Sensorimotor Predictors of Post-Landing Functional Task Performance

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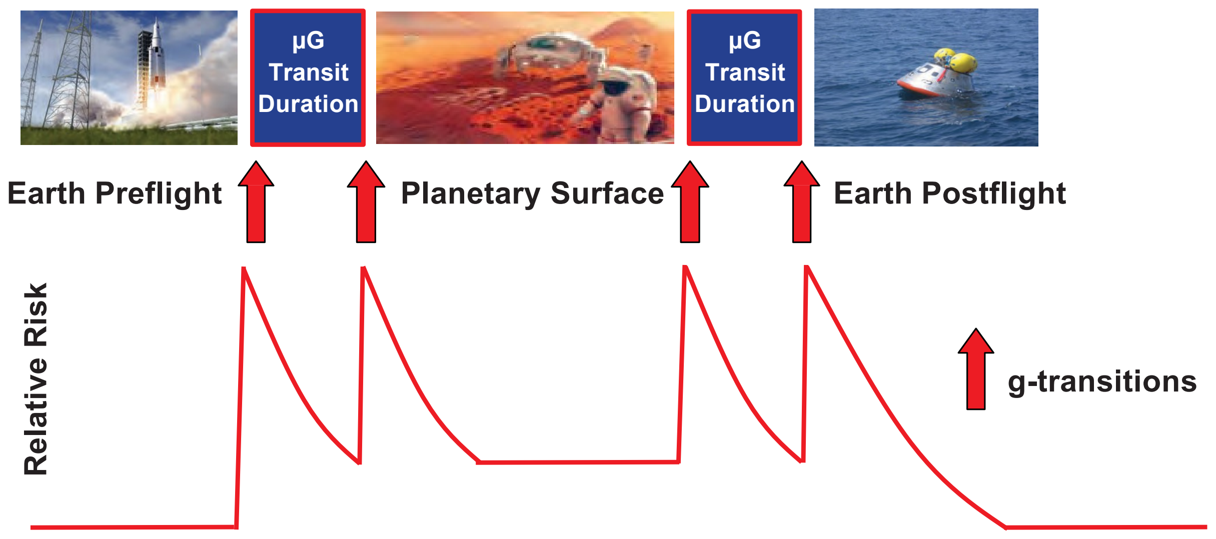
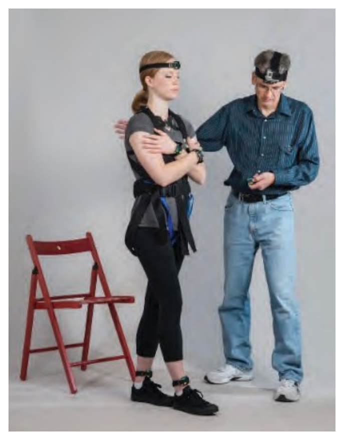
Background

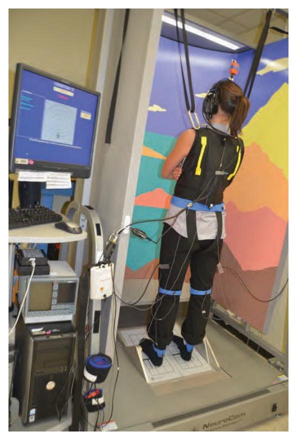
Spaceflight drives adaptive changes in healthy individuals appropriate for sensorimotor function in a microgravity environment. These changes are maladaptive for return to earth's gravity. The inter-individual variability of sensorimotor decrements is striking, although poorly understood. The goal of this study is to identify a set of behavioral, neuroimaging and genetic measures that can potentially be used to predict early performance following G-transitions such as return to Earth on a set of sensorimotor tasks. Astronauts are being recruited who previously participated in sensorimotor field tests and/or dynamic posturography (MedB) within R+1 days following long-duration spaceflight.

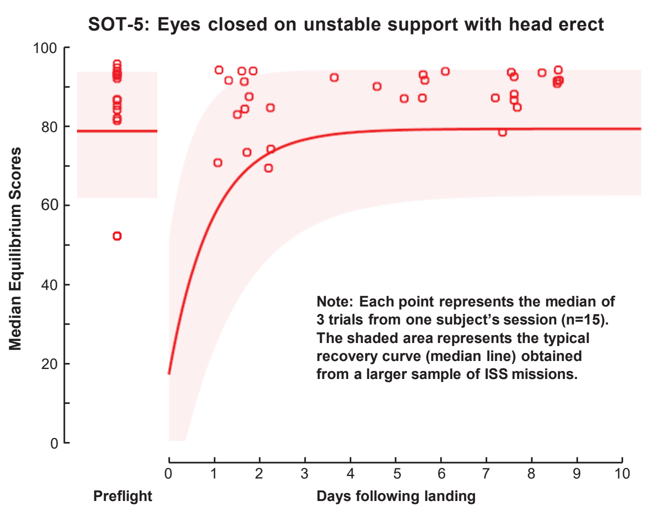


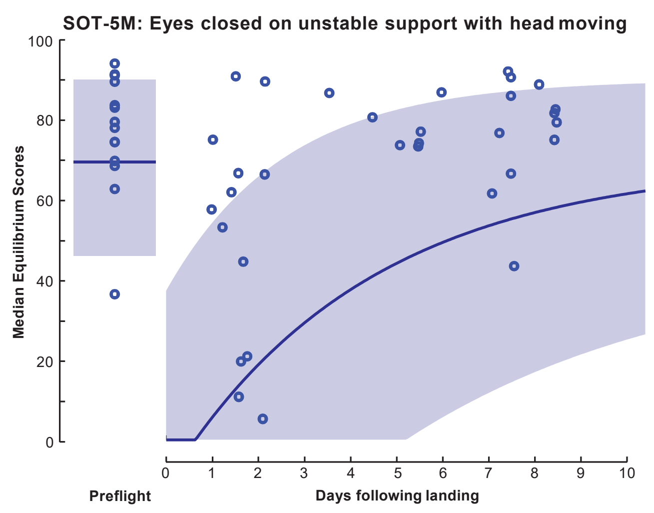
Spaceflight Measures

Building on the previous Predictors study (PI Mulavara), 15 ISS crewmembers have been tested to date. We will be utilizing a combination of three post-flight functional task outcomes: tandem walk, recovery from fall and dynamic posturography.

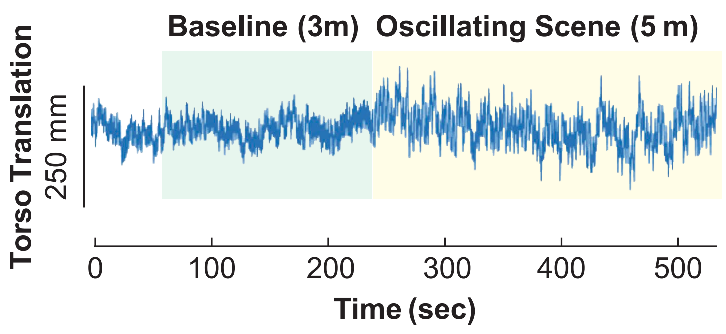




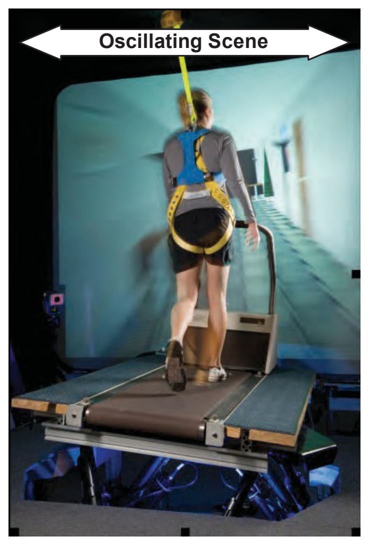


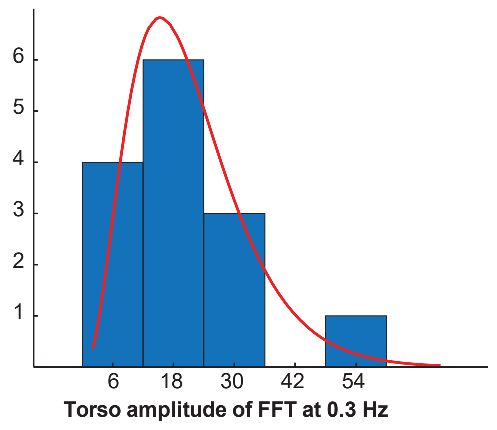


Although the posturography measures were obtained >24 hrs after landing, performance with eyes closed on an unstable support (SOT5), especially during head movements (SOT-5M), reflect the typical individual variability in performance. These objectives measures will be supplemented with motion sickness and subjective ratings of adaptation, both during early inflight and post-flight phases and across subsequent missions.

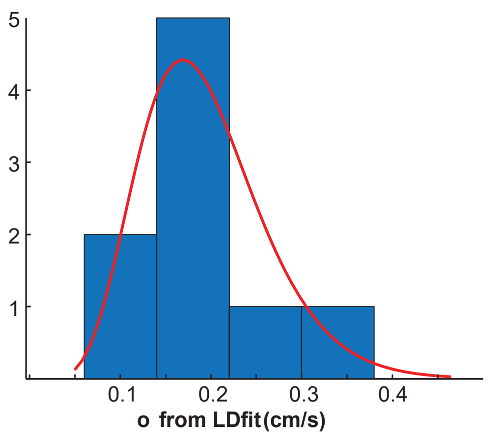


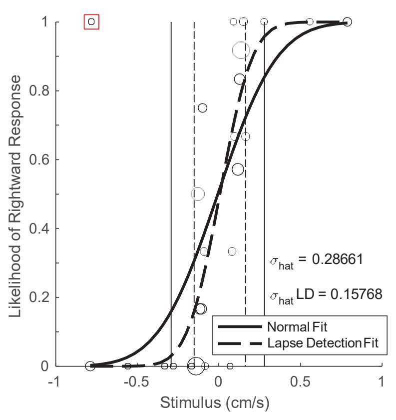
Sensitivity to **visual** motion is measured during treadmill walking while viewing a moving virtual visual scene. The dependent variable is lateral torso translation during scene oscillation.



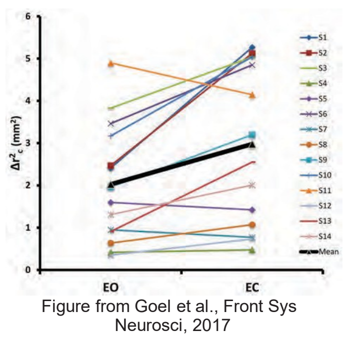


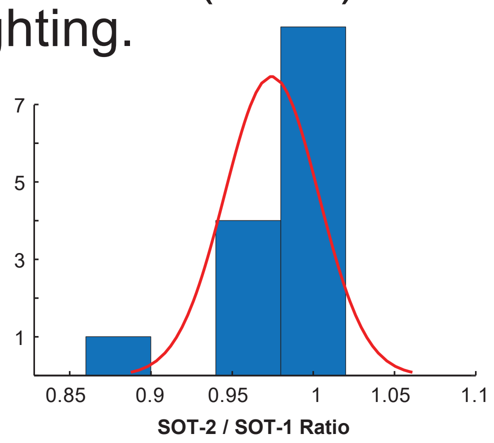
Vestibular sensitivity involves a perceptual direction-recognition task while seated with eyes closed during lateral translations. The dependent variables are derived from psychometric curve fit (see sample below).





The ability to balance using **proprioception** is assessed by monitoring medial-lateral COP during one-legged stance on a horizontal air-bearing surface (Goel, et al., 2017). Given one of the limitations of this study is the time from the participants spaceflights, we are exploring measures from their preflight posturography Sensory Organization Tests (SOTs) as additional markers of sensory weighting.



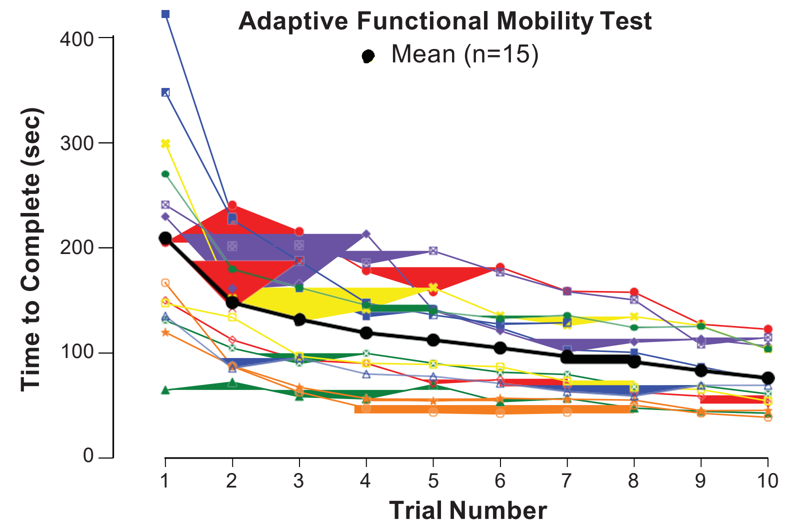


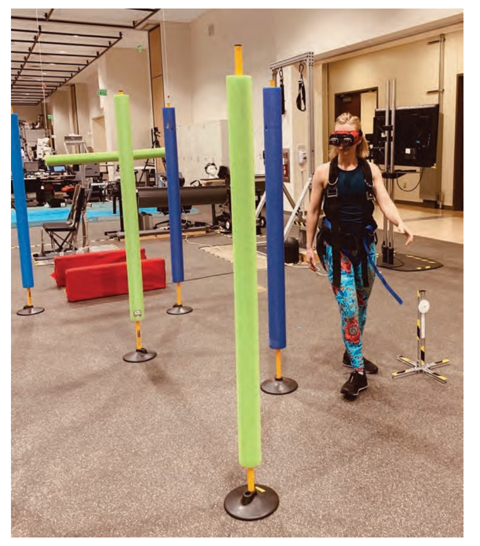
Neuroimaging

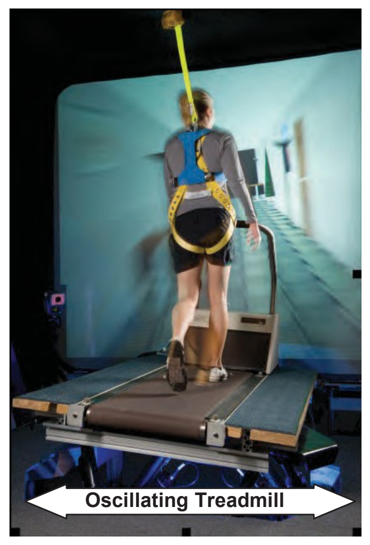
The neuroimaging tests will characterize individual differences in regional brain volumes (e.g., cerebellu volume) using Structural MRI and white matter microstructure (using Diffusion Tensor Imaging) to serve as potential predictors of adaptive capacity. These images will be primarily obtained from preflight medical testing associated with the same missions as the postflight sensorimotor tests.

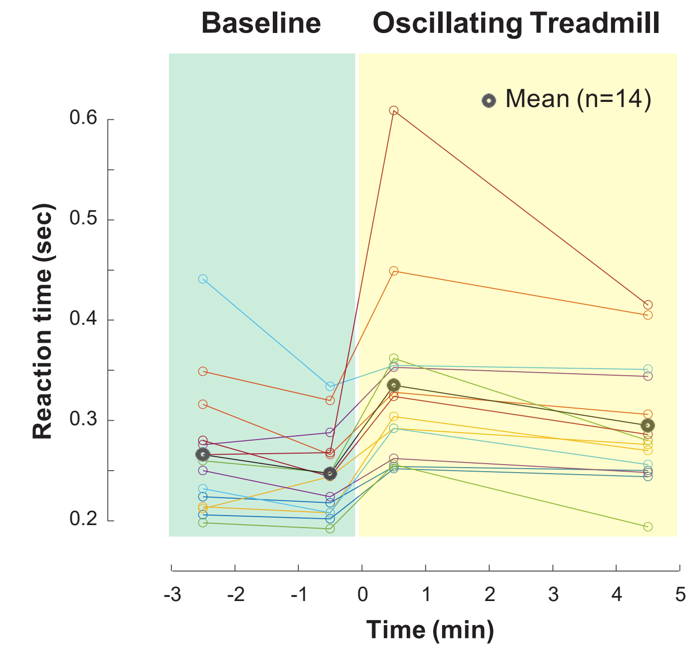
Adaptability

Ground assessment of adaptability is assessed with (1) time to complete multiple trials of navigating an obstacle course while wearing up/down reversing prisms, and (2) changes in stride frequency and reaction time to an auditory cue while walking with a virtual linear hallway on an oscillating treadmill.









Genetics

Our genetic tests utilize saliva samples to examine variations in four genes chosen because of their ability to differentiate sensorimotor adaptation ability in a normative population (Seidler et al, Front Syst Neurosci, 2015).

Catechol-O-methyltransferase (COMT) & Dopamine Receptor D2 (DRD2): polymorphisms associated with dopamine availability in the prefrontal cortex and corticostriatal circuits, and with rate of adaptation (Noohi et al., 2013)
Brain-derived neurotrophic factor (BDNF): polymorphism associated with visuomotor adaptive processes including adaptation& retention (Joundi et al., 2012)
α2-adrenergic receptor: polymorphism correlated with increased autonomic responsiveness to motion sickness stressors (Finley et al., 2004)

Forward Work

The statistical data analysis will consist of estimating models that can use combinations of behavioral metrics, brain structure metrics and genomic polymorphisms to predict individual decrements in these post-flight functional task outcomes. We expect that understanding the relationships between these sensorimotor biomarkers and post-flight functional task performance will improve both our understanding of the individual variability and our strategy to optimize sensorimotor countermeasures.

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