COUNTERMEASURES FOR MITIGATION OF SENSORIMOTOR DECREMENTS FOLLOWING HEAD-DOWN TILT BED REST

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BACKGROUND

Astronauts experience postflight disturbances in postural and locomotor control due to sensorimotor adaptations during spaceflight. These alterations may have adverse consequences if a rapid egress is required after landing. Although exercise is partially effective for mitigating cardiovascular and muscular deconditioning, additional countermeasures are needed to further preserve sensorimotor function. Proprioception training and electrical muscle stimulation (EMS) are two promising in-flight countermeasures. Since prolonged head down tilt bed rest (HDTBR) is a spaceflight analog for body unloading and causes postural and locomotor control decrements that parallel those observed after spaceflight, it can be used to facilitate the development of these countermeasures.

METHODS

This study will determine the effects of proprioception training and EMS on functional task performance and sensorimotor function following 60 days of 6° HDTBR. Subjects will be randomly assigned to one of four groups: 1) an EMS arm, 2) a proprioception training arm, 3) an exercise plus proprioceptive training arm, and 4) a control arm. The EMS countermeasure will include daily bilateral stimulation of selected bilateral lower extremity muscles (30 minutes per session). Proprioception training will be performed three days per week (25 minutes per session) consisting of body-loaded postural tasks in the horizontal position on an air bearing sled. Exercise training will mimic current protocols used on the International Space Station, but treadmill aerobic exercise will be replaced with additional cycling aerobic exercise. Primary outcome measures will include pre- and post- HDTBR functional tests that require high demand for dynamic control of postural stability. Secondary measures will be used to explore key physiological changes that underlie countermeasure benefits. All HDTBR and data collection activities will be completed by the German Aerospace Center (DLR) at the :envihab facility. Given the constrained samples size, a Bayesian modelling approach will be used to quantify the probability that there is an effect of a given magnitude.

HARDWARE AND PROTOCOL DEVELOPMENT

Final hardware modifications and protocol developments were completed in preparation for Campaign 1, which began in September 2024. These included shipment, setup, and operator training for the transportable gravity bed, horizontal squat device, foam obstacle course, EMS devices, leg dexterity system, foot sole skin sensitivity system, and Radiofrequency Echographic Multi Spectrometry (REMS) ultrasound device. In addition, specialized protocols were developed for data collection using DLR's equipment, including muscle morphology magnetic resonance imaging (MRI), optical coherence tomography, venous blood flow MRI and ultrasound, muscle ultrasound and impedance, and skin blood flow ultrasound. We will present early data from the first campaign, which concluded in November, 2024. These will be compared with previous data from the recent 30-day HDTBR campaigns (Spaceflight associated neuro-ocular syndrome countermeasures (SANS-CM)) conducted at DLR.

RELEVANCE

The deliverable from this project will be proof-of-concept sensorimotor countermeasure designs for functional task performance with full assessment of efficacy in a spaceflight analog. If one or more countermeasures are effective, they will be translated for validation with the suite of operationally implemented in-flight countermeasures.

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