# INDIVIDUAL DIFFERENCES IN THE TEMPORAL PROFILE OF CARDIOVASCULAR RESPONSES TO HEAD DOWN TILT AND ORTHOSTATIC STRESS WITH AND WITHOUT FLUID LOADING

Patricia Cowings[1], William Toscano[1], Dionisios Kanis[2], Fiyore Gebreyesus[3]

[1]NASA Ames Research Center, Human Systems Integration Division, Moffett Field, CA

[2] San Jose State University Foundation, [3]Universities Space Research Association, NASA Ames Research Center, Moffett Field, CA

## ABSTRACT

Susceptibility of healthy astronauts to orthostatic hypotension and presyncope is exacerbated upon return from spaceflight. Hypo-volemia is suspected to play an important role in cardiovascular deconditioning following exposure to spaceflight, which may lead to increased peripheral resistance, attenuated arterial baroreflex, and changes in cardiac function. The effect of altered gravity during space flight and planetary transition on human cardiovascular function is of critical importance to maintenance of astronaut health and safety. A promising countermeasure for post-flight orthostatic intolerance is fluid loading used to restore loss fluid volume by giving crew salt tablets and water prior to re-entry. Eight men and eight women will be tested during two, 6-hour exposures to 6º HDT: 1) fluid loading, 2) no fluid loading. Before and immediately after each HDT, subjects will perform a stand test to assess their orthostatic tolerance. Physiological measures (e.g., ECG, blood pressure, peripheral blood volume) will be continuously monitored while echocardiography measures are recorded at 30-minute intervals during HDT and stand tests. Preliminary results (N=4) clearly show individual differences in responses to this countermeasure and the time course of physiological changes induced by HDT.

## BACKGROUND

Approximately 64% of all astronauts experience post-flight orthostatic hypotension ( Buckey, et al. 1996). Following 14 day flights 20% of astronauts experience presyncope, whereas the rate rises to 83% following longer duration missions of 129-190 days (Meck, et al. 2001). Six-degree head-down bed rest (HDBR) has been shown to be an analogue to spaceflight as it removes the gravity vector directed from the head to the feet and induces a similar cephalad fluid shift as seen in spaceflight (Fortney Schneider and Greenleaf 1996; Charles and Bungo 1991).

Currently, echocardiography is the only non-invasive method for measuring cardiac responses during exposure to microgravity. Thoracic impedance cardiography provides an alternative method for observing cardiac responses that can be measured continuously. If impedance measures accurately reflect changes in orthostatic tolerance then this methodology may be used to monitor crews during planetary transitions when accurate measures of cardiac function are critical. Our highest priority is to know the time course of effects of fluid and salt loading on cardiac pre-load, so that we in the future can advise the astronauts as to how long before re-entering the atmosphere is optimal.

## OBJECTIVES

1. Define the temporal profile of cardiac responses to 6º Head Down Tilt (HDT) with fluid loading and without fluid loading.
2. Examine HDT effects on orthostatic tolerance with and without fluid loading.
3. Examine individual differences (e.g., gender and age effects) to HDT and fluid loading.
4. Correlate impedance and echocardiography measures obtained during HDT and orthostatic stress tests.

## CONTACTS

Principal Investigator, Patricia Cowings

Email: patricia.s.cowings@nasa.gov

Co-Investigator, William Toscano

Email: bill.toscano@nasa.gov

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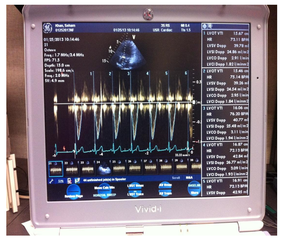
## METHODS

**Participants:** Eight men and eight women, unpaid healthy volunteers (ages of 18 and 65) will participate in this study. Each participant will be evaluated during two, 6-hour exposures to 6º Head Down Tilt (HDT): 1) fluid loading; 2) no fluid loading. Subjects will be instructed to limit their dietary salt intake to 2300 mg per day for 3 days before each HDT session. There will be a 7-day interval between each session and the test order will be counterbalanced. Subjects will be tested between 8AM and 4PM. The standard fluid loading protocol used with astronauts will be followed for this study (see table below).

| Subject Weight (lbs.) | Number of 8 oz. Water Bottles | Number of 1 gram Salt Tablets |
|---|---|---|
| <120 | 3 | 6 |
| 120-155 | 4 | 8 |
| 155-190 | 5 | 10 |
| >190 | 6 | 12 |

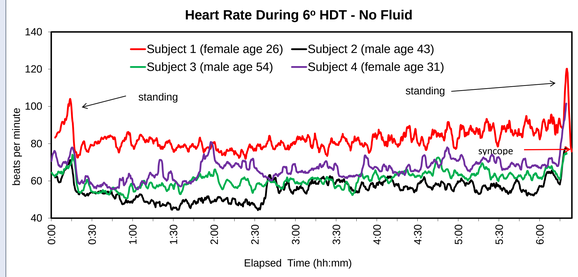
**Procedure:** 1) 10-minute sitting baseline; 2) 3-minute stand test to assess orthostatic tolerance; 3) begin 6-hour exposure to 6º HDT; 4) The calculated amount of fluid and salt will be ingested in 4 equal portions every 15 min over the first 1-hour period; 5) end 6º HDT after 6-hours ; 6) 3-minute stand test to assess changes in orthostatic tolerance. Urine sodium intake will be measured before and after each HDT test. Subjects will not be permitted to use the rest room during HDT sessions. External latex catheters will be provided for men and disposable diapers for women.

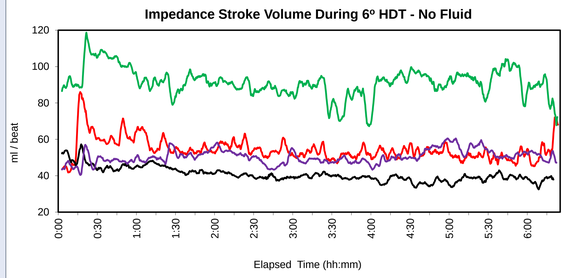
**Measures:** Echocardiography measures (stroke volume and cardiac output) will be obtained during pretest sitting baseline, each stand test, and at 30 minute intervals over the 6-hours of HDT. Each cardiac scan will be 1-minute in duration. Stroke volume is calculated as the product of the aortic artery cross sectional area and the velocity time integral of Doppler flow. Velocity time integral will be obtained using pulse Doppler of ascending aorta blood velocity at the supersternal notch.

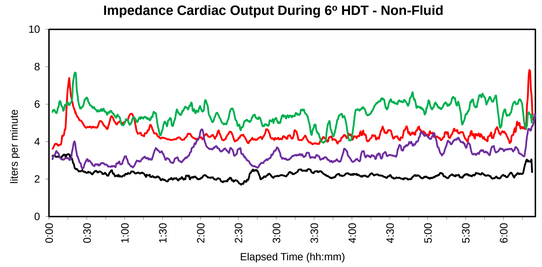


Other physiological measures will be continuously recorded. These measures include: impedance cardiography (stroke volume and cardiac output), heart rate, blood pressure , respiration rate, peripheral blood volume, electromyography, and skin conductance.

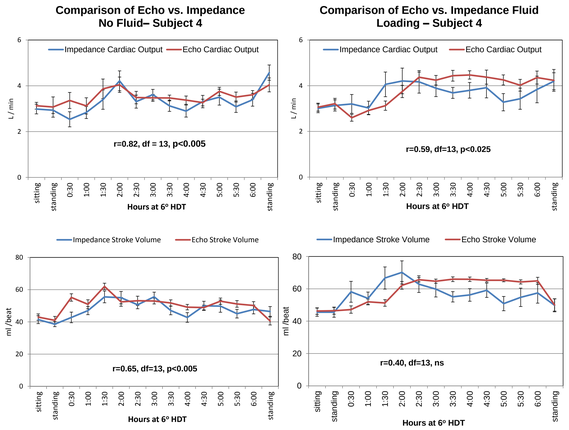
## PRELIMINARY DATA (N=4)



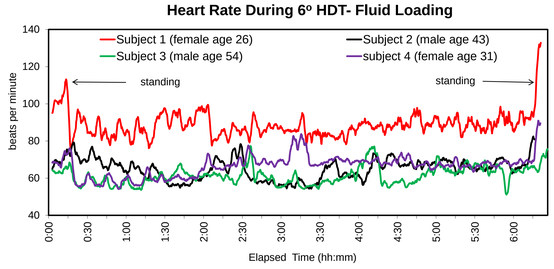



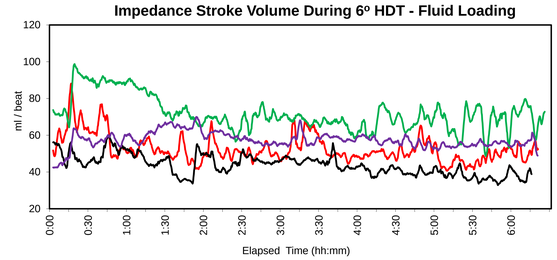

The figures above show temporal profiles for heart rate, stroke volume, and cardiac output (contiguous 15-sec means) of four subjects during a 6-hour HDT test with **no fluid loading**. Only subject 1 experienced syncope during the post HDT stand test.

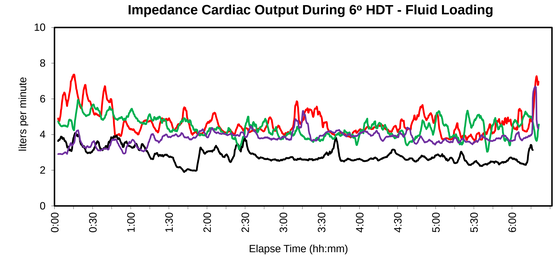



The figures above show the relationship between impedance and echo cardiography measures of stroke volume and cardiac output during the 1-minute periods when echo was scanned, across 6-hours of 6º HDT tests during conditions of No Fluid (left) and Fluid loading (right) (N=1).

## PRELIMINARY DATA (N=4)




The figures above show temporal profiles for heart rate, stroke volume, and cardiac output (contiguous 15-sec means) of four subjects during a 6-hour HDT test with **fluid loading**. Pre-syncopal symptoms were observed in subject 1 during the post HDT stand test. Subject 1 and 4 (both women) completed the 6-hour HDT test without urinating. However, subject 4 experienced some discomfort and requested to sit upright within 3 hours after fluid loading. Subjects 2 and 3 (both men) reported discomfort within 3 hours after fluid loading and requested to stand upright to urinate.

## CONCLUSIONS

These preliminary data (n=4) show large individual differences in cardiac responses to HDT and the fluid loading countermeasure. Significant correlations were observed between impedance and echocardiography measures of cardiac output during no fluid and fluid HDT conditions (n=1). Stroke volume was also significantly correlated for the two measures but only during the no fluid condition. This research is ongoing.

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