Fiscal Year:	FY 2021	**Task Last Updated:**	FY 07/22/2020
PI Name:	Stenger, Michael Ph.D.		
Project Title:	Distribution of Body Fluids during Long Duration Space Flight and Subsequent Effects on Intraocular Pressure and Vision Disturbance		
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		
PI Email:	michael.b.stenger@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	281-483-1311
Organization Name:	NASA Johnson Space Center		
PI Address 1:	SK3/Biomedical Research and Environmental Sciences Division		
PI Address 2:			
PI Web Page:			
City:	Houston	**State:**	TX
Zip Code:	77058	**Congressional District:**	22
Comments:	NOTE Aug 2018: Previously with KBRwyle at Johnson Space Center		
Project Type:	FLIGHT	**Solicitation / Funding Source:**	2011 Crew Health NNJ11ZSA002NA
Start Date:	10/01/2012	**End Date:**	10/01/2020
No. of Post Docs:	2	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Stenger, Michael	**Contact Phone:**	281-483-1311
Contact Email:	michael.b.stenger@nasa.gov		
Flight Program:	ISS		
Flight Assignment:	ISS NOTE: End date changed to 10/1/2020 as Dr. Steven Laurie took over the project in August 2020 (Ed., 7/15/21) NOTE: End date changed to 3/31/2022 per C. Ribeiro/HHC/HRP JSC (Ed., 5/6/21) NOTE: End date changed to 1/29/2021 per J. McFather/HRP JSC (Ed., 10/15/18) NOTE: End date is 9/30/2018 per PI (Ed., 7/8/15) NOTE: Risk/Gap changes per IRP Rev E (Ed., 3/24/14)		
Key Personnel Changes/Previous PI:			

COI Name (Institution):	Johnston, Smith M.D. (NASA Johnson Space Center) Lee, Stuart Ph.D. (KBR/NASA Johnson Space Center) Martin, David M.S. (KBR/NASA Johnson Space Center) Ploutz-Snyder, Robert Ph.D. (Universities Space Research Association, Columbia) Smith, Scott Ph.D. (NASA Johnson Space Center) Soller, Babs Ph.D. (Reflectance Medical Inc.) Laurie, Steven Ph.D. (KBR/NASA Johnson Space Center) Marshall-Goebel, Karina Ph.D. (KBR/NASA Johnson Space Center) Ribeiro, Laura Christine J.D., M.S. (KBR/NASA Johnson Space Center)
Grant/Contract No.:	Internal Project
Performance Goal No.:	
Performance Goal Text:	
Task Description:	The central objective of the proposed work is to characterize the magnitude of the headward fluid shift during long duration space flight and to measure the subsequent compartmentalization of this fluid. The second objective is to correlate in-flight alterations of eye structure, ocular vascular parameters, and vision with headward fluid shifts, vascular dimensions, and flow patterns. Finally, the third objective is to determine systemic and ocular factors of individual susceptibility to the development of these inflight alterations. In order to determine the effect of space flight on the headward fluid shift and subsequent redistribution across fluid compartments, biochemical, ultrasound, and other non-invasive cardiovascular measures will be performed before launch, during flight, and after landing. Total body water, extracellular, and intracellular fluid volume will be determined by biochemical dilution techniques. Ultrasound will be used to assess upper vs. lower body interstitial fluid and vascular flow and structure changes, ocular dimensions and optic nerve sheath diameter, and jugular venous pressure. Near infrared spectroscopy will be used to measure lower vs. upper body local tissue hydration, and total peripheral resistance will be calculated from noninvasively acquired blood pressure and cardiac output. It is currently unclear why only some astronauts experience vision disturbances with space flight. It is hypothesized that astronauts respond differently to the fluid shift inflight and that this impacts changes in ocular structure and function changes. The goal of this study is to test this hypothesis. In doing so, this proposal directly addresses the Integrated Research Plan Gap Cardiovascular (CV)7: How are fluids redistributed in-flight? and Gap Vision Impairment and Intracranial Pressure (VIIP)1: What is the etiology of visual acuity and ocular structural and function changes seen in-flight and post-flight? The research proposed here will determine the effect of long duration space flight on fluid shifts and subsequent redistribution across fluid compartments and attempt to discern the contribution of these adaptations to changes in ocular structure and function. NOTE: This study was merged with investigations from Dr. Alan Hargens (Fluid distribution before, during and after prolonged space flight) 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). NOTE: Continued by "Distribution of Body Fluids during Long Duration Space Flight and Subsequent Effects on Intraocular Pressure and Vision Disturbance (PI: Laurie)" due to Dr. Stenger's move to Element Scientist for Human Health & Countermeasures element.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	An early hypothesis considered elevated intracranial pressure (ICP) as a cause for space flight associated neuro-ocular syndrome. Because of this, novel noninvasive ICP techniques, included tympanic membrane displacement and otoacoustic emissions are being investigated to determine ICP changes associated with space flight. Knowledge gained from this study may inform medical professionals treating and studying patients suffering from idiopathic intracranial hypertension, a debilitating condition with some characteristics in common with that experienced by astronauts.
Task Progress:	Within this reporting period we completed 10 inflight and 7 post-flight tests. To date, all pre/in/post-flight data collection has been completed on 12 subjects for this experiment. The final subject will require 1 more post-flight session, which will mark the completion of data collection for this study. This is expected to be completed by November of 2020. Data collected as a part of this project were included in two presentations at the Human Research Program Investigators' Workshop in Galveston, TX, invited oral presentations at the Humans in Space Annual Meeting in Dubai, United Arab Emirates; University of Oregon Department of Human Physiology Seminar Series, Eugene, OR; Loma Linda University Integrated Biomedical Science Seminar, Loma Linda, CA; the Blind Veterans Association Annual Conference, Zoom Virtual Meeting; and the Rice University Keck Seminar, Zoom Virtual Meeting. In addition, a crew report was completed to highlight individual results from that crewmembers participation in this study. Partial results from this investigation were made available as part of 2 publications in the journals JAMA Ophthalmology and JAMA Network. Results published in JAMA Network revealed the first time a venous thrombosis was identified in a crewmember during space flight. This resulted in a number of news requests and media coverage. NOTE: Continued by "Distribution of Body Fluids during Long Duration Space Flight and Subsequent Effects on Intraocular Pressure and Vision Disturbance (PI: Laurie)" due to Dr. Stenger's move to Element Scientist for Human Health & Countermeasures element. See that project for additional reporting and for other CoInvestigators associated with the "Fluid Shifts" project over the life of the project.
Bibliography Type:	Description: (Last Updated: 05/20/2022)

Articles in Peer-reviewed Journals	Laurie SS, Lee SMC, Macias BR, Patel N, Stern C, Young M, Stenger MB. "Optic disc edema and choroidal engorgement in astronauts during spaceflight and individuals exposed to bed rest. " JAMA Ophthalmol. 2019 Dec 26;138(2):165-72. https://doi.org/10.1001/jamaophthalmol.2019.5261 ; PMID: 31876939; PMCID: PMC6990717 , Dec-2019
Articles in Peer-reviewed Journals	Marshall-Goebel K, Laurie SS, Alferova IV, Arbeille P, Auñón-Chancellor SM, Ebert DJ, Lee SMC, Macias BR, Martin DS, Pattarini JM, Ploutz-Snyder R, Ribeiro LC, Tarver WJ, Dulchavsky SA, Hargens AR, Stenger MB. "Assessment of jugular venous blood flow stasis and thrombosis during spaceflight." JAMA Netw Open. 2019 Nov 1;2(11):e1915011. https://doi.org/10.1001/jamanetworkopen.2019.15011 ; PMID: 31722025; PMCID: PMC6902784 , Nov-2019
Articles in Peer-reviewed Journals	Stenger MB, Laurie SS, Sadda SR, Sadun AA, Macias BR, Huang AS. "Focus on the optic nerve head in spaceflight-associated neuro-ocular syndrome." Ophthalmology. 2019 Dec;126(12):1604-6. https://doi.org/10.1016/j.ophtha.2019.09.009 ; PMID: 31759496 , Dec-2019
Articles in Peer-reviewed Journals	Greenwald SH, Macias BR, Lee SMC, Marshall-Goebel K, Ebert DJ, Liu JHK, Ploutz-Snyder RJ, Alferova IV, Dulchavsky SA, Hargens AR, Stenger MB, Laurie SS. "Intraocular pressure and choroidal thickness respond differently to lower body negative pressure during spaceflight." J Appl Physiol (1985). 2021 Aug 1;131(2):613-20. https://doi.org/10.1152/japplphysiol.01040.2020 ; PMID: 34166098 , Aug-2021
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 cerebral vein velocity elevation during long-duration spaceflight." J Appl Physiol (1985). 2021 Jul 29. Online ahead of print. https://doi.org/10.1152/japplphysiol.00231.2021 ; PMID: 34323592 , Jul-2021
Articles in Peer-reviewed Journals	Macias BR, Ferguson CR, Patel N, Gibson C, Samuels BC, Laurie SS, Lee SMC, Ploutz-Snyder R, Kramer L, Mader TH, Brunstetter T, Alferova IV, Hargens AR, Ebert DJ, Dulchavsky SA, Stenger MB. "Changes in the optic nerve head and choroid over 1 year of spaceflight." JAMA Ophthalmol. 2021 Jun;139(6):663-7. https://doi.org/10.1001/jamaophthalmol.2021.0931 ; PMID: 33914020; PMCID: PMC8085766 , Jun-2021
Articles in Peer-reviewed Journals	Garrett-Bakelman FE, Darshi M, Green SJ, Gur RC, Lin L, Macias BR, McKenna MJ, Meydan C, Mishra T, Nasrini J, Piening BD, Rizzardi LF, Sharma K, Siamwala JH, Taylor L, Vitaterna MH, Afkarian M, Afshinnekoo E, Ahadi S, Ambati A, Arya M, Bezdan D, Callahan CM, Chen S, Choi AMK, Chlipala GE, Contrepois K, Covington M, Crucian BE, De Vivo I, Dinges DF, Ebert DJ, Feinberg JI, Gandara JA, George KA, Goutsias J, Grills GS, Hargens AR, Heer M, Hillary RP, Hoofnagle AN, Hook VYH, Jenkinson G, Jiang P, Keshavarzian A, Laurie SS, Lee-McMullen B, Lumpkins SB, MacKay M, Maienschein-Cline MG, Melnick AM, Moore TM, Nakahira K, Patel HH, Pietrzyk R, Rao V, Saito R, Salins DN, Schilling JM, Sears DD, Sheridan CK, Stenger MB, Tryggvadottir R, Urban AE, Vaisar T, Van Espen B, Zhang J, Ziegler MG, Zwart SR, Charles JB, Kundrot CE, Scott GBI, Bailey SM, Basner M, Feinberg AP, Lee SMC, Mason CE, Mignot E, Rana BK, Smith SM, Snyder MP, Turek FW. "The NASA Twins Study: A multidimensional analysis of a year-long human spaceflight." Science. 2019 Apr 12;364(6436):eaau8650. https://science.sciencemag.org/content/364/6436/eaau8650.long ; PubMed PMID: 30975860 , Apr-2019