Fiscal Year:	FY 2017	**Task Last Updated:**	FY 07/28/2016
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:	HUMAN RESEARCH--Behavior and performance		
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:	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:	10/01/2014	**End Date:**	09/30/2018
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:	0	**No. of Bachelor's Degrees:**	3
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Williams, Thomas	**Contact Phone:**	281-483-8773
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Flight Program:			
Flight Assignment:	NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17) NOTE: End date is 9/30/2018 per NSSC information (Ed., 1/11/17)		
Key Personnel Changes/Previous PI:	N/A		
COI Name (Institution):	Abel, Ted Ph.D. (University of Pennsylvania) Basner, Mathias M.D., Ph.D. (University of Pennsylvania) Bhatnagar, Seema Ph.D. (Children's Hospital of Philadelphia) Dinges, David Ph.D. (University of Pennsylvania) Kirkpatrick, James (University of Washington) Weljie, Aalim Ph.D. (University of Pennsylvania)		
Grant/Contract No.:	NNX14AN49G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	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 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.
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 have integrated the complex, multifaceted five-day stress and sleep loss experiment into HERA and successfully collected data in all four 14-day 2015 missions (N=16 crewmembers). These data include the following biomarkers: blood markers from 6 time points in 16 crewmembers (95 blood markers; N=1 crewmember did not participate in one biomarker assessment); 2 saliva markers each from 6 time points in 16 crewmembers (190 saliva markers; N=1 crewmember did not participate in one biomarker assessment); blood pressure markers from 6 time points in 16 crewmembers (95 blood pressure markers; N=1 crewmember did not participate in one biomarker assessment); stroke volume and cardiac output from 6 time points in 16 crewmembers (95 stroke volume and cardiac output markers; N=1 crewmember did not participate in one biomarker assessment); and heart rate from 6 time points in 16 crewmembers (93 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 16 crewmembers (172 neurobehavioral tests; one crewmember did not participate in 4 neurobehavioral assessments). Almost all of the missing data can be attributed to one crewmember who experienced a medical emergency. Finally, we have continuous actigraphy data on N=16 subjects for 14-days each (a total of 224 days of actigraphy). In the first two 30-day missions of 2016, all project data were successfully collected. These data include the following biomarkers: blood markers from 6 time points in 8 crewmembers (48 blood markers); 2 saliva markers each from 6 time points in 8 crewmembers (96 saliva markers); blood pressure markers from 6 time points in 8 crewmembers (48 blood pressure markers); stroke volume and cardiac output from 6 time points in 8 crewmembers (48 stroke volume and cardiac output markers); and heart rate from 6 time points in 8 crewmembers (48 heart rate markers). We also have data from 11 neurobehavioral tests for 8 crewmembers (88 neurobehavioral tests). The third mission is currently ongoing, and the last mission of 2016 will begin in September. It is projected that biomarker, neurobehavioral, and actigraphy data collection will continue successfully and by the end of the last mission we will have data from a total of N=16 subjects in 30-day missions. Analyses of the wrist actigraphy data from the four 14-day HERA missions of 2015 (N=16) and the two 30-day HERA missions of 2016 indicate crew members (N=8) are compliant with the dictated sleep-wake times at baseline and recovery, and are not sleeping during the total sleep deprivation (TSD) night. As expected for these 24 crewmembers, on average, the performance variables show significant impairment with TSD (with individual differences in responses). Thus, the sleep loss manipulation in HERA has been highly effective.
Bibliography Type:	Description: (Last Updated: 06/03/2025)
Abstracts for Journals and Proceedings	Goel N, Dennis L, Ecker A, Abel T, Basner M, Bhatnagar S, Dinges DF, Kirkpatrick J, Weljie A. "Biomarkers as predictors of resiliency and susceptibility to stress in space flight." Presented at the 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016
Abstracts for Journals and Proceedings	Dennis L, Ecker A, Goel N. "Crewmembers show deficits and individual differences in neurobehavioral responses to.stress and sleep loss in HERA 14-day missions. " Presented at the 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016

Abstracts for Journals and Proceedings	Goel N, Sengupta A, Meerlo P, Abel T, Sehgal A, Weljie AM, Dinges DF. "Biomarkers for predicting susceptibility or resilience to sleep loss: implications for personalized countermeasures." Presented at the 87th Aerospace Medical Association Annual Meeting, Atlantic City, NJ, April 24-28, 2016. Aerosp Med Hum Perform. 2016 Mar;87(3):274. , Mar-2016
Articles in Peer-reviewed Journals	Basner M, McGuire S, Goel N, Rao H, Dinges DF. "A new likelihood ratio metric for the Psychomotor Vigilance Test and its sensitivity to sleep loss." J Sleep Res. 2015 Dec;24(6):702-13. Epub 2015 Jun 29. http://dx.doi.org/10.1111/jsr.12322 ; PMID: 26118830 , Dec-2015
Articles in Peer-reviewed Journals	Spaeth AM, Dinges DF, Goel N. "Resting metabolic rate varies by race and by sleep duration." Obesity (Silver Spring). 2015 Dec;23(12):2349-56. http://dx.doi.org/10.1002/oby.21198 ; PMID: 26538305 ; PubMed Central PMCID: PMC4701627 , Dec-2015
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Articles in Peer-reviewed Journals	Goel N. "Probing personalized genetic platforms for novel molecular clues for circadian chronotype." Ann Transl Med. 2016 May;4(10):207. http://dx.doi.org/10.21037/atm.2016.05.25 ; PubMed PMID: 27294243; PubMed Central PMCID: PMC4885892 , May-2016
Awards	Goel N. "Distinguished Visiting Scholar, University of South Australia, January 2016." Jan-2016