EXAMINING INDIVIDUAL DIFFERENCES IN THE TEMPORAL PROFILES OF CARDIOVASCULAR RESPONSES TO HEAD-DOWN TILT WITH AND WITHOUT FLUID LOADING: NARROWING A GAP

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Susceptibility of healthy astronauts to orthostatic hypotension and presyncope is exacerbated upon return from spaceflight. Buckey [1] reported that up to 64% of astronauts experience post-flight orthostatic hypotension. Meck [2] found that 14 day flights resulted in 20% of astronauts experiencing presyncope, whereas the rate rises to 83% following longer duration missions (129-190 days). Hypovolemia 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 lost plasma volume by giving crew salt tablets and water prior to re-entry. The primary goal of the current study was to determine the optimal time window prior to re-entry when crew would begin the fluid loading protocol. Specific Objectives: 1) to define the temporal profile of cardiovascular responses to simulated microgravity, six hour exposures to 6° Head-Down Tilt (HDT); 2) to examine gender differences in cardiovascular responses to HDT and fluid loading; and 3) to examine fluid loading effects on orthostatic tolerance and symptom mitigation following HDT. Method: Eight men and eight women, between the ages of 21 and 56, were tested during six-hour exposures to 6° HDT. Subjects were given two exposures to HDT (no fluid loading and fluid loading) where the order of tests were counterbalanced and were 7-days apart. The fluid loading protocol consisted of salt tablets and water with quantities of each determined by body weight. Subjects were instructed to limit their dietary intake of salt for 24 hours before each test (50-75 mmol.). Physiological measures were recorded continuously during pre-post stand tests (3-minutes) and during HDT tests. Measures included: heart rate (HR), skin conductance level (SCL), mean arterial pressure (MAP), peripheral blood flow (PBF) to hands and feet, total peripheral resistance (TPR), thoracic fluid volume (TFV) and both impedance and echocardiographic measures of cardiac output (CO) and stroke volume (SV). Data were analyzed with a repeated measures ANOVA with one between factor (gender), and two within factors: treatment (fluid loading vs. no fluid loading) and time (30-minute averages calculated at one hour intervals over the 6 hours of HDT for each physiological measure. Preliminary Results: A significant gender x time interaction was found only for PBF (p<0.05). The treatment x time interaction was significant for MAP, SCL, TPR (p<0.05), and TFV (p<0.001). Post-hoc comparisons revealed significant treatment effects for these responses were observed within 2-3 hours after fluid loading. Echocardiography data (SV and CO) of seven subjects were also analyzed with repeated measures ANOVA, with two within factors treatment and time: six 30-second averages calculated at one hour intervals over 6 hours of HDT). A significant treatment x time interaction was found for SV (p<0.05) and CO (p<0.01). Post-hoc comparisons revealed that SV significantly differed between conditions at hours 2, 4, 5 and 6 (p<0.05) with higher values observed during fluid loading. CO during fluid loading was significantly higher than no-fluid loading at hours 2 through 6 (p<0.05). Conclusion: Based on the findings of this study it was concluded that the gap for this countermeasure was narrowed but is not yet closed. It was determined that 2-3 hours prior to re-entry is the optimal time for fluid loading. Both SV and CO measures from echocardiography support this finding. Although echocardiography is the gold-standard for assessing cardiac function and effects of fluid loading in space, other measures are equally sensitive (MAP, SCL, TPR, and TFV). This study also demonstrated that there are significant individual differences in cardiovascular responses to HDT and to this countermeasure, specifically with regard to gender. The effectiveness of salt and fluid loading as a countermeasure for post-flight orthostatic intolerance could not be confirmed by this study as the 6 hour HDT was not long enough to simulate effects of spaceflight (i.e., hypovolemia). Only one of 18 subjects (female) experienced syncope and two reported pre-syncope during stand tests conducted after the non-fluid loading HDT condition. Russian and US research suggests that training of specific autonomic responses with instrumental learning methods may be an effective adjunct to this countermeasure [3].