

Fiscal Year:	FY 2017	Task Last Updated:	FY 09/30/2017
PI Name:	Czeisler, Charles A. M.D., Ph.D.		
Project Title:	Sleep-Wake Actigraphy and Light Exposure During Spaceflight		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
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 (2) Sleep: Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02115-5804	Congressional District:	8
Comments:			
Project Type:	Flight	Solicitation / Funding Source:	98-HEDS-02
Start Date:	01/24/2001	End Date:	06/30/2017
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:	0	Monitoring Center:	NASA JSC
Contact Monitor:	Williams, Thomas	Contact Phone:	281-483-8773
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Flight Program:	Shuttle/ISS		
Flight Assignment:	ISS-12 (added 12/5/13 per PI/CoI information) STS-133, STS-134, STS-135 (add'l flight info per PI report 11/2011) STS 129, 130, 131, 132 ; ISS increments 22-24 (add'l flight info per PI 11/2009) STS 126, STS 127, STS 128 ; ISS Increments 18-21 (add'l flight info per PI office, 11/2008) STS 122, STS 123, STS 124, STS 125; ISS Increment 17 (add'l flight info per PI office, 1/2008) STS 116, STS 118, STS 120; ISS Increments 14, 15, 16 (add'l flight info provided 11/06) STS 121, STS 115; ISS Increments 13-14 STS 104, STS 109, STS 111, STS 112, STS 113, STS 114 NOTE: Element change to Human Factors and Behavioral Performance (Ed., 5/8/17) NOTE: New end date is 6/30/2017 per K. Ohnesorge/JSC (Ed., 10/31/16) NOTE: New end date is 3/31/2017 per CoI L. Barger (Ed., 12/5/13) NOTE: Expected to be extended to 4/30/2017 per CoI L. Barger (Ed., 8/31/13)		

<p>NOTE: End date changed to 4/30/2013 per CoPI Barger (Ed., 9/10/2012)</p> <p>NOTE: End date is not firm per CoI/PI (Ed., 11/18/2011)</p> <p>NOTE: End date is 7/31/2012 per PI/CoI (Ed., 10/27/11)</p> <p>NOTE--end date should be around 4/30/2012 per JSC (11/08)</p>	
Key Personnel Changes/Previous PI:	Laura K. Barger, Ph.D. is assigned as Co-Principal Investigator (1/2008 report).
COI Name (Institution):	<p>Barger, Laura Ph.D. (Co-PI: Harvard Medical School)</p> <p>Wright, Kenneth Ph.D. (University of Colorado)</p> <p>Ronda, Joseph M.S. (Harvard Medical School)</p> <p>Evans, Erin Ph.D. (NASA Ames Research Center)</p>
Grant/Contract No.:	NCC9-119
Performance Goal No.:	
Performance Goal Text:	<p>BACKGROUND</p> <p>An inadequate quantity or quality of sleep may impair an astronaut's ability to maintain a high level of cognitive performance and vigilance while operating and monitoring sophisticated instrumentation during spaceflight. In order to understand sleep in space more completely, we conducted a large scale study of astronauts across multiple Space Shuttle (STS) and International Space Station (ISS) missions. Since 2000, crewmembers assigned to shuttle flights were briefed about the opportunity to participate in this experiment. ISS crews were briefed beginning in 2006. Participants wore a small light-weight ambulatory recording device [Actiwatch-L; manufactured by MiniMitter, then Respironics, then Philips, Bend, OR] for assessment of sleep-wakefulness activity via wrist actigraphy and light-exposure levels via wrist photometry during three Earth-based data-collection intervals and the spaceflight mission. Additionally, crewmembers were instructed to complete a sleep log within 15 minutes of awakening to record medication use (every day on STS and for approximately one-third of ISS mission days). Sleep was estimated using Actiware Software [Version 3.4] and circadian timing was estimated using Circadian Performance Simulation Software (CPSS).</p> <p>We studied 21 ISS crewmembers (3,201 ISS inflight days) from 2006-2011 during missions lasting, on average, 155 ± 39 days. Preliminary results indicate that the mean (\pm SD) nightly sleep duration, as estimated from actigraphy, was 6.1 ± 0.7 hours on ISS missions, which was significantly shorter than during Earth-based collections 90 days prior to the mission and one-week postflight ($p < 0.01$) [1]. To obtain even this limited amount of sleep, 75% of ISS crewmembers reported taking sleep-promoting medications inflight. Circadian misalignment occurred during 20% of mission days and was significantly associated with increased use of sleep medication, decreased sleep quality and shorter sleep durations [2].</p> <p>One US astronaut and one Russian cosmonaut plan to take part in a one-year ISS mission. Given that the duration of this mission will be essentially twice as long as the nominal ISS missions, it was unknown how the mind and body, including sleep and the circadian system, would respond or adapt to that much time in space. We objectively evaluated sleep and estimated circadian alignment throughout the mission via the previously employed protocol. Findings from this long duration mission are crucial to inform future exploration class missions.</p> <p>METHODOLOGY: Crewmembers wore a small light-weight ambulatory recording device [Spectrum; Philips, Bend, OR] for assessment of sleep-wakefulness activity and light-exposure during four Earth-based data-collection intervals and the spaceflight mission. Crewmembers also completed a sleep log within 15 minutes of awakening every day during ground collection intervals and for approximately one-third of ISS mission days. We evaluated sleep and circadian alignment via the analysis methodology previously used on the ISS.</p> <p>RESULTS: On the one-year mission, there was considerable variation in sleep between the two crewmembers. On average, the mean nightly sleep duration of the two crewmembers on ISS12 was one hour more (7.1 ± 0.4 hours) than the mean nightly sleep duration on the 2004-2011 shorter ISS missions (6.1 ± 0.7 hours). Several factors may have affected nightly sleep duration including less shifting of the sleep-wake cycle and thus, reduction in circadian misaligned days from 20% on the 2004-2011 missions to 3% on the one-year mission. During spaceflight, objective sleep efficiency was significantly correlated with reported sleep quality and alertness.</p> <p>CONCLUSION: In order to be able to make generalizations about sleep on longer duration missions, sleep should continue to be evaluated in additional crewmembers on one-year missions. Understanding sleep and circadian rhythms on long duration missions is crucial to inform future exploration class missions.</p> <p>REFERENCES</p> <p>[1] Barger LK, Flynn-Evans EE, Kubey A, Walsh L, Ronda JM, Wang W, Wright KP Jr, Czeisler CA. "Prevalence of sleep deficiency and use of hypnotic drugs in astronauts before, during, and after spaceflight: an observational study." <i>Lancet Neurol.</i> 2014 Sep;13(9):904-12. http://dx.doi.org/</p> <p>[2] Barger LK, Sullivan JP, Ronda JM, Czeisler CA. "Sleep-wake actigraphy and light exposure on a one-year International Space Station mission." 2015 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 13-15, 2015.</p> <p>See also http://www.nasa.gov/</p>
Rationale for HRP Directed Research:	

Research Impact/Earth Benefits:	A better understanding of sleep deficiency and insomnia is relevant to the millions of people on Earth who suffer nightly from insomnia. The advancement of state of the art technology for monitoring, diagnosing, and assessing treatment effectiveness is vital to the continued treatment of insomnia on Earth. This work has the potential to greatly benefit the health, productivity and safety of groups with a high prevalence of insomnia, such as shift workers and the elderly.
Task Progress:	<p>An inadequate quantity or quality of sleep may impair an astronaut's ability to maintain a high level of cognitive performance and vigilance while operating and monitoring sophisticated instrumentation during spaceflight. In order to understand sleep in space more completely, we conducted a large scale study of astronauts across multiple International Space Station (ISS) missions. Participants wore a small light-weight ambulatory recording device [Actiwatch-L; manufactured by MiniMitter, then Respironics, then Philips, Bend, OR] for assessment of sleep-wakefulness activity via wrist actigraphy and light-exposure levels via wrist photometry during three Earth-based data-collection intervals and the spaceflight mission. Additionally, crewmembers were instructed to complete a sleep log within 15 minutes of awakening to record medication use (every day on STS and for approximately one-third of ISS mission days). Sleep was estimated using Actiware Software [Version 3.4].</p> <p>We studied 21 ISS crewmembers (3,201 ISS inflight days) from 2006-2011 during missions lasting, on average, 155 ± 39 days. Preliminary results indicate that the mean (\pm SD) nightly sleep duration, as estimated from actigraphy, was 6.1 ± 0.7 hours on ISS missions, which was significantly shorter than during Earth-based collections 90 days prior to the mission and one-week postflight ($p < 0.01$). To obtain even this limited amount of sleep, 75% of ISS crewmembers reported taking sleep-promoting medications inflight. Circadian misalignment, as estimated by Circadian Performance Simulation Software, occurred during 20% of mission days and was significantly associated with increased use of sleep-promoting medication, all medication use, decreased sleep quality and shorter sleep durations.</p> <p>Using the same procedures we studied sleep and circadian alignment of two crewmembers on a one-year ISS mission. These data represent the only objective estimates of sleep of crewmembers for the entire duration of a one-year ISS mission. There was considerable variation in sleep between the two crewmembers. On average, the mean nightly sleep duration of the two crewmembers on ISS12 was one hour more than the mean nightly sleep duration on the 2004-2011 shorter ISS missions. Several factors may have affected nightly sleep duration including less shifting of the sleep-wake cycle and thus, a marked reduction in circadian misaligned days from the 2004-2011 missions to the one-year mission. In flight, objective sleep efficiency was significantly correlated with subjective reports of sleep quality and alertness.</p> <p>It is difficult to make any definitive conclusions due to the very limited number of crewmembers assigned to the one-year mission. We did find that sleep duration was, on average, increased in the one-year mission as compared to the shorter ISS missions. This can at least be partially attributed to the substantial reduction in circadian misalignment on the one-year mission, likely due to fewer shifts in the crewmembers' sleep-wake cycle. Although workload wasn't specifically measured in this study, conversations with schedulers noted reduced workloads for one-year mission subjects as compared to shorter duration ISS subjects. The relationship between workload and sleep duration during spaceflight needs further study.</p> <p>In order to be able to make generalizations about sleep on longer duration missions, sleep should continue to be evaluated in additional crewmembers on one-year missions. Understanding sleep and circadian rhythms on long duration missions is crucial to inform future exploration class missions.</p>
Bibliography Type:	Description: (Last Updated: 12/13/2023)
Abstracts for Journals and Proceedings	<p>Barger LK, Sullivan JP, Ronda JM, Czeisler CA. "Sleep-wake actigraphy and light exposure on a one-year international space station mission." 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016.</p> <p>2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016</p>
Abstracts for Journals and Proceedings	<p>Barger LK, Sullivan JP, Ronda JM, Czeisler, CA. "Sleep-wake actigraphy and light exposure on a one-year international space station mission." Presented at 2017 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 23-26, 2017.</p> <p>2017 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 23-26, 2017. , Jan-2017</p>
Articles in Peer-reviewed Journals	<p>Brainard GC, Barger LK, Soler RR, Hanifin JP. "The development of lighting countermeasures for sleep disruption and circadian misalignment during spaceflight." Curr Opin Pulm Med. 2016 Nov;22(6):535-44. https://doi.org/10.1097/MCP.0000000000000329 ; PubMed PMID: 27607152 , Nov-2016</p>
Articles in Peer-reviewed Journals	<p>Gottlieb DJ, Ellenbogen JM, Bianchi MT, Czeisler CA. "Sleep deficiency and motor vehicle crash risk in the general population: A prospective cohort study." BMC Med. 2018 Mar 20;16(1):44. https://doi.org/10.1186/s12916-018-1025-7 ; PubMed PMID: 29554902; PubMed Central PMCID: PMC5859531 , Mar-2018</p>
Articles in Peer-reviewed Journals	<p>St Hilaire MA, Kristal BS, Rahman SA, Sullivan JP, Quackenbush J, Duffy JF, Barger LK, Gooley JJ, Czeisler CA, Lockley SW. "Using a single daytime performance test to identify most individuals at high-risk for performance impairment during extended wake." Sci Rep. 2019 Nov 13;9(1):16681. https://doi.org/10.1038/s41598-019-52930-y ; PMID: 31723161; PMCID: PMC6853981 , Nov-2019</p>