Fiscal Year:	FY 2021	**Task Last Updated:**	FY 08/23/2020
PI Name:	Goel, Namni Ph.D.		
Project Title:	Biomarkers as Predictors of Resiliency and Susceptibility to Stress in Space Flight		
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:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	60612	**Congressional District:**	7
Comments:	NOTE: Formerly at the University of Pennsylvania until July 2019.		
Project Type:	Ground	**Solicitation / Funding Source:**	2013 HERO NNJ13ZSA002N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	10/23/2019	**End Date:**	09/20/2024
No. of Post Docs:	1	**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	3
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 9/20/2024 per NSSC information (Ed., 9/3/20)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):			
Grant/Contract No.:	80NSSC20K0243		
Performance Goal No.:			
Performance Goal Text:			
	NOTE: Continuation of "Biomarkers as Predictors of Resiliency and Susceptibility to Stress in Space Flight," grant NNX14AN49G, due to Principal Investigator (PI) move to Rush University from University of Pennsylvania in summer 2019, requiring issue of new grant. This proposal is responsive to the NASA Behavioral Health and Performance gap (BMed5) to find individual characteristics that predict successful adaptation and performance in an isolated, confined, and extreme environment, especially for long duration missions. The project also relates to Human Research Program (HRP) Sleep Gap 4 to identify indicators of individual susceptibilities and resiliencies to sleep loss and circadian rhythm disruption, to aid with individualized countermeasure regimens, for autonomous, long duration, and/or distance exploration missions. The proposal is also responsive to BMed 1 and BMed 2, and Sleep Gap 2 and Sleep Gap 9. To address these gaps, this		

Task Description:	proposal will assess biomarkers as predictors of resiliency and susceptibility (individual differences) to performance stress and sleep loss using the HRP Human Exploration Research Analog (HERA) and the Hawaii Space Exploration Analog and Simulation (HI-SEAS) high fidelity space analog facilities. We will conduct a ground-based experiment—strongly anchored in our previous laboratory-based research—on N=32 healthy men and women (ages 26-55) in the HERA facility (short-duration analog) and on N=6 healthy men and women (ages 21-65) in the HI-SEAS facility (long-duration analog) to determine the predictive validity of a set of relevant, valid, and reliable biomarkers for distinguishing those who are more resilient versus those who are more susceptible to the adverse neurobehavioral effects of the combination of high performance demands and total sleep deprivation (TSD) stressors—two conditions commonly experienced in space flight. These biomarkers include the following: cardiovascular measures (blood pressure, heart rate and heart rate variability, stroke volume, and cardiac output), salivary cortisol, catecholamines (dopamine, noradrenaline, and adrenaline), an inflammatory marker (C-reactive protein; CRP), metabolomic markers (via unbiased metabolomics), and microRNAs (epigenetic markers). The project deliverable will be a countermeasure (set of diverse biomarkers) for distinguishing those who are more resilient versus those who are more susceptible to the adverse neurobehavioral effects of high performance demands and sleep loss stressors. If valid markers of such susceptibility can be found, it will be possible to optimize and individualize crew resources, and mitigate stress and other behavioral health and performance risks autonomously during long-duration space flight. The SIRIUS (Scientific International Research In a Unique terrestrial Station) missions are the first time NASA's Human Research Program (HRP) partners with Russia's IBMP (Institute for Biomedical Problems) Ground-based Experimental Complex NEK (Nezemnyy Eksperimental'nyy Kompleks) to conduct a series of analog missions. Dr. Goel's project will be part of the 2019 mission as well as the upcoming 2020 mission.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The project's research will deliver a countermeasure (set of diverse biomarkers) for distinguishing those who are more resilient versus those who are more susceptible to the adverse neurobehavioral effects of high performance demands and sleep loss stressors. If valid markers of such susceptibility can be found, it will be possible to optimize and individualize crew resources, and mitigate stress and other behavioral health and performance risks autonomously during long-duration space flight. This information would also be of use on Earth in applied occupations that demand similar risks and stressors.
Task Progress:	We integrated the complex, multifaceted five-day stress and sleep loss experiment into HERA and successfully collected data in all four 14-day 2015 and all four 30-day 2016 missions (N=32 crewmembers). These data include the following biomarkers: blood markers from 6 time points in 32 crewmembers (190 blood markers; n=2 crewmembers did not participate in one biomarker assessment); 2 saliva markers each from 6 time points in 32 crewmembers (382 saliva markers; n=1 crewmember did not participate in one biomarker assessment); blood pressure markers from 6 time points in 32 crewmembers (191 blood pressure markers; n=1 crewmember did not participate in one biomarker assessment); stroke volume and cardiac output from 6 time points in 32 crewmembers (191 stroke volume and cardiac output markers; n=1 crewmember did not participate in one biomarker assessment); and heart rate from 6 time points in 32 crewmembers (189 heart rate markers: 3 heart rate monitor data points were not collected due to n=2 crewmembers mistakenly not turning on the heart rate device and n=1 crewmember not participating in one biomarker assessment; however, heart rate data collected from the echocardiography and/or blood pressure devices can be used as needed). We also have data from 11 neurobehavioral tests for 32 crewmembers (348 neurobehavioral tests; one crewmember did not participate in 4 neurobehavioral assessments). Almost all the missing data can be attributed to one crewmember who experienced a medical emergency. Finally, we have continuous actigraphy data on n=16 crewmembers for 14-days each (a total of 224 days of actigraphy) and on n=16 crewmembers for 30-days each (a total of 480 days of actigraphy). Analyses of the wrist actigraphy data from the four 14-day HERA missions of 2015 (n=16) and the four 30-day HERA missions of 2016 (n=16) indicate crew members were compliant with the dictated sleep-wake times at baseline and recovery, and were not sleeping during the total sleep deprivation (TSD) night. As expected for these 32 crewmembers, on average, the performance variables show significant impairment with TSD (with individual differences in neurobehavioral responses). Thus, the sleep loss manipulation in HERA was highly effective. We successfully completed the 17-day initial "shakedown" mission in November 2017 on N=6 subjects. Two miRNA samples were not collected due to blood flow issues with the blood draws, and one NTB test bout was not collected; all other pilot data were successfully collected. We successfully completed the 4-month, long duration mission in NEK in July 2019 on N=6 subjects, with all data collected. We are actively preparing for participation in the 8-month, long duration mission in NEK in November 2020 (mission start date has been pushed back to June 2021 due to COVID-19) on N=6 subjects. We also will be participating in the 12-month, long duration mission in NEK planned to begin in October 2022.
Bibliography Type:	Description: (Last Updated: 06/03/2025)
Abstracts for Journals and Proceedings	Goel N, Yamazaki EM, Ecker A. "Biomarkers as predictors of resiliency and susceptibility to stress in space flight." Presented at the 2020 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 27-30, 2020. HRP abstracts. 2020 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 27-30, 2020. , Jan-2020
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