Fiscal Year:	FY 2022	**Task Last Updated:**	FY 12/07/2021
PI Name:	Hargens, Alan R. Ph.D.		
Project Title:	Self-Generated LBNP for Deep-Space Missions		
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:	92037-0863	**Congressional District:**	52
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2017-2018 HERO 80JSC017N0001-BPBA Topics in Biological, Physiological, and Behavioral Adaptations to Spaceflight. Appendix C
Start Date:	01/31/2019	**End Date:**	01/30/2022
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	1
No. of Master's Candidates:	2	**No. of Bachelor's Degrees:**	2
No. of Bachelor's Candidates:	6	**Monitoring Center:**	NASA JSC
Contact Monitor:	Stenger, Michael	**Contact Phone:**	281-483-1311
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Flight Program:			
Flight Assignment:	NOTE: Project end date changed to 01/30/2022 per NSSC information. (Ed., 6/28/22) NOTE: Project end date changed to 10/31/2021 per L. Barnes-Moten / NASA JSC. (Ed., 12/7/21)		
Key Personnel Changes/Previous PI:	2021 report: James Friend, Linda Loerch, and Lonnie Petersen are no longer CoInvestigators on the project. 2020 report: Dr. Natalie Afshari is a new CoInvestigator for her ophthalmology expertise.		
COI Name (Institution):	Lee, Stuart Ph.D. (KBR/NASA Johnson Space Center) Macias, Brandon Ph.D. (NASA Johnson Space Center) Afshari, Natalie A. M.D. (University of California, San Diego)		
Grant/Contract No.:	80NSSC19K0409		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	This Ground-Based proposal will evaluate a novel, self-generated Lower Body Negative Pressure (LBNP) device as a countermeasure to prevent Spaceflight Associated Neuro-Ocular Syndrome (SANS). This device is ideal for off-normal conditions in space craft when power is low. The self-generated LBNP device was invented and published by our team almost 20 years ago and is presently on the Chinese Space Station Tiangong One. This concept is very timely now with NASA's need to provide a SANS countermeasure while at the same time, providing physiologically-integrated exercise hardware that is safe, low mass, low volume, low power, and simple for deployment on a small, confined deep-space vehicle. Previous ground-based tests of the self-generated LBNP device document that the maximum footward force at the peak of the exercise cycle is over 110 kg and pressure within the cylinder concomitantly decreases by over 25 mm Hg below ambient to help counteract SANS, maintain aerobic capacity and the musculoskeletal system. This proposal is a logical extension of our previous ground-based simulations validating the self-generated LBNP device to re-introduce daily gravitational pressures and footward reaction forces. Furthermore, it extends our ongoing International Space Station (ISS) project "Fluid Distribution Before, During and After Prolonged Space Flight," demonstrating short-term LBNP by the Russian Chibis Suit to reduce venous congestion in the neck. We will use state-of-the-art, non-invasive technologies and imaging to prove efficacy of our self-generated LBNP device by quantifying cerebral volumes, pressures, and compliance along with visual deficits and ocular remodeling in 16 healthy female and male volunteers during parabolic flight and ground simulations of microgravity. We will determine dose-response efficacy of self-generated LBNP and accompanying shoulder-vest and footward mechanical loads to re-introduce diurnal effects of gravitational stress. Our self-generated LBNP device is very timely now with NASA's need to provide an integrated countermeasure for SANS and musculoskeletal (MS) losses, while at the same time providing physiologically-integrated exercise hardware that is safe, low mass, low volume, no power, and simple for deployment in a confined deep-space vehicle. Taken together, we therefore propose low-level, almost daily application of self-generated LBNP as an integrated countermeasure to reintroduce diurnal cycles of gravitational fluid and pressure variability to preserve cerebral, ocular, cardiovascular, and musculoskeletal health, relevant to 2011 Decadal priorities AH6 ("Studies should be done to develop and test new prototype exercise devices, and to optimize physical activity paradigms/prescriptions targeting multi-system countermeasures"). A self-generated LBNP device will go from a Technology Readiness Level of 7 to 8.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This Ground-Based proposal will evaluate a novel, self-generated Lower Body Negative Pressure (LBNP) device as a countermeasure to prevent Spaceflight-Associated Neuro-Ocular Syndrome (SANS). The change in position and forces from an exercising astronaut in the device expands the accordion device to create a suction pressure. This suction trans-locates blood from the upper body to the lower body while applying musculoskeletal loads to crewmembers' bodies without a separate electricity source, making it ideally suited to spaceflight conditions when power supply is limited. This concept is very timely with NASA's need to provide a SANS countermeasure while at the same time, providing physiologically-integrated exercise hardware that is safe, low mass, low volume, low power and simple for deployment in a small, confined deep-space vehicle. Additionally, the self-generated LBNP device presents less of an engineering challenge than a short-radius centrifuge or whole space vehicle rotation.
Task Progress:	Our results indicate there is a significant difference between the upright posture and static lower body negative pressure (LBNP) conditions. These findings are in accordance with previous studies in which LBNP reduced intracranial pressure (ICP) in a supine posture, but not to upright levels. The internal jugular vein (IJV) cross-sectional area (CSA) was slightly larger in dynamic LBNP when compared to static LBNP, but the difference was not significant. Our data suggest that both static and dynamic LBNP have similar effects on IJV CSA. Despite the established efficacy of LBNP at reducing IJV CSA, our data do not indicate either LBNP condition significantly reduced IJV CSA when compared to the supine condition. Additionally, the supine condition was not significantly different when compared to the upright condition. There are several reasons why the differences were not significant. First, we had a small number of subjects with N=11. Variances were not equal, requiring large correction factors. Finally, there was a very large variability in IJV CSA in the supine position between subjects. These factors reduced power and significance. While neither LBNP condition reached statistical significance, both conditions trended toward reducing IJV CSA when compared to supine. Previous studies demonstrate the efficacy of static LBNP at reducing IJV CSA and ICP. Because both the static and dynamic LBNP conditions reduced IJV CSA to a similar extent, our results suggest dynamic, self-generated LBNP may have a similar effect of reducing IJV CSA, and potentially ICP, when compared to traditional static LBNP. These results warrant further investigation into self-generated LBNP as it may be a low-mass, low-volume, unpowered replacement for traditional LBNP chambers during long-duration spaceflight. (Ed. note December 2021: compiled from PI's technical report submitted July 2021.)
Bibliography Type:	Description: (Last Updated: 10/31/2023)
Articles in Peer-reviewed Journals	Arbeille P, Zuj KA, Macias BR, Ebert DJ, Laurie SS, Sargsyan AE, Martin DS, Lee SMC, Dulchavsky SA, Stenger MB, Hargens AR. "Lower body negative pressure reduces jugular and portal vein volumes and counteracts the elevation of middle cerebral vein velocity during long-duration spaceflight." J Appl Physiol (1985). 2021 Sep;131(3):1080-7. https://doi.org/10.1152/japplphysiol.00231.2021 ; PMID: 34323592; PMCID: PMC8461809 , Sep-2021
Articles in Peer-reviewed Journals	Ly V, Velichala SR, Hargens AR. "Cardiovascular, lymphatic, and ocular health in space." Life (Basel). 2022 Feb 11;12(2):268. Review. https://doi.org/10.3390/life12020268 ; PMID: 35207555; PMCID: PMC8875500 , Feb-2022