Fiscal Year:	FY 2017	**Task Last Updated:**	FY 02/05/2018
PI Name:	Barger, Laura Ph.D.		
Project Title:	Environmental Factors Associated with Sleep Deficiency During Spaceflight		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Human Factors and Performance Team		
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 (2) **Hypoxia**:Risk of Reduced Crew Health and Performance Due to Hypoxia [inactive]		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02115-5817	**Congressional District:**	7
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:	06/01/2016	**End Date:**	05/31/2017
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:**	0
No. of Bachelor's Candidates:	3	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Abercromby, Andrew Ph.D. (NASA Johnson Space Center) Alexander, David M.D. (NASA Johnson Space Center) Czeisler, Charles M.D., Ph.D. (Brigham And Women's Hospita) Flynn-Evans, Erin Ph.D. (NASA Ames Research Center) Limardo, Jose M.S. (NASA Johnson Space Center) Wang, Wei Ph.D. (Brigham And Women's Hospital)		
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Performance Goal No.:			

Performance Goal Text:	
Task Description:	BACKGROUND: After landing on the moon in 1969, Astronaut Neil Armstrong was reportedly unable to sleep all night and Astronaut Buzz Aldrin managed only a couple of hours of fitful drowsing during their 21.6 hours on the moon, reportedly because they could not escape from light and noise in the small cabin of their spacecraft and the spacesuit's cooling system made it too cold for sleeping. Environmental factors continue to impact sleep in the modern era of spaceflight. During a ten-year study of sleep aboard Shuttle and International Space Station (ISS) missions, crewmembers reported sleep disturbances via a daily log. Shuttle crewmembers reported sleep disturbance on 58 percent of inflight nights and ISS crewmembers reported sleep disturbance on 35 percent of inflight nights. There are numerous stressors that are unique to the spaceflight environment that might account for sleep disturbances and prompt use of sleep-promoting medications. Noise, which can disrupt slow wave and REM sleep, both of which are critical to the restorative function of sleep, remains a major source of sleep disruption in modern spaceflight. Both shuttle and ISS crewmembers attributed 1 in 5 inflight disruptions to noise. Although not included in the daily diary of the previous study due to its insidious nature, low levels of oxygen and high levels of carbon dioxide have been hypothesized to account for sleep disturbances during spaceflight. METHODOLOGY: Over the past ten years, we objectively assessed, via wrist actigraphy and daily logs, sleep-wake timing of 64 astronauts on 80 Space Shuttle missions, encompassing 26 Space Transportation System flights (1,063 inflight days), and 21 astronauts on the ISS (3,248 inflight days). Thus, we have a database of over 4,000 sleep episodes, which provides a unique opportunity to objectively analyze other environmental factors that may influence sleep during spaceflight. Our research team included NASA investigators and operational personnel who have collected time-stamped environmental data during spaceflight (e.g., noise levels, oxygen and carbon dioxide levels). We statistically evaluated the association among objective and subjective measures of sleep quantity and quality with varying levels of these environmental factors. RESULTS: None of the sleep variables showed any significant difference between the 14.7 psia and 10.2 psia conditions. There was a significant increase (22 minutes) in total sleep time (TST) when the mean $ppCO_2$ was = 4 mmHg ($t=2.62$, $p=0.01$). When controlling for age, gender, and the reported use of sleep-promoting medications, one mmHg increase in the mean partial pressure of oxygen was associated with an increase of 58.8 minutes of TST ($p<0.001$), a 4.3% increase in sleep efficiency (SE) ($p=0.01$), an increase 62.1 minutes in somatic symptom disorder (SSD) ($p=0.0004$) and a 15.3 unit increase in sleep quality (SQ) ($p=0.0008$). One mmHg increase in the mean $ppCO_2$ was associated with a decrease of 8.8 minutes of TST ($p<0.001$) and a decrease of 7.4 minutes in SSD ($p=0.009$). There were no personal acoustic dosimetry recordings at or above 80dBA during actigraphy-defined main sleep episodes; 94% of dosimetry recorded during main sleep episodes were less than 60dBA. CONCLUSIONS: Environmental factors, such as hypoxia and hypercapnia impact sleep during spaceflight. The collection of environmental data should continue with coordination between the life science and environmental teams so that the data that is collected will have the necessary detail to be usable by both groups. This coordinated research approach could have a substantial impact on countermeasures, interventions and/or policies affecting spaceflight crewmembers in an effort to improve their health, performance, and safety.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	We investigated whether noise, hypoxia, and hypercapnia were associated with sleep deficiency during spaceflight. The results of this research have major implications for all operational personnel who are required to sleep under less than ideal environmental conditions, such as military personnel. The results of this work could lead to further guidance, policies, and/or countermeasures to improve sleep during spaceflight missions and on Earth.
Task Progress:	This one-year research project required the merging of databases from several different sources. All of the sleep data we collected in our decade-long study resided in the Life Sciences Data Archive (LSDA). From several NASA environmental groups we requested: time-stamped environmental CO_2 – hypercapnia data from shuttle missions and ISS expeditions with overlapping sleep data; time-stamped environmental O_2 – hypoxia data from shuttle missions with overlapping sleep data and time-stamped environmental noise – acoustic dosimetry from ISS expeditions with overlapping sleep data; time-stamped individual acoustic dosimetry from ISS crewmembers with overlapping sleep data. The request to use data from the sleep database and environmental sources was approved by the Lifetime Surveillance of Astronaut Health (LSAH) advisory boards. An amendment to perform these secondary analyses was submitted and approved at the NASA Johnson Space Center Institutional Review Board. The LSDA reviewed the consents given by all the crewmembers. The data from crewmembers who chose free use of any of their data or free use of the sleep data was released to us. We learned that repository consent forms do not cover individual acoustic monitoring exposure data. Thus, LSDA had to re-consent all crewmembers with overlapping sleep data in order for us to be able to use those data in secondary analyses. Data with appropriate consent was released to investigators. The multiple databases were aligned by date and time so that comparisons between sleep and environmental factors could be analyzed. Statistical analysis was performed by the statistician at Brigham and Women's Hospital. Following the submission of this final report, a presentation will be made to NASA co-investigators and National Space Biomedical Research Institute (NSBRI) personnel and a manuscript may be submitted to a scientific journal for publication.
Bibliography Type:	Description: (Last Updated: 04/11/2021)