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Project Title:	Functional Task Tests in Partial Gravity during Parabolic Flight		
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Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
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Human Research Program Risks:	(1) **Sensorimotor**:Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
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Space Biology Special Category:	None		
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Zip Code:	77058-3711	**Congressional District:**	36
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Flight Assignment:	NOTE: End date changed to 12/31/2022 per PI; original end date was 9/30/2021 (Ed., 5/3/21)		
Key Personnel Changes/Previous PI:	May 2022 report: Gilles R. Clément, PhD, Principal Investigator, KBR, NASA Johnson Space Center, Houston TX; Marissa J. Rosenberg, PhD, Co-Investigator, KBR, NASA Johnson Space Center, Houston TX; Timothy Macaulay, PhD, Co-Investigator, KBR, NASA Johnson Space Center, Houston TX; Scott Wood, PhD, Co-Investigator, NASA Johnson Space Center, Houston TX. Millard Reschke, Ph.D. has retired from NASA and has left the project.		
COI Name (Institution):	Rosenberg, Marissa Ph.D. (KBR/NASA Johnson Space Center) Macaulay, Timothy Ph.D. (KBR/NASA Johnson Space Center) Wood, Scott Ph.D. (NASA Johnson Space Center)		
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Task Description:

Critical mission tasks that are required by crews immediately after landing on a planetary surface are seat egress, jump, and walk. To be able to define an effective and comprehensive countermeasure strategy for preserving crew performance during exploration-class missions, there is a need to understand how these functional tasks are performed in partial gravity such as on the Moon or Mars.
We will analyze the execution of four critical mission tasks (Seat Egress and Walk, Recovery from Fall and Stand, Jump Down, Tandem Stance) during the partial gravity and normal gravity phases of parabolic flight by using the same equipment and procedures than those previously used on astronauts returning from International Space Station (ISS) missions and ground-based subjects during axial body unloading. Our hypothesis is that the limits of stability for these activities get larger when the gravity level is reduced. The largest decreases in performance are expected at the lowest gravity level (0.25 g) because subjects will no longer be able to use the gravitational reference for their perception of upright. Ultimately, this information could be used to assess performance risks and inform the design of countermeasures for NASA exploration-class human missions.

The four specific aims include:

Specific Aim 1: Seat Egress and Walk. The purpose of this test is to measure the ability to rise from a seated position and walk while avoiding obstacles to test mobility. This test is identical to the Sit-to-Stand and Walk-&-Turn test used for Standard Measures after spaceflight and bed rest. In this test, subjects are requested to rise from a seated position as quickly as possible without using their hands and walk as quickly and safely as possible straight ahead towards a cone (4 m distance), walk around the cone, then return and sit back down in the chair. On the way to and back from the cone, subjects step over a 30-cm obstacle. Two trials will be performed per parabola. A video camera records each trial and body motion (head and torso) is recorded from triaxial inertial measurement units. Performance during this test include times to complete the trial, turn rate during the turn, obstacle contact, and head-torso coordination.

Specific Aim 2: Tandem Stance. The Tandem Stance test is a standard test of static postural stability. This test is similar to the computerized dynamic posturography (CDP) test performed on astronauts as part of their Medical Requirements and on bed rest subjects as part of the Human Research Program (HRP) standard measures (Postural Equilibrium Control). In this test, at the sound of a tone subjects are instructed to stand upright in a heel-to-toe fashion with their arms crossed on their chest. This test is performed with the eyes open and with the eyes closed. A video camera records each trial and body motion (head and torso) is recorded from triaxial inertial measurement units. The maximum time (prior to taking a step) as well as the medial-lateral peak-to-peak sway angle (p-p sway) is used quantify postural stability.

Specific Aim 3: Recovery from Fall and Stand. The purpose of this test is to measure the ability to maintain postural control after standing up from a prone position. Impairment in the ability to rise from a prone position is one of the strongest independent risk factors associated with serious fall-related injuries. In this test, subjects rest in a prone position, then stand up as quickly as possible and maintain a quiet standing position. A video camera records each trial and body motion (head and torso) is recorded from triaxial inertial measurement units. The anterior-posterior and medial-lateral peak-to-peak sway angle (p-p sway) is used to compute the equilibrium score, where 12.5 is the maximum theoretical p-p sway. This test also induces an orthostatic challenge. Therefore, heart rate is collected continuously throughout this test. This cardiovascular data is used to detect potential signs of orthostatic intolerance during this active head-up tilt test.

Specific Aim 4: Jump Down. In the Jump Down test, at the sound of a tone subjects perform a two-footed hop from a height of 30 cm onto a force plate that measures the ground reaction forces on landing. After landing, subjects are instructed to remain still on the force plate, in the standing position, with arms at their sides for 10 s. After 10 s, subjects will also perform a maximal voluntary lean in one direction to quantify changes in the limits of stability at different g-levels. Two jump down trials will be performed per parabola. A video camera records each trial and body motion (head and torso) is recorded from triaxial inertial measurement units.

Study Participants. Twelve subjects (6 male, 6 female) will be tested during 3 flights of 30 parabolas, including 10 parabolas at 0.25 g, 10 parabolas at 0.5 g, and 10 parabolas at 0.75 g. In addition, each subject will perform all the functional task tests in 1 g during the flight between parabolas when the aircraft flies straight and level.

Risk Characterization, Quantification\Evidence. This task will contribute to gap closure by providing information regarding any changes in functional task performance deficits in partial gravity. The dose-response relationship between gravity level and task performance decrement will also help determining the gravity threshold for these functional tasks. These functional task tests are selected to simulate critical mission tasks that crewmembers may be required to perform when they land on another planet with partial gravity.

Countermeasure\Prototype Hardware or Software. This task will contribute to gap closure by determining the gravity threshold for these functional tasks.

Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

The functional tasks tests in the proposed study will challenge balance control, a function that is paramount to the efficient completion of critical mission tasks. The vestibular and sensorimotor systems are playing a fundamental role in balance control, and the functioning of these systems is altered during parabolic flight. Knowledge gained from the proposed study will allow us to characterize the risk for partial gravity levels, thus ensuring a more effective and comprehensive countermeasure strategy for preserving crew performance during exploration-class missions.

Task Progress:

The experiment is in Definition Phase. The current plan is to use NOVESPACE Airbus Zero-G aircraft for 3 flights with 30 parabolas per flight, including 10 parabolas at each g-level per flight (0.25, 0.50, 0.75) and 2 flights with 15 parabolas at 0g. The campaign is scheduled in June 2023.
The NASA Human Health Countermeasures (HHC) Element has required that 12 subjects are tested per experiments, for 10 parabolas at each g-level. We have updated our study proposal and budget to accommodate these requirements. These changes were approved by the HHC Element Scientist.

We have submitted the protocol and informed consent to the NASA Institutional Review Board (eIRB). The submission is in review. The aim is to have all studies approved by the NASA eIRB no later than August 2022. We have also started looking at and finalizing the physical layout, as well as the mechanical and electrical requirements of the experiment,

	and we have submitted a draft of our Experimental Safety Data Package to NOVESPACE.
Bibliography Type:	Description: (Last Updated: 06/20/2023)
Articles in Peer-reviewed Journals	Rosenberg MJ, Koslovsky M, Noyes M, Reschke MF, Clément G. "Tandem walk in simulated Martian gravity and visual environment." Brain Sci. 2022 Sep 20;12(10):1268. https://doi.org/10.3390/brainsci12101268 ; PMID: 36291202; PMCID: PMC9599924 , Sep-2022
Articles in Peer-reviewed Journals	Macaulay TR, Peters BT, Wood SJ, Clément GR, Oddsson L, Bloomberg JJ. "Developing proprioceptive countermeasures to mitigate postural and locomotor control deficits after long-duration spaceflight." Front Syst Neurosci. 2021 Apr 27;15:658985. Review. , Apr-2021