Fiscal Year:	FY 2024	**Task Last Updated:**	FY 12/04/2023
PI Name:	Willey, Jeffrey S. Ph.D.		
Project Title:	A Technology to Measure Gait, Egress, and Locomotor Performance in Perturbed Environmental Conditions After Simulated Spaceflight		
Division Name:	Space Biology		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	None		
Human Research Program Risks:	None		
Space Biology Element:	(1) Animal Biology: Vertebrate		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:	NOTE: PI formerly at Clemson University when NSBRI Postdoctoral Fellow Feb 2008-Oct 2010 (Ed., 12/18/2014)		
Project Type:	Ground,New Investigation	**Solicitation / Funding Source:**	2018 Space Biology (ROSBio) NNH18ZTT001N-FG2. App D: Flight and Ground Space Biology Research
Start Date:	02/01/2021	**End Date:**	01/31/2024
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	2	**No. of Master' Degrees:**	0
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA ARC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 01/31/2024 per NSSC information (Ed., 1/4/23). NOTE: End date changed to 01/31/2023 per NSSC information (Ed., 2/1/22).		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Danelson, Kerry Ph.D. (Wake Forest University)		
Grant/Contract No.:	80NSSC21K0294		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Long-duration spaceflight is challenging for the many body parts that help us maintain normal movements and perform well, which include our bones, joints, vision, and brain. Astronauts must perform to the best of their abilities when they are traveling to a destination like the Moon or Mars, and when they reach the destination. During the travel to the destination, or on the surface of the planet/moon, astronauts could face dangerous situations that require rapid escape movements, or situations where the body could be in peril due to surroundings (like when climbing the rough terrain of a mountain or into a valley). If an astronaut is not performing well due to altered visual performance, but also has damaged bones due to low gravity or radiation, the astronaut could be at risk of catastrophic joint tears or bone breaks while exploring uneven/dangerous terrains, or during a required rapid escape into or out of a spacecraft. Our laboratory has measured that performance is altered in rodents after ~35 days in orbit on the International Space Station. However, these measurements were taken on a treadmill moving forward at a constant speed. This does not represent the dangerous terrain of the Moon or Mars, or other rapid movements astronauts would face during spaceflight. Thus our intent is to develop and fabricate a method to better reflect locomotor performance in rodent models over uneven and dangerous lunar/Martian surfaces in order to best assess how combined spaceflight hazards (e.g, microgravity and radiation) cause deficits in astronaut performance, measure time to recovery, and identify countermeasures. We will create a platform on which sits our treadmill that can measure mouse and rat performance. However, the platform can move (one movable portion under each corner support of the treadmill) in a manner that can reflect uneven terrain or a rapid escape motion. Then we can measure how the animals that have previously been exposed to spaceflight conditions (like reduced gravity or radiation) respond. This platform and performance measurement device can then be used to test ways to maximize performance, and thus improve the technologies and approaches used during successful crewed space exploration.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This technology will permit us to measure how stability is affected after actual and simulated spaceflight, using rodents. Instability is a common biomedical problem that results from multiple conditions, including central nervous system diseases or injury, after orthopaedic procedures or injuries, after cancer treatment, among others. Maintaining stablilty while walking is essential for maintaining a patient's quality of life. Thus this technology will help us study the extent and mechanisms leading to instability in rodents models for these biomedical conditions, and then find ways to improve stability while walking or running.
Task Progress:	FRAME: A frame was modified to be more efficient than what was constructed in 2022; the unit continues to function as a module that integrated with the existing system without permanently altering the system’s structure or component capability. This frame functions like a universal joint having two independent axes of rotation. We selected commercially-available aluminum t-channel to build the frame, as this material is easy to machine and adapt for our application. In other words, the frame acts like a gyroscope. POWER SUPPLY: The power supply connects the wall outlet to two motors. CONTROLLED MOTION: The DigiGait has 2 degrees of freedom, pitch and roll. In both directions (clockwise and counterclockwise, defined as forward and backwards), the motors can be moved by being given power. The power given directly corresponds to the force applied by the motor; this power is variable. More power can be provided to make the motor move more quickly. It is advantageous to gradually increase and decrease the power of the motors as it increases movement accuracy. Currently, the motors are given a gradual acceleration and deceleration period, and do not hold a constant velocity for any substantial time. This is not a limitation; a constant velocity can be held if desired. The rate of acceleration, as well as the duration of the periods, can be changed. Note that upon reaching any destination, the DigiGait takes some time to settle. This time is at a max of 5 seconds by default, but can be reduced substantially with slower speeds, or potentially increased with higher speeds. The DigiGait is capable of simple and complex movement commands. The most basic command often utilized is "There and Back". An example use of this command is to roll the DigiGait 5 degrees and then bring it back 5 degrees. It is possible to vary the speed of this movement, as well as the distance traveled. It is also possible to add a pause at the target destination. Note that increasing the speed of the movement can result in decreased precision, while reducing the speed can increase precision. Tolerance is set at 1 degree by default, but can be reduced with slower movements. The accelerometer measures the movement and returns a value within 0.3 degrees of the actual positions. A complex command, "Return to Zero", allows the DigiGait to return from any position to zero, within 0.5 degrees by default. This involves a series of gradual movements stepping towards zero. The speed of the command can be changed to adjust the tolerance; increasing the duration of command will lower the tolerance to as low as 0.3 degrees, which is the tolerance of the accelerometer. Another complex command, "Shake", allows the DigiGait to rapidly move back and forth on either axis. It is possible to change how quickly this occurs, for how long it occurs, the direction this occurs in, and more. An example of this command is to shake in the pitch direction, varying position between 0 and 3.0 degrees, and taking 1 second to move between both ends of the range. Note that the shake command does possess an amount of uncontrollability associated with the settling of the DigiGait; uncontrollable does not mean unpredictable or unmeasurable, this simply means that we are relying on the settling of the DigiGait to contribute to the command. RODENT STUDIES: The pilot study of twelve male mice included include both hind limb unloaded (HU) and full weight-bearing GROUND controls. Gait assessment of each mouse was be performed prior to HU or before the start of the study as a GROUND control, and then again after 14 days. From these mice we determined if: i] the system is functional and we can modify the design if necessary, and ii] the system can reliably measure gait data across a range of speeds and displacements METRICS ASSESSMENT 1. General: We had originally planned to use 20º displacements as the baseline metric. However, when moving on the treadmill, displacements of this magnitude, even at relatively low speeds, can result in mice being pushed laterally and forward into the enclosure. Thus, displacements of 5º appear optimal for this sex and strain. 2. Speed: When the speed of the treadmill gets below ~12 cm/s, the rodents can essentially “ride” the displacement in the lateral direction. It remains useful for a forward pitch in terms of identifying if braking gait responses are altered. The utility in the lateral direction (roll) would be to identify if stability is altered by some stimulus (e.g., Radiation).

17.5 cm/s appears to be an optimal speed to promote forward locomotion and recovery with perturbations. Faster speeds and this strain of mouse runs to the back of the encasement.

3. Pitch: Forward pitch appears to provide a good metric of the ability to brake and remain in motion – both if the motion is continuous (without pause after forward pitch) and when a pause at a downward angle is provided. Time to return to linear locomotion is also a valued metric and is affected by treatment.

4. Roll: Rolling metrics (with and without pause) likewise appear to reflect stability, with important metrics including stance width and paw angle variability, with time to recovery of linear locomotion serving as a putative important metric regarding effects of treatments.

5. Pauses for both pitch and role: Pausing in the midst of motion (e.g., at 5 º) of roll or pitch permits the assessment of 2 “recoveries” – first from the initial perturbation (with associated gait pattern changes reflective of neuromotor and sensorimotor deficits) and then a timing of return to normal locomotion, if possible, and then with a return to baseline position, another set of recoveries.

6. Shaking: The shaking feature appears very useful in measuring gait pattern metrics associated with stability, and also a return to normal locomotor behavior upon cessation. We feel that for shaking especially, measuring gait parmaters prior to, during, and after the shaking challenge (and then comparison with baseline (“pre”) measures are of particular importance).

Bibliography Type:	Description: (Last Updated: 01/22/2025)