RELATIONSHIPS BETWEEN VESTIBULAR MEASURES AS POTENTIAL PREDICTORS FOR SPACEFLIGHT SENSORIMOTOR ADAPTATION

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INTRODUCTION

During space exploration missions astronauts are exposed to a series of novel sensorimotor environments, requiring sensorimotor adaptation. Until adaptation is complete, sensorimotor decrements occur, affecting critical tasks such as piloted landing or docking. Of particularly interest are locomotion tasks such as emergency vehicle egress or extra-vehicular activity. While nearly all astronauts eventually adapt sufficiently, it appears there are substantial individual differences in how quickly and effectively this adaptation occurs. These individual differences in capacity for sensorimotor adaptation are poorly understood. Broadly, we aim to identify measures that may serve as pre-flight predictors of and individual's adaptation capacity to spaceflight-induced sensorimotor changes. As a first step, since spaceflight is thought to involve a reinterpretation of graviceptor cues (e.g. otolith cues from the vestibular system) we investigate the relationships between various measures of vestibular function in humans.

METHODS

In a set of 15 ground-based control subjects, we quantified individual differences in vestibular function using three measures: 1) ocular vestibular evoked myogenic potential (oVEMP), 2) computerized dynamic posturography and 3) vestibular perceptual thresholds. oVEMP responses are elicited using a mechanical stimuli approach. Computerized dynamic posturography was used to quantify Sensory Organization Tests (SOTs), including SOT5M which involved performing pitching head movements while balancing on a sway-reference support surface with eyes closed.

We implemented a vestibular perceptual threshold task using the tilt capabilities of the Tilt-Translation Sled (TTS) at JSC. On each trial, the subject was passively roll tilted left ear down or right ear down in the dark and verbally provided a forced-choice response regarding which direction they felt tilted. The motion profile was a single-cycle sinusoid of angular acceleration with a duration of 5 seconds (frequency of 0.2 Hz), which was selected as it requires sensory integration of otolith and semicircular canal cues. Stimuli direction was randomized and magnitude was determined using an adaptive sampling procedure. One hundred trials were provided and each subject's responses were fit with a psychometric curve to estimate the subject's threshold.

RESULTS

Roll tilt perceptual thresholds at 0.2 Hz ranged from 0.5 degrees to 1.82 degrees across the 15 subjects (geometric mean of 1.04 degrees), consistent with previous studies. The inter-individual variability in thresholds may be able to help explain individual differences observed in sensorimotor adaptation to spaceflight. Analysis is ongoing for the oVEMPS and computerized dynamic posturography to identify relationships between the various vestibular measures.

DISCUSSION

Predicting individual differences in sensorimotor adaptation is critical both for the development of personalized countermeasures and mission planning. Here we aim to develop a basis of vestibular tests and parameters which may serve as predictors of individual differences in sensorimotor adaptability through studying the relationship between these measures.

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