Fiscal Year:	FY 2022	**Task Last Updated:**	FY 11/09/2023
PI Name:	Petersen, Lonnie M.D., Ph.D.		
Project Title:	Mobile Gravity Suit (an Integrative Countermeasure Device)		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **SANS**:Risk of Spaceflight Associated Neuro-ocular Syndrome (SANS)		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	La Jolla	**State:**	CA
Zip Code:	92037-1337	**Congressional District:**	52
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2017 HERO 80JSC017N0001-Crew Health and Performance (FLAGSHIP1, OMNIBUS). Appendix A-Flagship1, Appendix B-Omnibus
Start Date:	10/04/2018	**End Date:**	10/01/2023
No. of Post Docs:	0	**No. of PhD Degrees:**	
No. of PhD Candidates:	2	**No. of Master' Degrees:**	
No. of Master's Candidates:	2	**No. of Bachelor's Degrees:**	20
No. of Bachelor's Candidates:	40	**Monitoring Center:**	NASA JSC
Contact Monitor:	Brocato, Becky	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 10/1/2023 per NSSC information (Ed., 4/3/23) NOTE: End date changed to 10/1/2022 per NSSC information (Ed., 9/19/21) NOTE: End date changed to 10/3/2021 per NSSC information (Ed., 8/21/20) NOTE: End date changed to 10/3/2020 per NSSC information (Ed., 10/28/19)		
Key Personnel Changes/Previous PI:	Change (FY2021 report): Co-I Alan Hargens is no longer affiliated with this project.		
COI Name (Institution):	Levine, Benjamin M.D., Ph.D. (University of Texas Southwestern Medical Center at Dallas)		
Grant/Contract No.:	80NSSC19K0020		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Because all parts of human physiology are affected by microgravity, an integrative countermeasure strategy is needed. Loss of muscle and bone mass along with deconditioning of the heart and vessels are well described effects of microgravity. More recently structural and functional changes of the eye, experienced by some astronauts during long-term missions, have been described and summarized in the Spaceflight Associated Neuro-ocular Syndrome (SANS). While the exact etiology of SANS remains unknown, the microgravity induced headward fluid shift is likely part of the pathophysiology and countermeasures that can reverse this fluid shift are prioritized. Based on our experimental data from short-term microgravity by parabolic flights and 24-hour simulated microgravity, we suggest that fluid redistribution in space may not give rise to a pathological increase in intracranial pressure, but rather the lack of diurnal fluctuations in intracranial volume and pressures may be responsible for the remodeling of the eye. In ambulatory neurosurgical patients with pressure sensors inserted in the brain tissue, we therefore demonstrated the feasibility of lower body negative pressure to reduce intracranial pressure as means of re-introducing diurnal pressure variability. Extending on this, in a recent 3-day, 6° head-down tilt bedrest trial we applied lower body negative pressure (LBNP) for 8 hours every day, to demonstrate safety and efficacy to significantly reduce long-term swelling at the back of the eye believed to be early symptoms of SANS. At the Aerospace Physiology Lab at University of California San Diego (UCSD) we have developed and tested a mobile "Gravity Suit" comprised of pressurized-trousers and attached vest. The suit simulates the effects of gravitational stress by application of low-levels lower body negative pressure to re-introduce an Earth-like fluid shift while at the same time inducing a ground reaction force at the bottom of the feet and a mechanical load along the entire body axis. Preliminary tests involving healthy human subjects in simulated microgravity have demonstrated the efficacy of 20 mmHg lower body negative pressure within the suit to reduce internal jugular vein cross-sectional area by some 45% and induce mechanical load of 57% bodyweight. The intravehicular suit is comfortable enough to wear 8-10 hours a day and flexible enough to be combined with daily activity and even exercise with the overall aim to provide an integrative countermeasure. As an overall long-term aim, we suggest that use of the Gravity Suit will 1) re-introduce the diurnal variability of intracranial pressure and volume to help prevent development of SANS; 2) stimulate the cardiovascular system to maintain cardiac muscle mass and vascular compliance; 3) counteract loss of postural muscle mass and bone density; 4) finally, the axial loading may preserve curvature of the spine, paraspinal muscle, and disc morphology to both ameliorate in-flight back pain, and reduce risk of post-flight disc herniation. Within the scope of this proposal, we will finalize and further test our prototype by integrating vacuum- and monitoring systems within the waist-belt to increase safety and allow for free and un-tethered movement. Comfort, range of motion, and gait will be assessed during relevant activities simulating daily work tasks on the International Space Station (ISS) and in combination with resistive exercise device relevant for cislunar and deep space missions. High levels and/or prolonged exposure to lower body negative pressure can potentially compromise blood flow to the brain; however, activity and use of the muscle pump increases orthostatic tolerance. To establish a safe range and optimize the user scenario, we will test cardiovascular responses and cerebral perfusion during graded lower body negative pressure with and without a combined ground reaction force and in combination with rowing exercise. Successful funding of this proposal will bring our Gravity Suit to Countermeasure Readiness Level 7.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	While designed as a countermeasure for use in space, LBNP may hold benefits for life on Earth. One specific example is reduction of pressure inside the brain which may hold potential for patients on Earth with elevated intracranial pressure.
Task Progress:	Ed. Note -- May 2023 Update Compiled from January 2023 report to NASA 2022/23 UPDATE -- COVID IMPACT: University of California, San Diego (UCSD) closed down early in 2020 and regrettably did not fully open for human-subject testing until 2022 (only COVID-related research could be done). The Aerospace Physiology lab (Petersen lab) submitted, and was approved for, onsite research ramp-up; however, all work has been under significant restrictions and 6 feet distance has to be maintained at all times. Thus, research with human subjects has been close to impossible. Based on this, I was granted a no-cost extension on this grant. Because no human subject research was possible for a significant period, I focused efforts on work that was possible; therefore significant technical / engineering advances have been made. Based on feedback from NASA's Human Research Program (HRP), it is important to move away from a lithium battery-based system. However, this poses a challenge for weight, size, and lifetime of the alternative batteries. My team and I have tested multiple vacuum systems and customized functionality to be specifically tailored towards a wearable lower body negative pressure (LBNP) device. Additionally, much experimental work has gone into material selection. Based on this, my recommendation is a two-layer softshell with the inner lining being a soft material with optimized wicking capacity and an outer layer of more robust and airtight material. Mobility across the individual joint has also been a focus and we have created a knee design that allows for full mobility without contact with the skin. We are currently evaluating materials for the structural support of the knee joint.
Bibliography Type:	Description: (Last Updated: 03/21/2025)