95% confidence intervals.

Figure 5. Strain margins are not significantly different between days of bed rest within vessels. Error bars represent 95% confidence intervals.
Arterial Mechanics Discussion

- Carotid, brachial, and tibial arteries react differently to HDTBR as a ground based analog of spaceflight.

- After slight variations during bed-rest, arterial mechanical properties and IMT return to pre-bed rest values. This does not appear to be true for the tibial stiffness and PSE, which continue to decrease post-bed rest while the DC increases.

- Limitations:
  - Small n value
  - Boundary determination methods
  - Small measurement differences
  - Single, non-blinded analysis
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Sources


