Analysis of Arterial Mechanics During Head-Down-Tilt Bed Rest

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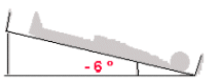
BACKGROUND

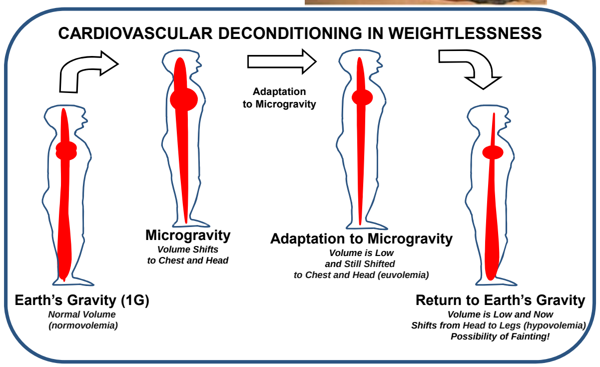
Cardiovascular Lab

- Investigate how the spaceflight environment affects the cardiovascular system to aid in the improvement of astronaut health, develop countermeasures, and potentially benefit other populations on Earth
- Models of spaceflight: head-down-tilt bed rest (HDTBR), parabolic flight, and hypovolemia
- Study objective: retrospective data analysis to understand HDTBR effects on arterial mechanics as a spaceflight analog

HDTBR

- Physiological deconditioning, specifically a fluid shift, similar to space
- -6° head down 24hrs/day for 60 days
- Ground based simulation
- Pilot data indicating carotid distensibility coefficient is lower during spaceflight similar to increased vascular age in a clinical setting





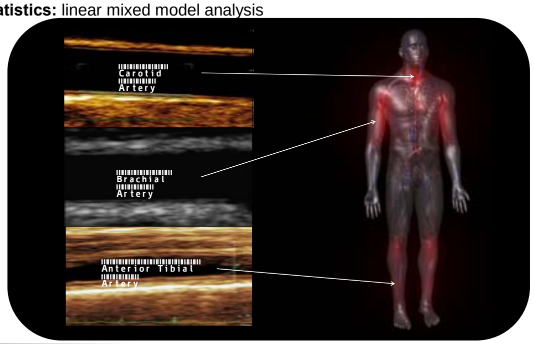
METHODS

Days analyzed: 5 days pre- (-5), after 60 days (60), 3 days post- (+3) HDTBR

3 arteries analyzed (healthy subjects):

- Carotid Artery – 13 subjects (7M, 6F, mean age 35±8, weight 71±10 kg, and height 168±9 cm)
- Brachial and Anterior Tibial Arteries – 11 different subjects (8M, 3F, mean age 34±9, weight 74±16 kg, and height 170±9 cm)

Statistics: linear mixed model analysis



HYPOTHESIS AND SPECIFIC AIMS

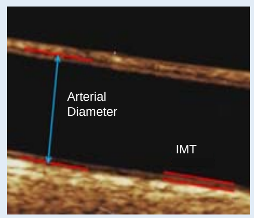
- **Hypothesis:** responses of vessels will vary with physiological location and arterial mechanics will change with days of HDTBR
- **Specific aim 1:** describe relative difference in arterial structure and function in the upper compared to lower body as the result of HDTBR
- **Specific aim 2:** define changes in arterial morphology and mechanics during HDTBR due to changing load and pressure profile

RESULTS

Morphological Analysis

Intima Media Thickness (IMT)

- Measured: arterial wall thickness (IMT), systolic diameter (SD), diastolic diameter (DD), systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse pressure (PP = SBP-DBP)



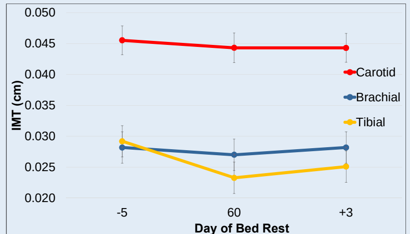


Figure 1. Carotid IMT margins were significantly thicker than the brachial and tibial IMT ($p < 0.001$). The tibial IMT decreased relative to the brachial response from BR-5 to BR60 and BR+3 ($p < 0.05$). The tibial IMT was thinned on BR60 ($p < 0.001$) and did not recover by BR+3 ($p = 0.02$). Error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

Functional Analysis

Strain (ε)

- Arterial deformation

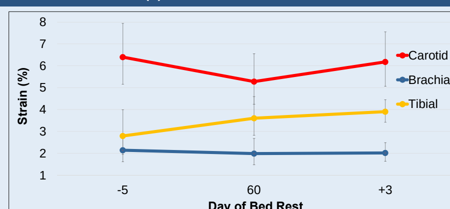


Figure 2. Strain margins are not significantly different between days of bed rest within vessels. Error bars represent 95% confidence intervals.

Pressure-Strain Elastic Modulus (PSE)

- Stress-to-strain ratio

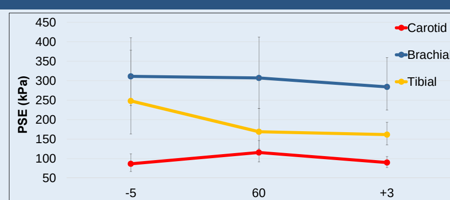


Figure 3. The tibial artery trended towards smaller moduli ($p = 0.1$) from BR-5 to BR+3. Error bars represent 95% confidence intervals.

Functional Analysis Cont.

Distensibility Coefficient (DC)

- Elasticity

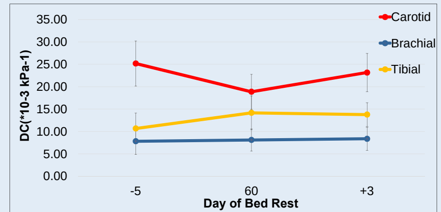


Figure 4. The tibial artery trended towards increased DC ($p = 0.1$) from BR-5 to BR+3. Error bars represent 95% confidence intervals

Stiffness (β)

- Subclinical index of atherosclerosis

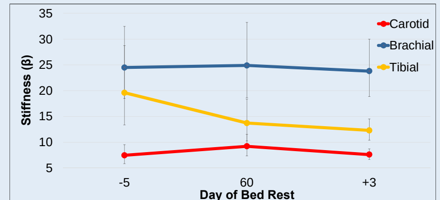


Figure 5. The tibial artery trended towards decreased stiffness ($p = 0.06$) from BR-5 to BR+3. Error bars represent 95% confidence intervals.

Discussion

- Carotid, brachial, and tibial arteries reacted differently to HDTBR. Previous studies have not analyzed the mechanical properties of the human brachial or anterior tibial arteries.
- After slight variations during bed-rest, arterial mechanical properties and IMT returned to pre-bed rest values, with the exception of tibial stiffness and PSE, which continued to be reduced post-bed rest while the DC remained elevated.
- The tibial artery remodeling was probably due to decreased pressure and volume. Resulting implications for longer duration spaceflight are unclear.
- Arterial health may be affected by microgravity, as shown by increased thoracic aorta stiffness in other ground based simulations (Aubert).

Limitations:

- Small n value
- Imprecise boundary determination methods
- Formulas sensitive to small measurement differences
- Single, non-blinded analysis

Acknowledgements

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