Fiscal Year:	FY 2019	**Task Last Updated:**	FY 07/24/2019
PI Name:	Ploutz-Snyder, Lori L. Ph.D.		
Project Title:	Gravitational Dose and Multi-system Physiologic Response		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Cardiovascular**:Risk of Cardiovascular Adaptations Contributing to Adverse Mission Performance and Health Outcomes (2) **Muscle**:Risk of Impaired Performance Due to Reduced Muscle Size, Strength and Endurance (3) **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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Zip Code:	48109-2013	**Congressional District:**	12
Comments:	Previously at Universities Space Research Association/NASA Johnson Space Center until July 2016.		
Project Type:	Ground	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-Artificial Gravity. Appendix D: NASA HRP Artificial Gravity Opportunity
Start Date:	07/26/2016	**End Date:**	07/25/2019
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Laurie, Steven Ph.D. (Wyle Laboratories, Inc./NASA Johnson Space Center) Lee, Stuart Ph.D. (Wyle Laboratories, Inc./NASA Johnson Space Center) Martin, David M.S. (Wyle Laboratories, Inc./NASA Johnson Space Center) Ploutz-Snyder, Robert Ph.D. (Universities Space Research Association) Scott, Jessica Ph.D. (Memorial Sloan-KetteringCancer Center) Stenger, Michael Ph.D. (Wyle Laboratories, Inc./NASA Johnson Space Center) Arbeille, Philippe M.D., Ph.D. (CNES (Centre national d'études spatiales), France)		
Grant/Contract No.:	NNX16AO73G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Artificial gravity (AG), by substituting for the missing gravitational cues and loading in space, offers significant promise as an effective, efficient multi-system countermeasure against virtually all of the identified risks associated with bone loss, muscle weakening, cardiovascular deconditioning, and sensorimotor disturbances. However, the optimal AG load required for maintaining normal physiological function is unknown. Furthermore even with an AG capability exercise is very likely to remain in the countermeasure suite as it provides additional physiological and psychological benefits. Two important early steps in understanding AG are to evaluate how AG interacts with exercise and how this interaction is influenced by partial gravity between 0 and 1 G. Parabolic flight creates the only condition that allows assessment of the effects of partial gravity between 0 and 1 G in humans without the need for launching into space. On this basis, we contend that parabolic flight research with a range of gravitational loads provides a unique model to characterize the relationships among gravitational dose, exercise, and the acute physiologic responses of the sensorimotor, cardiovascular, cerebrovascular, and ocular systems. Ultimately, this information will help to identify the optimal operating range of AG on exploration class missions. It is possible that AG levels below 1 G could be used with exercise supplementing the additional required loading potentially reducing the engineering requirements of future AG-compatible living quarters. The objective of this grant is to identify the AG dose-physiological response relationship. This proposal involves a multidisciplinary collaboration between investigators at Johnson Space Center who bring collective expertise in cardiovascular physiology, exercise physiology, muscle physiology, sensorimotor function, and statistical analysis. The proposal is arranged in four individual projects that are integrated together to complement each other and maximize data sharing. The overall aim of the study is: Specific Aim: Characterize the relationship between gravitational dose and acute physiologic responses of the cardiovascular, cerebrovascular, ocular, muscular, and sensorimotor systems.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	There is little understanding of the effects of gravity on the human body apart from zero G and one G; we know nearly nothing about partial gravity in between 0-1. It is important to understand whether there are thresholds of gravity, above which, blood flow to the head is relatively normal. If, for example, blood flow to the head was the same at both 0.5 and 1.0 G this would allow for the development of countermeasures (such as artificial gravity) to be developed more easily and with less resource use.
Task Progress:	Chronic exposure to the spaceflight-induced cephalad fluid shift is hypothesized to be a primary contributor to the development of Spaceflight-Associated Neuro-ocular Syndrome (SANS). The objective of this study was to characterize the relationship between gravitational level (G-level) and acute cardiovascular and ocular changes to determine if G-levels less than normal gravity (1-G) mitigate SANS-related parameters associated with headward fluid shifts during weightlessness. Methods. Internal jugular vein cross-sectional area (IJVA) and inferior vena cava (IVC) diameter (VividQ, GE Health Care, Chicago, IL), intraocular pressure (Triggerfish, Sensimed, Switzerland), heart rate, and beat-to-beat finger blood pressure (Finapres Medical Systems, Amsterdam-Zuidoost, Netherlands) were measured in 9 subjects (5F, 4M) while supine before flight and while seated when exposed to 1-G, 0.75-G, 0.50-G, and 0.25-G during parabolic flights flown by Novespace, Inc. (Bordeaux-Mérignac, France) as part of the first International Space Life Sciences Working Group Campaign in June 2018. Results. There was a main effect of condition on IJVA ($p=0.0001$). IJVA was smallest in the 1-G seated posture, progressively increased in the seated subjects as G-levels decreased, and was largest during 1-G supine, our surrogate for 0-G. IJVA during 1-G seated was smaller than when subjects were exposed to 0.25- and when supine in 1-G. In contrast, there was no difference ($p=0.71$) in IVC diameter at any level of acceleration or while supine in 1-G. There was a main effect of condition on mean arterial pressure ($p=0.004$) such that MAP during 1-G seated rest was significantly greater than during any of the other conditions. Conversely, there was no effect of condition ($p=0.09$) on heart rate. Conclusions. Preliminary analysis of these data, particularly IJVA, suggest (a) that a G-level greater than 0.25-G may be required in the z-axis to reverse weightlessness-induced venous fluid shift to the extent that artificial gravity would be a viable countermeasure to SANS development during long-duration spaceflight and (b) that G-levels experienced on the moon and Mars may not be sufficient to prevent the development of SANS. Future work should include validation of these findings with similar measures during the application of countermeasures in spaceflight and with exposure to partial gravity environments.
Bibliography Type:	Description: (Last Updated: 06/04/2024)
Articles in Peer-reviewed Journals	Lee SMC, Martin DS, Miller CA, Scott JM, Laurie SS, Macias BR, Mercaldo ND, Ploutz-Snyder L, Stenger MB. "Venous and arterial responses to partial gravity." Front Physiol. 2020 Jul 28;11:863. https://doi.org/10.3389/fphys.2020.00863 ; PMID: 32848835; PMCID: PMC7399573 , Jul-2020