Fiscal Year:	FY 2021	**Task Last Updated:**	FY 02/23/2021
PI Name:	Zhang, Quan Ph.D.		
Project Title:	Characterizing the Baselines of Sleep Quality, Cognitive / Operational Performance, Immune Function, and Intracranial Fluids for Deep Space Expeditions		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02129-2020	**Congressional District:**	7
Comments:			
Project Type:	Flight	**Solicitation / Funding Source:**	2017-2018 HERO 80JSC017N0001-BPBA Topics in Biological, Physiological, and Behavioral Adaptations to Spaceflight. Appendix C
Start Date:	04/22/2019	**End Date:**	05/31/2026
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:	3	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	6	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 05/31/2026 per NSSC information (Ed., 2/3/2020) NOTE: End date changed to 9/30/2020 per NSSC information (Ed., 2/3/2020)		
Key Personnel Changes/Previous PI:	February 2021 report: Vladimir Ivkovic is now CoInvestigator on the project.		
COI Name (Institution):	Kimberly, William M.D., Ph.D. (Massachusetts General Hospital) Vujovic, Nina Ph.D. (Brigham And Women's Hospital, Inc.) Spielmann, Guillaume Ph.D. (Louisiana State University and A&M College) Strangman, Gary Ph.D. (Massachusetts General Hospital) Ivkovic, Vladimir Ph.D., Sc.D. (Massachusetts General Hospital)		
Grant/Contract No.:	80NSSC19K0925		
Performance Goal No.:			

Performance Goal Text:	
Task Description:	Sleep is central physiological regulator of cognitive / behavioral, neurophysiological, and immune functions. The study of sleep quality and duration on orbit may thus yield important insights into etiology and mechanisms of adverse cognitive/behavioral, Spaceflight Associated Neuro-ocular Syndrome (SANS), and immunological responses during long duration deep space exploration missions. We propose to use an integrated approach combining assessments of (1) sleep quality and duration, (2) intracranial physiology, (3) cognitive performance, and (4) immunological response. We propose to collect data on crewmembers participating in integrated one-year mission project (CIPHER) aboard the International Space Station (ISS), and demographically matched control subjects in Human Exploration Research Analog (HERA) for missions of similar durations. Our specific aims are: (SA1) Characterize cognitive task performance changes during the integrated 1 Year Mission Project (1YMP) on the ISS; (SA2) Characterize brain and systemic physiology changes during 1YMP on the ISS; (SA3) Characterize the effects of sleep duration and quality on cerebral hemodynamics on ISS and in HERA; and (SA4) Quantify the effects of sleep duration and quality on immune response. The outcomes of the study will contribute to quantification of crew health and performance risks associated with human spaceflight, and aid in development of technologies for monitoring and mitigating crew health and performance.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Successful completion of this project will be a milestone in spaceflight behavioral, neurophysiological, and immune investigation. It will be the largest study of operational performance in space, and the first to conduct in-flight resting-state and task-related functional brain imaging. In addition, it will be the first study to probe the relationships and interactions between behavioral, neurophysiological, and immune functioning. The use of three different length missions will further enable us to extrapolate any effects towards longer missions. The findings will be important on Earth as well, by helping to better understand the complex inter-relationships between sleep, brain physiology, immune function, and cognitive performance.
Task Progress:	PROJECT OVERVIEW Sleep is a central physiological regulator of cognitive / behavioral, neurophysiological, and immune functions. The study of sleep quality and duration on orbit may thus yield important insights into etiology and mechanisms of adverse cognitive/behavioral, Spaceflight Associated Neuro-ocular Syndrome (SANS), and immunological responses during long duration deep space exploration missions. We propose to investigate these relationships via an integrated approach combining assessments of (1) sleep quality and duration, (2) intracranial physiology, (3) cognitive performance, and (4) immunological response. We will collect data on crewmembers participating in integrated one-year mission project (CIPHER), including flyers on short-duration (<3 months), nominal-duration (~6 months), and long-duration (~12 months) missions aboard the International Space Station (ISS). We also plan to study demographically matched control subjects in Earth-based analogs (e.g., the Human Exploration Research Analog, or HERA) during missions of similar duration. Our specific aims are: (SA1) Characterize cognitive task performance changes during the integrated 1 Year Mission Project (1YMP) on the ISS; (SA2) Characterize brain and systemic physiology changes during 1YMP on the ISS; (SA3) Characterize the effects of sleep duration and quality on cerebral hemodynamics on ISS and in HERA; and (SA4) Quantify the effects of sleep duration and quality on immune response. The outcomes of the study will contribute to quantification of crew health and performance risks associated with human spaceflight, and aid in development of technologies for monitoring and mitigating crew health and performance. Our CIPHER project seeks in particular to provide a wide range of brain-related measures for all subjects in all study arms. These include changes in (i) blood flow in/out of the brain, (ii) cerebral blood flow, (iii) brain perfusion and oxygenation, (iv) blood distribution along the body axis, (v) intracranial pulsatility, (vi) sagittal sinus imaging of potential, (vii) intracranial water concentration, (xiii) functional brain activation, (ix) electrical brain activity, as well as (x) cognitive performance data (Cognition). We also plan to compare these measures with measures from other groups including ocular measures, mood and sleep, 1-carbon single nucleotide polymorphisms, and MRI. In addition, a Psycho-Neuro-Immunological (PNI) supplement to this project seeks to investigate the influence of headward fluid shifts on facial expressiveness, ability to convey non-verbal affective cues, and compromised cognitive and immune functioning. SUMMARY TO DATE We are reaching the end of year 2 of this project, and by that time we will have achieved the following milestones: • Full IRB (Institutional Review Board) approval (NASA and Massachusetts General Hospital) was obtained and we initiated subject recruitment as part of the integrated CIPHER complement informed consent process. Final approvals from partnering space agencies are expected by the end of year 2. • Integration of NINscan-sleep project measurements with other CIPHER complement investigators was completed, involving numerous decisions regarding data- and sample-sharing arrangements to ensure maximal science with a minimal crew-time footprint. • Overall CIPHER integration and timeline revision was completed. This involved—for all CIPHER investigators—significant reductions in the number of testing days as well as reductions in measurement times to meet the collective flight and crew-time requirements. • In coordination with NASA Research Operations and Integration (ROI) Human Research Program element, we completed the design and development of v3, and subsequently v4, of our NINscan physiological monitoring hardware (NINscan systems). Changes were required in electrical, interface, and shielding components to achieve flight certification. We expect to have a finalized version of NINscan (v4)—including control hardware, enclosure, and sensors—completed by the end of year 2. • We sought and received approval to expand serum cytokine measurements using Multiplex technology, providing a more comprehensive assessment of immunological status of the astronauts. • We sought and gained approval for the PNI supplement project and have initiated preliminary work including pilot work collecting 3D scans of individuals at multiple head-up and head-down tilt angles.

	• The project also provided numerous educational activities for six bachelor’s and three graduate students on both the CIPHER and PNI supplement projects. This included learning how to develop research procedures and protocols, how to conduct pilot testing and data quality control, as well as writing up summaries and abstracts and poster presentations of the research for the 2021 NASA Human Research Program’s Investigators' Workshop.
Bibliography Type:	Description: (Last Updated: 04/12/2022)