52.10 Thoracic Impedance as a Potential Indicator of Gz-induc Presyncope

MS Howarth[1], FB Moore[2], H Hinghofer-Szalkay[3], D Jezova[4], A Diedrich[5], MB Ferris[1], TT Schlegel[6], AR Patwardhan[1], CF Knapp[1] and JM Evans[1]

[1]Center for Biomedical Engineering, University of Kentucky; [2]NASA Ames Research Center, CA; [3]Institute of Adaptive and Spaceflight Physiology, Graz, Austria; [4]Slovak Academy of Sciences; [5]Vanderbilt University, TN; [6]NASA Johnson Space Center, TX

UNIVERSITY OF KENTUCKY
BIOMEDICAL ENGINEERING

ABSTRACT: We investigated fluid shifts and regulatory responses to variations of posture, exercise, Gz level and radius of rotation in subjects riding NASA Ames' 20G centrifuge. Results are from 4 protocols that address radius and exercise effects only. Protocol A: After 10 min supine control, 12 healthy men (35 ± 9 yr, 82.8 ± 7.9 kg) were exposed to rotational 1 Gz (2.5 m radius) for 2 min followed by 20 min alternating between 1 and 1.25 Gz. Blood samples were taken pre and post spin. Protocol B: Same as A, but lower limb exercise (70% V02max) preceded ramps to 1.25 Gz. Protocol C: Same as A but radius of rotation 8.3 m. Protocol D: Same as B but at 8.3 m. RESULTS: The 8 subjects who completed all protocols, increased heart rate (HR) from control by: A: 5, B: 39, C: 11, D: 44 bpm; and the 4 who did not: A: 6, B: 35, C: 20, D: 50 bpm. For thoracic fluid volume, (bioimpedance), the 8 subjects changed from control: A: -394, B: -548, C: -537, D: -708 mL; and the 4: A: -516, B: -652, C: -583, D: -1263 mL. The 4 subjects lost more thoracic fluid volume than the 8, especially in protocol D. A slightly greater increase in HR for the 4 compared to the 8 was not adequate to maintain cardiac output during D. Our data support the concept that thoracic impedance can detect inability to return adequate fluid to the heart, thereby predicting presyncope. *Supported by NASA EPSCoR WKU52611 and Ames Res. Center.*

BACKGROUND: Cardiovascular deconditioning is a persistent problem associated with spaceflight. Artificial gravity (AG) training has potential to provide a multi-system countermeasure to the deleterious effects of spaceflight. However, for AG to be an effective countermeasure the device must be as small as possible with time and intensity of application optimized. The purpose of this study was to conduct basic experiments to determine cardiovascular responses to changes in centrifugation parameters and to the influence of exercise. Findings from this study may serve as a guide for new experiments of artificial gravity as a countermeasure.

HYPOTHESES: As an effective countermeasure, the greater the lower body fluid pooling and resulting regulatory responses the better, of course within safe limits. Therefore, we hypothesize that fluid pooling and regulatory responses induced by long radius centrifugation will be greater than short radius centrifugation and fluid pooling and regulatory responses induced by centrifugation following bouts of exercise will be greater than centrifugation with no exercise.

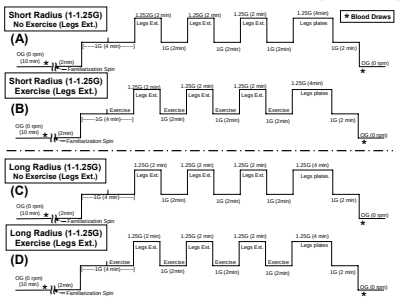
METHODS:

Subjects: 12 healthy men (age 35 ± 9 yrs, wt 82.8 ± 7.9 kg)

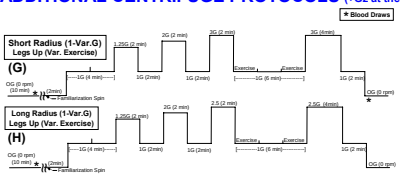
Instrumentation: 3-lead ECG (Coliln Pilot), Continuous Blood Pressure (Portapres), 4 Segment Bio-Impedance [Thorax, Abdomen, Upper Leg, Lower Leg] (UFI THRIM), Calf Circumference (Hokanson), High-fidelity 12-lead ECG (CardioSoft)

Blood Draws: Blood was drawn before and after each centrifuge run. The following blood analytes were measured: Hematocrit, Vasopressin, Plasma Renin Activity, Aldosterone, ACTH, Cortisol, Dopamine, Norepinephrine, Epinephrine, Prolactin and Growth Hormone.

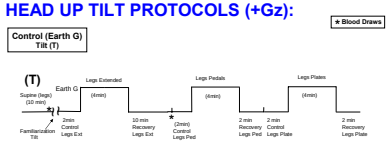
PRIMARY CENTRIFUGE PROTOCOLS (+Gz at the feet):

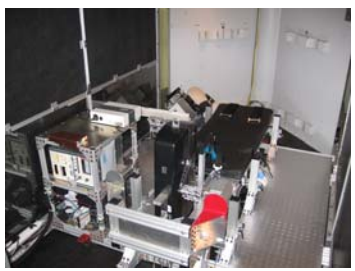


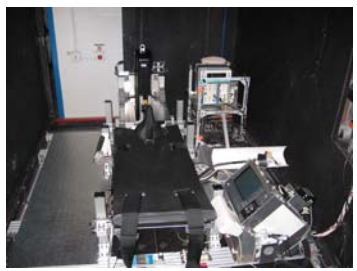
ADDITIONAL CENTRIFUGE PROTOCOLS (+Gz at the feet):



HEAD UP TILT PROTOCOLS (+Gz):

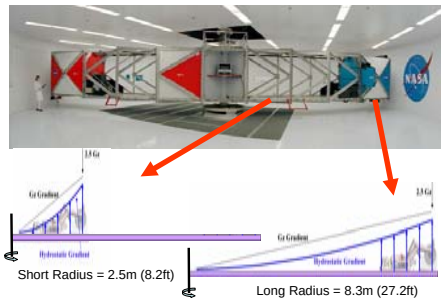






Figures: Subject bed/seat configuration on centrifuge with instrumentation racks.

AMES 20G CENTRIFUGE SHORT and LONG RADIUS +Gz GRADIENTS:



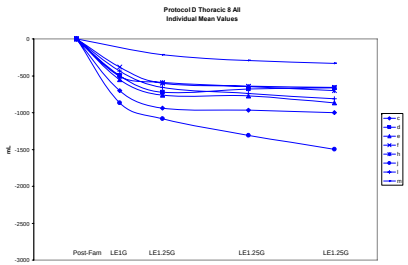
Short Radius = 2.5m (8.2ft)

Long Radius = 8.3m (27.2ft)

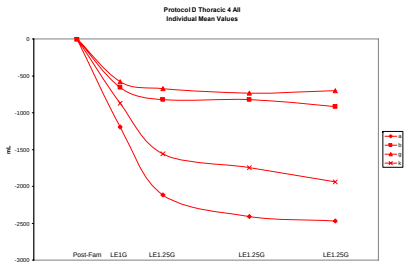
PRELIMINARY RESULTS:

Data were averaged over each segment. Results are presented from Protocols A, B, C, and D only. Eight subjects completed the full duration of all four protocols whereas four subjects did not complete protocol D. The data was separated accordingly with respect to all four protocols.

Protocol D Thorax Fluid Shift mL
8 Subjects Who Completed



Protocol D Thorax Fluid Shift mL
4 Subjects Who Did NOT Complete

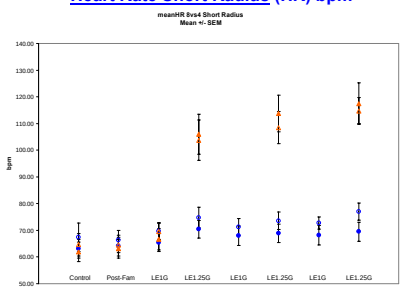


REASONS FOR ENDING PROTOCOL:

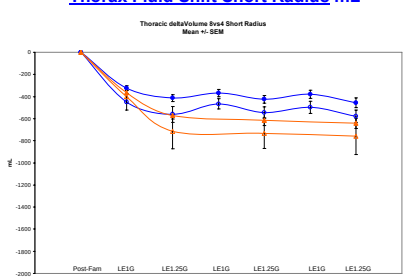
Subject a – felt signs of impending syncope, reported being close to blackout
Subject b – requested to end protocol due to exercise demands
Subject g – first protocol run after having the flu for a week or so, felt nausea
Subject k – sweaty, visual inputs changed, felt syncope coming within minutes

PRELIMINARY RESULTS cont.:

Heart Rate Short Radius (HR) bpm



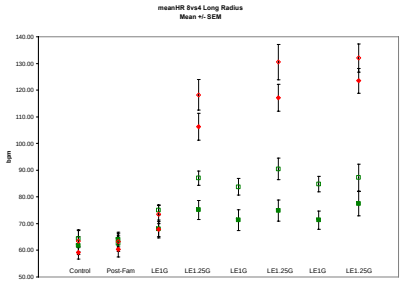
Thorax Fluid Shift Short Radius mL



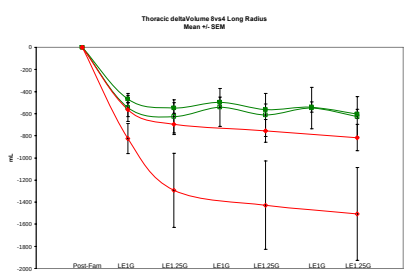
(A) Short Radius
(B) Short Radius/Exer.
(C) Long Radius
(D) Long Radius/Exer.

Solid = 8 subject
Hollow = 4 subject
LE = Legs Extended

Heart Rate Long Radius (HR) bpm



Thorax Fluid Shift Long Radius mL



PRELIMINARY CONCLUSION: Thoracic impedance shows promise as a potential indicator of Gz-induced presyncope. To accompany the larger shifts in thoracic volume were increased heart rates among the 4 subjects. In our data set, it helps show how and why some subjects exhibited classical type presyncope symptoms. Thoracic impedance may prove to be a useful measurement in medical monitoring of astronauts undergoing artificial gravity training during spaceflight.

FUTURE PERSPECTIVE: Find ways of statistically testing these findings. Also, use thoracic impedance as a measurement in future artificial gravity and orthostatic intolerance studies.

ACKNOWLEDGEMENTS: The authors would like to greatly thank the centrifuge facility support staff at NASA Ames in the conduct of the study and Helena Truszczynska (University of Kentucky) for ongoing statistical consultation. This study was supported by NASA EPSCoR WKU52611 and NASA Ames Research Center.

CORRESPONDING AUTHOR: *Mark S. Howarth – mark.howarth@uky.edu*