Fiscal Year:	FY 2022	**Task Last Updated:**	FY 09/16/2021
PI Name:	Wood, Scott J. Ph.D.		
Project Title:	Sensorimotor Predictors of Postlanding Functional Task Performance		
Division Name:	Human Research		
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Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Sensorimotor**:Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:	NOTE: PI returned to NASA JSC in January 2017. PI was at Azusa Pacific University from August 2013 – January 2017; prior to August 2013, PI was at NASA JSC.		
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No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
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No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 9/30/2023 per PI (Ed., 7/7/21)		
Key Personnel Changes/Previous PI:	September 2021 report: None.		
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Task Description:	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 be used to predict early post-flight performance on a set of sensorimotor tasks. Astronauts are being recruited who previously participated in sensorimotor field tests and/or posturography within R+1 days following long-duration spaceflight. Behavioral tests include assessments of sensory dependency and adaptability. Visual dependency involves treadmill walking while viewing a moving virtual visual scene. Vestibular sensitivity is measured while seated with eyes closed during lateral translations. Proprioception dependency is measured during one-legged stance with eyes closed on a horizontal air-bearing surface. Ground assessment of adaptability is performed (1) during treadmill walking with a virtual linear hallway and a moving walking surface, and (2) during multiple trials of navigating an obstacle course while wearing reversing prisms. The neuroimaging tests will characterize individual differences in regional brain volumes (using Structural MRI) and white matter microstructure (using Diffusion Tensor Imaging) to serve as potential predictors of adaptive capacity. The genetic tests will utilize saliva samples to examine variations in four genes chosen because of their ability to differentiate sensorimotor adaptation ability in a normative population, including Catechol-O-methyltransferase (COMT), Dopamine Receptor D2 (DRD2), Brain-derived neurotrophic factor (BDNF), and the a2-adrenergic receptor. This study will utilize data (n=6 astronauts) from a previous Predictors study (Principal Investigator (PI) Mulavara, National Space Biomedical Research Institute (NSBRI) grant NCC 9-58-SA03801). Deliverables: Statistical models will use combinations of behavioral metrics, brain structure metrics, and genomic polymorphisms to understand individual decrements in 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. Study Participants: This study will target recruitment of up to 30 astronauts who previously flew on the International Space Station (ISS), including 6 obtained via the original Predictors study. Risk Characterization, Quantification, Evidence: This project was directed toward the Sensorimotor gap SM24 [Integrated Research Plan (IRP) Rev F): Determine if the individual capacity to produce adaptive change (rate and extent) in sensorimotor function to transitions in gravitational environments can be predicted with preflight tests of sensorimotor adaptability.] [Ed. note October 2021: Gaps have since change; see Human Research Roadmap https://] Countermeasure, Prototype Hardware, or Software: The information derived from this study may be applied towards optimizing countermeasures based on preflight tests of sensorimotor biomarkers.
Rationale for HRP Directed Research:	The proposed works qualifies for directed research under the "Highly Constrained Research" category in the Human Research Program (HRP) Unique Processes, Criteria, and Guidelines. This project will utilize the findings from two previous studies (SM Predictors-Ground, SM Predictors-Retrospective) that were funded by the NASA Human Research Program (HRP) through a National Space Biomedical Research Institute (NSBRI) cooperative agreement. These studies have validated, in a non-astronaut ground population, a unique set of measures that were predictive of adaptation in response to exposure to novel sensorimotor environments. Predictors were evaluated in three categories, including: 1) behavioral tests to assess sensory bias and adaptability; 2) imaging to determine individual brain morphological and functional features; and 3) genotype markers for genetic polymorphisms that play a role in the neural pathways underlying sensorimotor adaptation. These two studies were conducted to help characterize the sensorimotor risk profile and design sensorimotor adaptability training countermeasures that may be customized for each crewmember's individual characteristics. In addition to collecting data from ground subjects, the SM Predictors-Retrospective study gathered data from six crewmembers, and from three subjects who participated in a bed rest campaign in the past. While these data supported the validity of the tested measures, the small number of subjects in this part of the study limited the interpretation of the collected data, and logistical challenges (namely, the end of the NSBRI cooperative agreement) precluded recruiting additional astronaut subjects until now. Meeting HRP's goal of addressing gap SM 24 requires collection of data from additional crewmembers who fit the recruitment criteria for this study (crewmembers for whom functional task performance data sets exists after previous spaceflight missions). This proposed effort will thus build-upon the findings from the previous studies, with the full data set (from both the prior study and the proposed one) used to build predictive models of postflight functional task performance capabilities. Since this study directly builds upon the two prior studies and data needs to be collected seamlessly, it requires the specific expertise that has been developed within the NASA Johnson Space Center Neurosciences Laboratory. Therefore, the work reflects "focused and constrained data gathering and analysis that is more appropriately obtained through a non-competitive proposal."
Research Impact/Earth Benefits:	The goal of this study is to identify a set of behavioral, neuroimaging, and genetic measures that can be used to better understand the inter-subject variability in early post-flight performance on a set of sensorimotor tasks. We expect that understanding the relationships between biomarkers and post-flight functional task performance will improve our strategy to optimize sensorimotor countermeasures. These same biomarkers may also be useful for understanding individual variability in balance function in the general population, and predicting sensory compensation associated with aging and/or the onset of vestibular disease.
	A total of 15 of 30 long duration astronauts have participated in this study to date. Testing has been on hold for most of this past year due to COVID travel restrictions. During this timeframe, we have focused our efforts in three main areas. (1) To supplement our quantitative post-flight outcome measures, a new survey was added to capture participant's subjective self-rating of how severely their adaptation impacted their ability to perform functional tasks and how long it took to adapt (recover) so that they were no longer restricting movement (both early inflight and postflight). This survey will be completed retrospectively for previous participants using a Qualtrics link and will be obtained prospectively for future participants. (2) Dr. Koppelmans (University of Utah) has performed additional neuro-imaging processing using a new myelin mapping pipeline to augment the prior Diffusion Tensor Imaging analyses. It was determined that a software upgrade at the Victory Lakes imaging facility during the middle of the testing timeframe required a correction step that may limit the utility of this pipeline.

Task Progress:	(3) The six degree-of-freedom platform that is used for some of the sensory dependency and adaptability tests has been upgraded (MOOG model 130 to model 170). This changeout allowed upgrades to the software (unsupported DOS to Windows based), increased payload rating, and improved the emergency stop functionality. The LabView code for stimulus control and data acquisition was also upgraded. Participant recruitment was recently resumed for the study and Qualtrics survey data collection on the existing 15 participants is ongoing. Preliminary results (presented at the February Investigator Workshop-IWS): The 15 participants to date include 13M/2F and 9 veterans/6 first time flyers. The behavioral and genetic measures have been obtained an average of 3.4 years following the last mission (range 0.5 – 14.1 yr). Post-flight Outcome Measures: Posturography data is available for all 15 participants. Field testing (recovery from fall and tandem walk) are available for 14 of 15 subjects. Of the two posture conditions (Sensory Organization Test (SOT) 5 and 5M)), trials requiring head movements with eyes closed on a sway-referenced (unstable) surface resulted in more variable responses. A ratio score (post-flight performance / pre-flight performance) was calculated, with a ratio of 1.0 being representing recovery to preflight baseline levels. The range of SOT-5 (head erect) ratios was 0.57-1.09 while the range of SOT-5M (head moving) was 0.08-1.07. Thus, the SOT-5M ratio scores are preferred to understand the variability in performance given the timeframe of these measures (>R+24hrs). Ratios for both recovery from fall and tandem walk were highly correlated across the three landing day test sessions (R0a medical tent/airport, R0b refueling stop, R0c JSC-Johnson Space Center). Since there were additional missing data from the R+0a and R0b sessions, the R0c session data was used for this preliminary analysis. The range of ratios for the recovery from fall was 0.32-1.24 and for tandem walk was 0.00-0.61. Given the differences in recovery time constants, and differences in what sensorimotor functions they are designed to reflect (e.g., eyes open versus eyes closed), it is not surprising that the ratio scores for this limited sample set were not correlated. Sensory Dependency Measures: Sensitivity to visual motion was measured during treadmill walking while viewing a moving (virtual hallway) visual scene. The dependent variable was lateral torso translation during scene oscillation (amplitude at 0.3 Hz scene motion). Higher visual dependency appears related with lower recovery on tandem walk eyes closed (rho = -0.47). Vestibular sensitivity involves a perceptual direction-recognition task while seated with eyes closed during lateral translations. The dependent variables (threshold and bias) were derived from psychometric curve fit. Although data was only available for 9 subjects for this task, preliminary analysis suggests higher vestibular sensitivity was correlated with higher recovery on SOT-5M (rho = -0.71, p=0.03). The ability to balance using proprioception is assessed by monitoring medial-lateral center of pressure (COP) during one-legged stance on a horizontal air-bearing surface (eyes open & eyes closed). Measures include both range and root mean square (RMS) center of pressure (COP) although medial-lateral and anterior-posterior directions from the force plate. The resultant COP Range varied between 20 – 150 mm with eyes closed. Sensory Adaptability Measures: The Adaptive Functional Mobility Test (AFMT) measured the time to complete navigating an obstacle course while wearing up/down reversing prisms (10 trials). While the performance continued to improve on average throughout the 10 trials, the variability in performance was greatest during the first trial (range 65 – 422 sec to complete the course). Slower AFMT times were significantly correlated with lower recovery on tandem walk eyes closed (n=14, rho = -0.62, p=0.02). Adaptability is also being assessed with the Treadmill Sensory Discordance Test. Changes in both stride frequency and reaction time to an auditory cue while walking with a virtual linear hallway on an oscillating treadmill are recorded after 1 and 4 min of walking on the oscillating treadmill. Neuroimaging measures: Individual differences in regional brain volumes (using Structural MRI) and white matter microstructure (using Diffusion Tensor Imaging) are analyzed as potential predictors of adaptive capacity. Based on our preliminary analysis, differences in cerebellar volume Lobule VI (involved in sensorimotor adaptation) appears positively correlated with higher post-flight scores on SOT-5M (p=.044, eta2=.35) and higher recovery ratios on RFF prone-to-stand test (left: p=<.001, eta2=.75). Genetic measures: Variations in four genes have been analyzed from saliva samples, including Catechol-O-methyltransferase (COMT), Dopamine Receptor D2 (DRD2), Brain-derived neurotrophic factor (BDNF), and the a2-adrenergic receptor. The distribution of the different alleles were within expected range. There does not appear to a clear pattern of alleles in any of the four genes that predict post-flight performance. Summary of Preliminary Findings: There is considerable variability among the post-flight performance outcomes for the 15 participants to date. While there is a strong association within tests obtained at different R+0 timepoints, by R+24 hr performance on one post-flight test does not necessarily correlate with performance on other post-flight tests. There are apparent relationships between individual measures and specific post-flight outcome measures; however, additional data is needed to draw conclusions. Preliminary statistical analysis indicates combining biomarkers will increase predictive power and this will be explored with future analyses.
Bibliography Type:	Description: (Last Updated: 03/08/2024)
Abstracts for Journals and Proceedings	Wood SJ, De Dios YE, Peters BT, Beltran NE, Caldwell EE, Rosenberg MJ, Koppelmans V, Clark TK, Seidler RD, Oddsson L, Theriot CA, Reschke MF, Feiveson AF, Bloomberg JJ. "The Relationship between Behavioral, Neuroimaging and Genetic Measures and Post-Landing Sensorimotor Functional Task Performance." 2021 NASA Human Research Program Investigators' Workshop, Virtual, February 1-4, 2021. Abstracts. 2021 NASA Human Research Program Investigators' Workshop, Virtual, February 1-4, 2021. , Feb-2021
Abstracts for Journals and Proceedings	Wood SJ. "Sensorimotor Functional Task Performance Measures Following G-Transitions." Society for Brain Mapping and Therapeutics (SBMT) Neuro-Oncology Conference, Virtual, July 9, 2021. Abstracts. Society for Brain Mapping and Therapeutics (SBMT) Neuro-Oncology Conference, Virtual, July 9, 2021. , Jul-2021