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| **Fiscal Year:** | FY 2016 | **Task Last Updated:** | FY 02/03/2016 |
| **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<br>(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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| **PI Organization Type:** | UNIVERSITY | **Phone:** | 858-534-7837 |
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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:** | 1 | **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:** | Villarreal, Jennifer | **Contact Phone:** | 281-483-7306 |
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| **Flight Program:** | ISS | | |
| **Flight Assignment:** | | | |
| **Key Personnel Changes/Previous PI:** | February 2016: No changes. | | |
| **COI Name (Institution):** | Arbeille, Phillipe ( CERCOM )<br>Chang, Douglas ( University of California, San Diego )<br>Gunga, Hanns-Christian ( CHARITE - UNIVERSITATSMEDIZIN BERLIN )<br>Liu, John ( University of California, San Diego )<br>Macias, Brandon ( University of California, San Diego ) | | |
| **Grant/Contract No.:** | NNX13AJ12G | | |
| **Performance Goal No.:** | | | |
| **Performance Goal Text:** | | | |

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| **Task Description:** | Editor's Note (4/24/2013): NOTE THIS IS A CONTINUATION OF FUNDING FOR NNX12AL66G WITH THE SAME TITLE AND PRINCIPAL INVESTIGATOR.<br>We will use state-of-the-art, non-invasive technologies to quantify upper-body compartmental volumes and pressures in crew members 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.<br><br>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.<br><br>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 crew members 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 crew members 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.<br>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:** | We have made significant progress over the past year preparing applications and receiving approvals from the NASA-Johnson Space Center (JSC) and University of California San Diego (UCSD) Institutional Review Boards (IRBs). Moreover, we also made significant progress with optimizing and scheduling our pre-, in-, and post-flight tests to maximize their scientific value and to minimize impacts and risks to International Space Station (ISS) crew members. The "Fluid Shifts: Space Flight Study" was approved by the NASA JSC IRB. In addition, the "Fluid Shifts" study has been approved by the UCSD IRB. Moreover, we have received Japanese Space Agency (JAXA) IRB approval.<br>To date our team has met with one another with the coordination of Erik Hougland, our flight project manager, who has led our bi-weekly Fluid Shifts (FS) team telecons.<br><br>We have updated our "Fluid Shifts" NASA Experimental Document and its revision.<br><br>We have completed five upright MRI sessions pre-flight data collections on ISS crew members. We have also been involved with inflight data acquisition and quality control. Our first post-flight data collections on ISS crew members are expected in March 2016.<br><br>Our team attended the National Space Biomedical Research Institute (NSBRI) VIIP Working Group Jan. 13th, 2015, during the NASA Human Research Program (HRP) Investigators' Workshop in Galveston, TX.<br><br>Our team attended the NSBRI Ultrasound working group to present on ultrasound based ICP data collection.<br><br>In addition to these FS operational activities, we were successful in leveraging our NASA funded research to host an undergraduate Howard University student last summer, Amarachi Uzosike, funded by the American Physiological Society Undergraduate Summer Research Fellowship. |

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| | Brandon Macias attended the 2015 Heidelberg Engineering Academy: Spectralis Hands-On Operation Course. |
| **Bibliography Type:** | Description: (Last Updated: 10/31/2023) |
| **Abstracts for Journals and Proceedings** | Lee PC, Siamwala JH, Macias BR, Hargens AR. "Tibial Bone Hemodynamics during Simulated Microgravity and Lower Body Negative Pressure." Presented at the 30th Annual Meeting of the American Society for Gravitational and Space Research, Pasadena, CA, October 22-26, 2014.<br>30th Annual Meeting of the American Society for Gravitational and Space Research, Pasadena, CA, October 22-26, 2014. , Oct-2014 |
| **Abstracts for Journals and Proceedings** | Macias BR, Watkins W, Baird S, Clary E, Hargens AR. "Lower Body Negative Pressure Counters Simulated Microgravity-Induced Elevations of Intracranial Pressure and Jugular Vein Engorgement." 31st Annual Meeting of the American Society for Gravitational and Space Research, Alexandria, VA, November 11-14, 2015.<br>31st Annual Meeting of the American Society for Gravitational and Space Research, Alexandria, VA, November 11-14, 2015. , Nov-2015 |
| **Articles in Peer-reviewed Journals** | Siamwala JH, Lee PC, Macias BR, Hargens AR. "Lower-body negative pressure restores leg bone microvascular flow to supine levels during head-down tilt." J Appl Physiol (1985). 2015 Jul 15;119(2):101-9. Epub 2015 Apr 30. http://dx.doi.org/10.1152/japplphysiol.00028.2015 ; PubMed PMID: 25930022 , Jul-2015 |
| **Awards** | Siamwala JH, Macias BR, Healey R, Hargens AR. "American Physiological Society Exercise & Environmental Physiology Section's National Space Biomedical Research Institute's Gravitational Physiology Beginning Investigator Award, April 2015." Apr-2015 |