PHYSIOLOGICAL MONITORING OF FLUID SHIFTS DURING ORTHOSTATIC TILT

G.E. Strangman[1], K. Marshall-Goebel[1,2], S. Moestl[3], J. Tank[3], and E.M. Bershad[4]
[1]Massachusetts General Hospital / Harvard Medical School, Charlestown, MA, [2]KBR, Houston, TX, [3]German Aerospace Center (DLR), Institute of Aerospace Medicine, Cologne, Germany, [4]Baylor College of Medicine, Department of Neurology and Center for Space Medicine, Houston, TX

BACKGROUND

While the etiology of the Spaceflight Associated Neuro-ocular Syndrome (SANS) is currently unknown, headward fluid shifts due to the removal of all gravitational vectors in space is hypothesized to be a major contributing factor. A countermeasure (CM) that can successfully redistribute body fluids similar to the upright position on Earth may thus be important for the prevention of SANS. Our SPACE-CENT Study (Studying the Physiological and Anatomical Effects of Centrifugation and Head-Down Tilt) seeks to investigate the cerebral, ocular and vestibular effects of 60-day exposure to strict 6° head-down tilt bed rest as a spaceflight analog with and without daily centrifugation.

METHODS

This study is part of the ongoing AGBRESA study at the DLR :envihab facility. As one component of our SPACE-CENT project, near-infrared spectroscopy (NIRS) derived total hemoglobin concentrations ([HbT]) from 4 body locations (head, chest, thigh, and calf) was measured before, during and after the international-standard orthostatic tilt test: tilt from supine to +80°, maintain for 15 min, then increase lower-body negative pressure (LBNP) by +10 mmHg every 3 minutes until subjects exhibit pre-syncope signs via a simultaneous drop in blood pressure and heart rate.

RESULTS

As of October 2019, the entire protocol has been completed on n=12 subjects (4 females), 5 days before bed rest onset and on R+0 following 60 days of -6° HDT bed rest. Significant shifts in [HbT]—proportional to blood volume—were observed from the head towards the feet during tilt to +80° in all subjects (Figure 1). All subjects had tests terminated sooner on R+0 (462±346 sec) than on BDC-5 (1105±464 sec), although the inter-subject variability was large (range=125-1751 sec). Interestingly, a subset of subjects (n=3) exhibited an initial increase in cerebral [HbT] at the onset of +80°, whereas the remainder showed no change or a decrease in cerebral [HbT] following tilt onset, which was predictive of longer orthostatic trials (t=2.46, p=0.022). All subjects exhibited an accelerating decrease in cerebral [HbT] that preceded test termination by 59±54 sec.

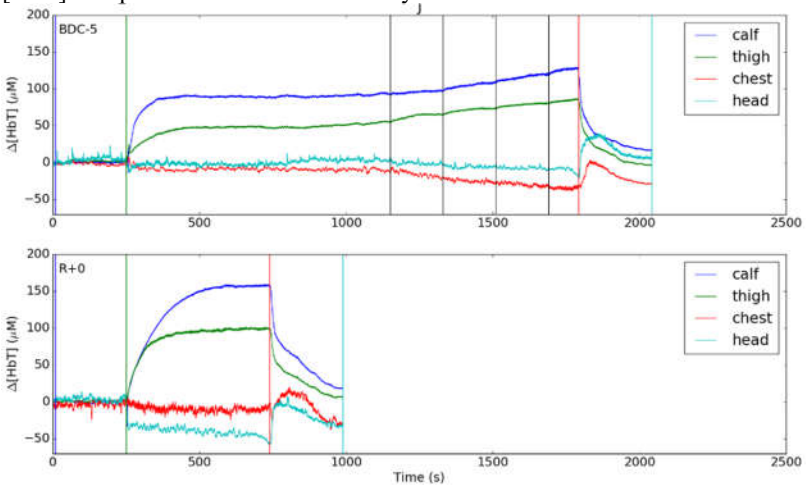

Figure 1: Changes in [HbT] in different body segments during orthostatic tolerance tilt-testing in a prototypical subject. (Top) Recording 5 days prior to bed rest (BDC-5). (Bottom) Recording in the same subject following 60 days of 6° head-down tilt (R+0). Green bar marks tilt onset, red bar indicates tilt offset, and black bars indicate onset each stage of LBNP. Note the fall in [HbT] in the head starting approximately 60 sec prior to termination of tilt.

CONCLUSIONS

This represents preliminary findings from the first campaign of the study (12 of a planned 24 subjects). As such, final conclusions are not yet possible. However, the consistency of findings across subjects suggests that NIRS-based measures of fluid shifts along the body axis—and particularly out of the head—can predict the onset of pre-syncope by up to nearly a minute. Such data could be combined with the simultaneously acquired European Space Agency measurements of blood pressure to improve predictions of orthostatic tolerance.

* Supported by NASA grant NNX17AE04G. We acknowledge DLR personnel Dr. Edwin Mulder, and technicians Insa Naendrup and Antonia Thamm for their tremendous support on this project.