Fiscal Year:	FY 2019	**Task Last Updated:**	FY 07/24/2018
PI Name:	Ethier, Christopher Ph.D.		
Project Title:	VIIP Simulations of CSF, Hemodynamics and Ocular Risk (VIIP SCHOLAR)		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:		**TechPort:**	Yes
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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Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-Crew Health (FLAGSHIP, NSBRI, OMNIBUS). Appendix A-Crew Health, Appendix B-NSBRI, Appendix C-Omnibus
Start Date:	10/01/2016	**End Date:**	09/30/2019
No. of Post Docs:	2	**No. of PhD Degrees:**	
No. of PhD Candidates:	2	**No. of Master' Degrees:**	
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:	2	**Monitoring Center:**	NASA GRC
Contact Monitor:	Norsk, Peter	**Contact Phone:**	
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Martin, Bryn Ph.D. (University of Idaho, Moscow) Myers, Jerry Ph.D. (NASA Glenn Research Center) Oshinski, John Ph.D. (Emory University) Samuels, Brian M.D., Ph.D. (University of Alabama, Birmingham)		
Grant/Contract No.:	NNX16AT06G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Visual Impairment/Intracranial Pressure (VIIP) syndrome [Ed. note July 2018: now referred to as Spaceflight Associated Neuro-ocular Syndrome (SANS)] occurs in a significant fraction of astronauts undergoing long-duration space flight, and is characterized by a spectrum of ophthalmic changes (see http://humanresearchroadmap.nasa.gov/). Astronauts with VIIP can suffer permanent loss of visual acuity, and thus this condition is a major health concern for NASA. The pathophysiology of VIIP is poorly understood. However, evidence points to an important role for alterations in cerebrospinal fluid (CSF) and vascular flow dynamics/pressures in microgravity. In view of the above, we hypothesize that the pathophysiology of VIIP involves alterations in biomechanical loads on the neural and connective tissues of the posterior globe/optic nerve due to changed CSF/blood pressures in microgravity. We further postulate that risk factors for VIIP can be identified through numerical modeling of these processes, and that such models can be used to evaluate proposed VIIP countermeasures. In this proposal we will develop modeling tools that: (i) compute fluid shifts in microgravity; (ii) compute how these shifts lead to biomechanical insult to the optic nerve in astronauts; and (iii) estimate the effect that these insults have on optic nerve function. These tools will directly build upon, and interface with, models of ocular biomechanics and fluid shifts that we are currently developing in our NASA-funded MONSTR Sim project. Towards this end, we propose 4 specific aims: SA1: Measure key physiologic parameters needed for modeling, including effects of intracranial pressure on optic nerve sheath diameter, optic nerve tortuosity, craniospinal volume, and cerebral blood flow. SA2: Incorporate “quasi-1D” effects into existing compartment models, allowing us to evaluate the effects of microgravity and countermeasures on CSF and blood flows/pressures. SA3: Extend finite element models of ocular biomechanics, specifically modeling: (i) optic nerve kinking, and (ii) compression of optic nerve fiber bundles in the lamina cribrosa; and relate kinking/compression to an index of axoplasmic insult/stasis. SA4: Carry out parametric studies integrating the above models to identify individual-specific factors that: (i) predispose for the development of VIIP syndrome, and (ii) influence the efficacy of proposed countermeasures, both useful for risk profiling. The resulting models will provide a powerful platform for better understanding individual-specific risks for VIIP and, eventually, for evaluating VIIP mitigation strategies, thus contributing to astronaut health. More specifically, these models will allow us to quantify the biomechanical environment of the optic nerve at the level of individual nerve fiber bundles, with outcome measures designed to predict the risk of two specific clinical features of VIIP: optic nerve kinking and papilledema. This proposal directly addresses an explicit requirement of NASA Research Announcement NNJ15ZSA001N, namely to “...to develop and deliver detailed numerical models that quantify how CSF and vascular flow dynamics are altered in microgravity, and the propagative effects on the structure of the eye. The models must also be developed with the capability to interact with other pre-existing numerical models of the cardiovascular system, central nervous system, and eye ...” The team assembled for this work has highly complementary skills that together address all relevant aspects of this complex, interdisciplinary problem. In addition to Ethier (Principal Investigator (PI) at Georgia Tech; expertise in modeling optic nerve head and ocular biomechanics), co-investigators include Myers (NASA Glenn; expertise in cephalad fluid shift models and space physiology); Samuels (Alabama; expertise in clinical ophthalmology and neuroscience); Oshinski (Georgia Tech/Emory; expertise in MR imaging of CSF and blood flow dynamics); and Martin (Idaho; expertise in modeling CSF dynamics).
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	May also help the understanding of idiopathic intracranial hypertension, an analogous condition that occurs in patients on Earth.
Task Progress:	We have made progress on multiple fronts. We have completed MR scans of 10 volunteers under supine and head-down-tilt (HDT) positions, focusing on changes in ocular and optic nerve sheath (ONS) dimensions. These scans have been analyzed to extract quantitative information about ONS expansion as a function of posture and estimated cerebrospinal fluid pressure. This information has been used to drive models enabling us to determine material properties of the ONS tissue, and we will be extending this methodology to additional subjects in the upcoming several months. The techniques that we are developing for this purpose will enable us to determine whether changes in the connective tissues of astronauts may be playing a role in certain of the physiological changes seen in Spaceflight Associated Neuro-ocular Syndrome (SANS). Additionally, we have made progress on validating our whole body fluid shift models and incorporating effects of autoregulation. These allow us to predict how fluid volumes and pressures change in the head and other locations under the action of microgravity, and will be coupled to the eye-specific models mentioned above. This will help illuminate the role of blood and CSF in the pathophysiology of SANS.
Bibliography Type:	Description: (Last Updated: 11/26/2021)
Abstracts for Journals and Proceedings	Rohr JJ, Sass AM, Sater S, Macias B, Oshinski JN, Ethier CR, Stenger M, Martin BA. "MRI-based quantification of optic nerve tortuosity and subarachnoid space 3d geometry: reliability assessment." 2018 NASA Human Research Program Investigators’ Workshop, Galveston, TX, January 22-25, 2018. 2018 NASA Human Research Program Investigators’ Workshop, Galveston, TX, January 22-25, 2018. , Jan-2018

Abstracts for Journals and Proceedings	Rohr JJ, Sass AM, Sater S, Aldrimk B, Stenger M, Macias B, Ethier CR, Sargsyan A, Martin BA. "Inter-operator Reliability Assessment of Optic Nerve Tortuosity in Long-duration Flight Astronauts." 33rd Annual Meeting of the American Society for Gravitational and Space Research, Seattle, WA, October 25-28, 2017. 33rd Annual Meeting of the American Society for Gravitational and Space Research, Seattle, WA, October 25-28, 2017. , Oct-2017
Abstracts for Journals and Proceedings	Sass AM, Sater S, Rohr JJ, Macias B, Oshinski JN, Ethier CR, Stenger M, Martin BA. "Methods for Quantifying Tortuosity and 3d Geometry Changes Occurring to the Optic Nerve During Long-Duration Spaceflight." University of Idaho Undergraduate Research Symposium, Moscow, ID, April 30, 2018. University of Idaho Undergraduate Research Symposium, Moscow, ID, April 30, 2018. , Apr-2018
Abstracts for Journals and Proceedings	Sass AM, Rohr JJ, Stenger M, Macias B, Ethier CR, Sargsyan AE, Martin BA. "Automated Method to Quantify 3D Geometric Alterations of the Optic Nerve and Sheath in Astronauts." 2018 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2018. The Gateway to Mars. 2018 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2018. , Jan-2018
Abstracts for Journals and Proceedings	Myers J, Werner C, Nelson E, Feola A, Raykin J, Samuels B, Ethier CR. "Modeling Microgravity Induced Fluid Redistribution: Physiological Parameters." 2017 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 23-26, 2017. 2017 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 23-26, 2017. , Jan-2017
Abstracts for Journals and Proceedings	Ethier CR, Myers JG, Nelson E, Martin B, Oshninski JN, Samules B, Feola AJ. "Effects of CSF Pressure on the Eye: A Computational-Experimental Comparison." 2018 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2018. 2018 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2018. , Jan-2018
Articles in Peer-reviewed Journals	Feola AJ, Nelson ES, Myers JG, Ethier CR, Samuels BC. "The impact of choroidal swelling on optic nerve head deformation. " Invest Ophthalmol Vis Sci. 2018 Aug 1;59(10):4172-81. https://doi.org/10.1167/iovs.18-24463 ; PubMed PMID: 30120486 [Note: reported in June 2018 as in press] , Aug-2018