Fiscal Year:	FY 2017	**Task Last Updated:**	FY 01/30/2017
PI Name:	Hargens, Alan R. Ph.D.		
Project Title:	Fluid Distribution before, during and after Prolonged Space Flight		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
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) **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:	Flight	**Solicitation / Funding Source:**	2011 Crew Health NNJ11ZSA002NA
Start Date:	04/05/2013	**End Date:**	09/30/2018
No. of Post Docs:	2	**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	1
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	3
No. of Bachelor's Candidates:	4	**Monitoring Center:**	NASA JSC
Contact Monitor:	Allcorn, Aaron	**Contact Phone:**	281.244.8402
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Flight Program:	ISS		
Flight Assignment:			
Key Personnel Changes/Previous PI:	February 2017: No changes.		
COI Name (Institution):	Arbeille, Phillipe (CERCOM) Chang, Douglas (University of California, San Diego) Gunga, Hanns-Christian (CHARITE - UNIVERSITATSMEDIZIN BERLIN) Liu, John (University of California, San Diego) Macias, Brandon (University of California, San Diego)		
Grant/Contract No.:	NNX13AJ12G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Editor's Note (4/24/2013): NOTE THIS IS A CONTINUATION OF FUNDING FOR NNX12AL66G WITH THE SAME TITLE AND PRINCIPAL INVESTIGATOR. We will use state-of-the-art, non-invasive technologies to quantify upper-body compartmental volumes and pressures in crewmembers before, during, and after prolonged space flight. Importantly, we will correlate these data with vision deficits that occur in order to establish pathophysiologic mechanisms that will serve as a basis for future countermeasure development. After successful completion of our investigation, we will deliver a comprehensive database of microgravity-induced, head-ward volume and pressure changes (type and magnitude) and a prioritization of these changes as to their deleterious effects on vision in crewmembers during and after prolonged space flight. We are proposing a well-documented and validated battery of non-invasive or minimally-invasive, image-based tests developed to identify and quantify microgravity-induced, head-ward volume and pressure changes. We hypothesize that prolonged microgravity-induced, head-ward volume and pressure shifts are responsible for elevating intracranial pressure (ICP) and producing deficits in crewmembers' vision. Our project directly addresses Critical Path Roadmap Risks and Questions regarding "Risk of Microgravity-Induced Visual Alterations and Intracranial Pressure," specifically Integrated Research Plan (IRP) Gap Cardiovascular (CV) 7: How are fluids redistributed in-flight? and IRP Gap Vision Impairment and Intracranial Pressure (VIIP) 1: What is the etiology of visual acuity and ocular structural and functional changes seen in-flight and post-flight? Our first specific aim is to study periocular fluid volumes, intraocular pressure (IOP), upper-body compartment volumes before, during, and after prolonged microgravity exposure. The second specific aim is to measure jugular vein dimensions and blood flow using ultrasound before, during, and after prolonged microgravity exposure. The third specific aim is to quantify ventricular and cerebrospinal volumes using ultrasound before, during, and after prolonged microgravity exposure. A fourth specific aim is to perform retinal imaging to observe retinal venous distension in space. Tests of ocular structure will include optic nerve head tomography, nerve fiber layer thickness, axial length, and orbital retrolaminar subarachnoidal space. Tests of ocular function will include visual acuity, total retinal blood flow, and capillary blood flow in the optic nerve head and macula. Finally, changes in ICP, IOP, and ocular structures and functions will be investigated while applying a purely-mechanical countermeasure of low-level lower body negative pressure or thigh cuffs to counteract the head-ward fluid shift in space. To our knowledge, this study will be the first to provide detailed and non-invasive measures of compartmental volume and pressure changes in the upper body induced by prolonged microgravity and to correlate these specific changes with decrements in vision for crewmembers. The proposed techniques represent the best available, state-of-the-art tools to quantify and document features that are clinically suspected as vision deficit generators. By correlating volume and pressure changes with vision problems, we expect to identify factors that will later motivate targeted development of effective physiologic countermeasures such as low-level lower body negative pressure exposure or thigh cuffs in space. This project has the potential to prevent loss of vision in crewmembers exposed to prolonged space flight and upon return to Earth. NOTE: This study was merged with investigations from Dr. Michael Stenger (Distribution of Body Fluids during Long Duration Space Flight and Subsequent Effects on Intraocular Pressure and Vision Disturbance) and Dr. Scott Dulchavsky (Microgravity associated compartmental equilibration) resulting in a comprehensive study titled "Fluid Shifts Before, During and After Prolonged Space Flight and Their Association with Intracranial Pressure and Visual Impairment" (short title: Fluid Shifts).
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Our proposed tests represent a comprehensive set of state-of-the-art, noninvasive technologies to quantify upper-body compartmental volumes and vascular parameters in crewmembers before, during, and after prolonged space flight. Importantly, we will correlate these data with vision deficits that occur in order to establish pathophysiologic mechanisms that will serve as a basis for future countermeasure development. After successful completion of our investigation, we will deliver a database of microgravity-induced, head-ward volume and vascular changes (type and magnitude) and a prioritization of these changes as to their deleterious effects on vision in crewmembers during and after prolonged space flight. Finally, our project includes use of lower body negative pressure (LBNP), which is known to sequester fluid in lower body tissues and counteract head-ward fluid shifts. Importantly, these procedures have the potential to reduce intracranial pressure and counteract papilledema, even if the proposed countermeasure acts transiently. This research has immense Earth benefits such as development and validation of a noninvasive ICP device and greater understanding of glaucoma using the latest technology for measuring intraocular and intracranial pressures.
Task Progress:	Significant progress was made over the past year; all approvals and schedules were finalized. Data collection is well underway; preflight data from all 10 crewmembers have been completed and are now being analyzed. Inflight data from 7 of the 10 crewmembers have been collected along with postflight data from two crewmembers. Current regulations preclude us from publishing data at this point. Our team continues the bi-weekly Fluid Shifts (FS) team telecons, coordinated and led by our flight project manager Erik Hougland. We have updated our "Fluid Shifts" NASA Experimental Document and its revision. We have completed all ten upright MRI sessions pre-flight data collections on International Space Station (ISS) crewmembers. We have also been directly involved with inflight and postflight data acquisition and quality control. Our team attended and presented ground based preliminary and supportive ICP and cardiovascular data at the National Space Biomedical Research Institute (NSBRI) Numerical Modeling to Understand VIIP symposium Nov 17th – 18th 2016 at NSBRI HQ, Houston, TX. In addition, we will attend and present in numerous scientific sessions during the Human Research Program (HRP) meeting in Galveston in January 2017. In 2016 Postdoctoral Fellow Dr. Lonnie G Petersen M.D., Ph.D. joined our team. She brings both clinical and experimental experience in diagnostics and treatment of intracranial hypertension as well as application of LBNP (lower body negative pressure) as means to non-invasively reduce ICP.
Bibliography Type:	Description: (Last Updated: 06/30/2025)

Abstracts for Journals and Proceedings	Petersen LG et al. "Effects of posture and lower body negative pressure on intracranial pressure." Presentation at NSBRI Numerical Modeling to Understand VIIP, Houston, TX, November 2016. NSBRI Numerical Modeling to Understand VIIP, Houston, TX, November 2016. , Nov-2016
Articles in Peer-reviewed Journals	Macaulay TR, Macias BR, Lee SMC, Boda WL, Watenpaugh DE, Hargens AR. "Treadmill exercise within lower-body negative pressure attenuates simulated spaceflight-induced reductions of balance abilities in men but not women." npj Microgravity. 2016;2:16022. eCollection 2016. Published online: 30 June 2016. http://dx.doi.org/10.1038/npjmgrav.2016.22 ; PMID: 28725733; PMCID: PMC5515523 , Jun-2016
Articles in Peer-reviewed Journals	Schneider SM, Lee SM, Feiveson AH, Watenpaugh DE, Macias BR, Hargens AR. "Treadmill exercise within lower body negative pressure protects leg lean tissue mass and extensor strength and endurance during bed rest." Physiol Rep. 2016 Aug;4(15):e12892. http://dx.doi.org/10.14814/phy2.12892 ; PubMed PMID: 27495299; PubMed Central PMCID: PMC4985554 , Aug-2016
Articles in Peer-reviewed Journals	Hargens AR, Vico L. "Long-duration bed rest as an analog to microgravity." J Appl Physiol (1985). 2016 Apr 15;120(8):891-903. Review. http://dx.doi.org/10.1152/japplphysiol.00935.2015 ; PubMed PMID: 26893033 , Apr-2016
Awards	Watkins W (medical student mentee), Hargens A, Macias B. "First Place Student Research Award, American College of Sports Medicine for “Noninvasive Intracranial Pressure following Simulated Head Contact Events” , October 2016." Oct-2016