Examining Individual Differences in Temporal Profiles of Cardiovascular Responses to the Head Down Tilt During Fluid Loading

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Introduction

Upon returning to Earth from space flight astronauts are susceptible to orthostatic hypotension and presyncope (dizziness and fainting from standing up). The maintenance of astronaut health and safety during space flight and planetary transition is critical because of the effects altered gravity has on the human cardio-vascular system. Hypovolemia, reduced plasma volume, is a condition suspected to play a vital role in cardiovascular deconditioning following exposure to space flight, which may lead to increased peripheral resistance, attenuated arterial baroreflex, and change in cardiac function. A promising countermeasure for post-flight orthostatic intolerance is fluid loading to restore lost plasma volume by giving the crew salt tablets and water prior to re-entering the earth's atmosphere. The main purpose of this study is to define individual differences in the temporal profile of cardiac stroke volume responses to simulated 0-G conditions, 6˚ Head Down Tilt (HDT), and the effects of a fluid loading countermeasure. This project may lead to development of an impedance cardiography system used during extra vehicular activities (EVA) and planetary transitions to Lunar or Mars surfaces.

Background

A summary of the results of echocardiography data collected in space studies on Skylab, the Space Shuttle, and Russian spaceflight indicates that the lower body negative pressure stress is a fairly good sign of the cardiovascular response to entry and landing.[1] Operational impracticalities of echocardiography include the inability to take measurements while subjects are wearing EVA suits, the need for trained technician to perform the echo in addition to the crew person, and it cannot be used for continuous measurement throughout extended periods of exposure to altered gravity. The major advantages offered by impedance cardiograph are that the electrodes could easily be placed underneath an EVA suit and real-time data can be recorded for extended periods of time.

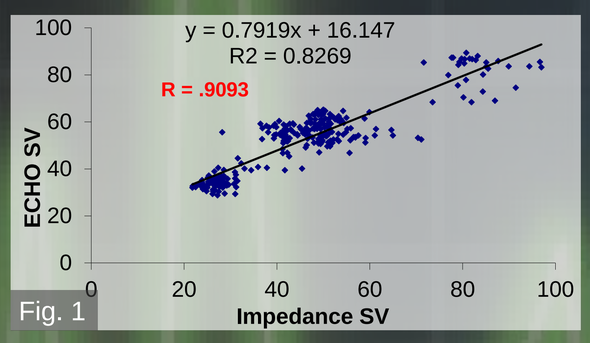


Fig. 1

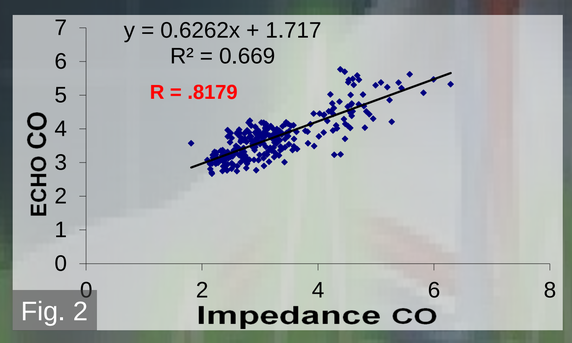


Fig. 2

Figures 1 and 2 illustrate the relatively high correlations of stroke volume and cardiac output obtained with echocardiography versus impedance cardiography.

The Psychophysiology Laboratory at Ames Research Center has extensive experience in monitoring human physiology in low gravity environments and has carried out laboratory studies of orthostatic challenge. In one study, four participants were subjected to 60˚ head up tilt and other autonomic nervous system (ANS) function tests, which included cold pressor, mental arithmetic and valsalva. Earlier studies by Cowings[2,3] successfully showed space shuttle crews and cosmonauts could learn voluntary blood pressure control in response to an orthostatic challenge (tilt table). The proposed study will include a larger sample of subjects and will include a stand test as the orthostatic challenge.

Methods

Sixteen men and women between the ages of 18 and 65 will participate in this study. Participants will be instructed to limit their dietary salt intake for 24 hours before each session (low salt = 50 - 75 mmol/24 hrs). Each participant will be evaluated during two separate 6-hour HDT tests using a hospital bed(1 test with fluid loading and 1 test without fluid loading). Order of tests will be counterbalanced. There will be a seven day interval between each of the two tests. The standard fluid loading protocol used with astronauts will be followed for this study. Before and following each HDT test, participants will be tested for orthostatic tolerance. This test will require subject to stand for a 3 minute duration. Echocardiography will be recorded while the subject is standing and at 30 minute intervals (2-minute duration) throughout the HDT tests.

Subject Weight	No. of 8 oz. Drink Containers	AND	No. of 1g Salt Tablets
< 120 lbs.	3		6
120-155	4		8
155-190	5		10
> 190 lbs.	6		12

Figure 3. Standard fluid loading protocol for astronauts will be used in this study.

Apparatus

Physiological data will be recorded using a Flexcomp encoder (Thought Technology, Inc.). This is a self-contained battery operated commercial instrument that will record electrocardiography (ECG), respiratory rate (RR), finger pulse volume (FPV), skin temperature (ST), skin conductance level (SCL), and electromyography (EMG) which measures muscle activity in the left and right forearms. The objective for this position is to simulate microgravity by inducing a fluid shift from the feet towards the upper body. Blood pressure will be monitored beat-to-beat using a noninvasive arterial tonometry (Colins Medical Instruments, model BP-508). Additional physiological measures will be impedance cardiography (I-C) and echocardiography using the Vivid Q from GE Healthcare. Urine samples will be collected before and after HDT from each participant to analyze the concentration of electrolytes and osmolarity. The HDT test will require the participant to lie in a hospital bed placed in a 6˚ HDT position for 6 hours.

Preliminary Results

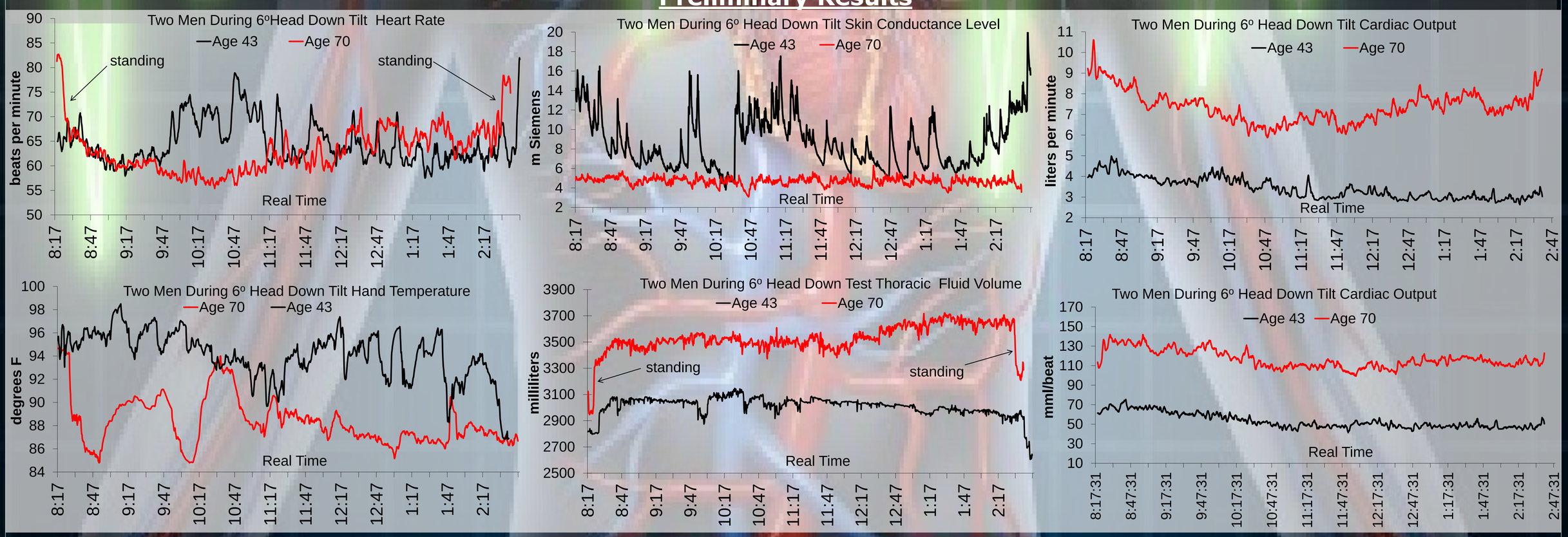


Fig.4 Individual differences of physiological responses between two men during HDT without fluid loading.

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References

1 Mcphee, Jancy C., Charles, John B., Eds. (2009). Human Health and Performance Risks of Space Exploration Missions. NASA SP-2009-3405.

2 Cowings, P.S., Toscano, W.B., Miller, N.E., Pickering, T. and Shapiro, D. (1993). Autogenic Feedback Training: A Potential Treatment for Post-Flight Orthostatic Intolerance in Aerospace Crews. J. of Clinical Pharmacology Vol. 34, (6):599-608.

3 Kornilova, L.N., Cowings. P.S., Arlaschenko, N.I., Toscano, W.B., Korneev, D.Ju., Ponomarenko, A.V., and Kozlovskaya I.B., (2000). Correction of the parameters of autonomous reactions in the organism of cosmonauts with the method of adaptive Aviaspace & Ecology Medicine (Russian journal).ISSN 0233-528X ; 66-69.