

Fiscal Year:	FY 2015	Task Last Updated:	FY 03/31/2015
PI Name:	Smith, Scott M Ph.D.		
Project Title:	Nutritional Status Assessment: SMO 016		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:	TechPort:	No	
Human Research Program Elements:	(1) HHC: Human Health Countermeasures		
Human Research Program Risks:	(1) Bone Fracture: Risk of Bone Fracture due to Spaceflight-induced Changes to Bone (2) Food and Nutrition: Risk of Performance Decrement and Crew Illness Due to Inadequate Food and Nutrition (3) Immune: Risk of In Mission Impacts, Adverse Health Events or Long-Term Health Impacts due to Altered Immune Response (4) Nutrition: Risk of Inadequate Nutrition (5) Osteo: Risk Of Early Onset Osteoporosis Due To Spaceflight (6) Renal Stone: Risk of Renal Stone Formation		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	scott.m.smith@nasa.gov	Fax:	FY 281-483-2888
PI Organization Type:	NASA CENTER	Phone:	281-483-7204
Organization Name:	NASA Johnson Space Center		
PI Address 1:	Biomedical Research and Environmental Sciences Division/SK3		
PI Address 2:	2101 NASA Pkwy		
PI Web Page:			
City:	Houston	State:	TX
Zip Code:	77058-3607	Congressional District:	36
Comments:			
Project Type:	Flight	Solicitation / Funding Source:	Directed Research
Start Date:	10/01/2005	End Date:	11/30/2014
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:	Baumann, David	Contact Phone:	
Contact Email:	david.k.baumann@nasa.gov		
Flight Program:	Shuttle/ISS		
Flight Assignment:	ISS NOTE: End date is 11/30/2014; misunderstanding re previous note of 9/30/20 end date (Ed., 3/31/15) NOTE: End date is 9/30/2020 per L. Smith/HRP/JSC (Ed., 6/10/14) NOTE: End date is 5/30/2014 per HRP Master Task List dtd 7/12/2011 (Ed., 8/9/2011)		
Key Personnel Changes/Previous PI:			

COI Name (Institution):	Zwart, Sara (USRA) Heer, Martina (University of Bonn) Coburn, Stephen (Indiana University, Purdue University Fort Wayne)
Grant/Contract No.:	Directed Research
Performance Goal No.:	
Performance Goal Text:	
Task Description:	SMO 016. These studies are designed to provide information about the changes in nutritional status and calcium and bone metabolism during and after space flight. It is well known that the status of some vitamins (i.e., folate, vitamin K, vitamin D) is decreased after long-duration space flight. Never before have we been able to investigate most of these changes during flight. In-flight data will assist in the interpretation of post-flight data, and it will help to assess countermeasure efficiency during flight. The investigators will measure blood levels of vitamins, minerals, oxidative damage markers, markers of iron and calcium metabolism, bone- and calcium-regulating hormones, markers of cardiovascular risk (associated with nutritional status), stress hormones, and urinary markers of bone turnover. These will provide a complete profile of nutritional status and bone and calcium metabolism, and will be important for understanding the effects of the countermeasures under consideration as well as the mechanisms of alterations that occur during space flight. Data will be collected before, during, and after flight. The main potential benefit of this research is obtaining more information about the bone loss and changes in nutritional status that occur during space flight, and knowledge of how effective bone-loss countermeasures are for extended duration space flight. The information gained here will also be important for developing new treatments for metabolic disorders in the general population. See also http://www.nasa.gov/
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Nutritional status is clearly altered after long-duration space flight. As indicated above, several nutrients demonstrate decreased status (despite adequate intake in some cases) after long-duration space flight. It is imperative that we determine the mechanism and kinetics of these changes if we are going to send crew members on exploration-class missions. The inclusion of in-flight blood/urine collections and expansion to include more parameters to better monitor nutritional status is required to better understand the role of nutrition in bone health, changes in body composition, oxidative damage, and defining nutritional requirements. Maintaining and monitoring nutritional status are important for ensuring crew health during space flight, and will be critical as we begin to embark on the longer duration exploration missions in the future. Understanding the interrelationship between nutritional status and other physiological systems in flight may also help to better understand human health for those on Earth. Several findings have arisen from this study, and resulted in publications. These contribute to the understanding of the role of nutrition in health and disease in all populations, including and well beyond astronauts.
Task Progress:	<p>SUPPLEMENTAL REPORTING FOR FINAL REPORT (March 2015)</p> <p>This study is complete. The findings from the Nutrition SMO have shed light on a number of metabolic issues that are important for human long-duration space flight. Given the comprehensive nature of the Nutritional Status Assessment protocol, there are likely many lessons to be learned, beyond those already identified. These data will be a valuable resource for years to come.</p> <p>Sample collection protocols were well executed, and samples were returned on Space Shuttle and SpaceX flights. 32 subjects completed the protocol. Individual data briefings have been provided to all available crewmembers. Findings have been briefed to the Human Health and Performance Directorate, the Human Research Program (HRP) and its Human Health Countermeasures Element, and the International Space Station Medical Project. Data have been published in peer-reviewed journals, presented at the HRP Investigators' Workshop, and have been presented at national and international scientific meetings. A recent update to the nutrition evidence report, published in book form, includes large amounts of Nutrition SMO data (Smith SM, Zwart SR, Heer M. Human Adaptation to Spaceflight: The Role of Nutrition (NP-2014-10-018-JSC). Houston, TX: National Aeronautics and Space Administration Lyndon B. Johnson Space Center; 201) (available through open access at http://www.nasa.gov/sites/default/files/human-adaptation-to-spaceflight-the-role-of-nutrition.pdf) http://www.nasa.gov/; http://go.nasa.gov/QS1KW1) http://go.nasa.gov/). Data have been shared with other investigators, per data sharing agreements and documentation, and the database transferred to the Life Sciences Data Archive.</p> <p>ANNUAL REPORT FROM JULY 2014</p> <p>As of July 2014, 32 subjects have completed the protocol, and all samples have been returned to Earth from ISS. Some analyses are pending, and should be completed in the coming months. Individual data briefings have been provided to most crewmembers. Preliminary findings have been briefed to the Space Life Sciences Directorate, the Human Research Program (HRP) and its Human Health Countermeasures Element, and the International Space Station Medical Project, and have been presented at the HRP Investigators' Workshop. Preliminary data have also been published in peer-reviewed journals, and presented at national and international scientific meetings, and transferred to the Life Sciences Data Archive.</p>
Bibliography Type:	Description: (Last Updated: 05/15/2025)
Articles in Peer-reviewed Journals	Smith SM, Zwart SR, Heer M, Hudson EK, Shackelford L, Morgan JL. "Men and women in space: bone loss and kidney stone risk after long-duration space flight." J Bone Miner Res. 2014 Jul;29(7):1639-45. http://dx.doi.org/10.1002/jbmr.2185 ; PubMed PMID: 24470067 , Jul-2014
Articles in Peer-reviewed Journals	Crucian BE, Zwart SR, Mehta S, Uchakin P, Quiarte HD, Pierson D, Sams CF, Smith SM. "Plasma cytokine concentrations indicate that in-vivo hormonal regulation of immunity is altered during long-duration spaceflight." J Interferon Cytokine Res. 2014 Oct;34(10):778-86. http://dx.doi.org/10.1089/jir.2013.0129 ; PubMed PMID: 24702175 ; PubMed Central PMCID: PMC4186776 (originally reported as Epub 2014 Apr 4) , Oct-2014
Articles in Peer-reviewed Journals	Zwart SR, Launius R, Coen GK, Charles JB, Smith SM. "Body mass changes during long-duration spaceflight." Aviat Space Environ Med. 2014 Sep;85:897-904. http://dx.doi.org/10.3357/ASEM.3979.2014 ; PMID: 25197887 , Sep-2014

Articles in Peer-reviewed Journals	Smith SM, Abrams SA, Davis-Street JE, Heer M, O'Brien KO, Wastney ME, Zwart SR. "50 years of human space travel: implications for bone and calcium research." <i>Annu Rev Nutr.</i> 2014 Jul 17;34:377-400. http://dx.doi.org/10.1146/annurev-nutr-071813-105440 ; PubMed PMID: 24995691 , Jul-2014
Articles in Peer-reviewed Journals	Smith SM, Zwart SR. "Magnesium and space flight." <i>Nutrients.</i> 2015 Dec 8;7(12):10209-22. http://dx.doi.org/10.3390/nu7125528 ; PubMed PMID: 26670248 ; PubMed Central PMCID: PMC4690080 , Dec-2015
Articles in Peer-reviewed Journals	Smith SM, Castaneda-Sceppa C, O'Brien KO, Abrams SA, Gillman P, Brooks NE, Cloutier GJ, Heer M, Zwart SR, Wastney ME. "Calcium kinetics during bed rest with artificial gravity and exercise countermeasures." <i>Osteoporos Int.</i> 2014 Sep;25(9):2237-44. Epub 2014 May 27. http://dx.doi.org/10.1007/s00198-014-2754-x ; PubMed PMID: 24861908 ; PubMed Central PMCID: PMC4521405 , Sep-2014
Articles in Peer-reviewed Journals	Smith SM, Heer M, Shackelford LC, Sibonga JD, Spatz J, Pietrzyk RA, Hudson EK, Zwart SR. "Bone metabolism and renal stone risk during International Space Station missions." <i>Bone.</i> 2015 Dec;81:712-20. Epub 2015 Oct 8. https://doi.org/10.1016/j.bone.2015.10.002 ; PubMed PMID: 26456109 , Dec-2015
Articles in Peer-reviewed Journals	Heacox HN, Gillman PL, Zwart SR, Smith SM. "Excretion of zinc and copper increases in men during 3 weeks of bed rest, with or without artificial gravity." <i>J Nutr.</i> 2017 Jun;147(6):1113-20. https://doi.org/10.3945/jn.117.247437 ; PMID: 28490676 ; PMCID: PMC543469 , Jun-2017
Articles in Peer-reviewed Journals	Patel ZS, Brunstetter TJ, Tarver WJ, Whitmire AM, Zwart SR, Smith SM, Huff JL. "Red risks for a journey to the red planet: The highest priority human health risks for a mission to Mars." <i>npj Microgravity.</i> 2020 Nov 5;6(1):33. Review. https://doi.org/10.1038/s41526-020-00124-6 ; PMID: 33298950 ; PMCID: PMC7645687 , Nov-2020
Articles in Peer-reviewed Journals	Frings-Meuthen P, Luchitskaya E, Jordan J, Tank J, Lichtinghagen R, Smith SM, Heer M. "Natriuretic peptide resetting in astronauts." <i>Circulation.</i> 2020 May 12;141(19):1593-5. https://doi.org/10.1161/CIRCULATIONAHA.119.044203 ; PMID: 32392103 , May-2020
Books/Book Chapters	Heer M, Titze J, Smith SM, Baecker N. "Nutrition, physiology and metabolism in spaceflight and analog studies." Cham, Switzerland: Springer, 2015. 69 p. http://dx.doi.org/10.1007/978-3-319-18521-7 , Jul-2015
Books/Book Chapters	Smith SM, Heer M, Zwart SR. "Nutrition and Bone Health in Space." in "Nutrition and Bone Health, 2nd ed." Ed. M. Holick, J. Nieves. New York : Springer, 2015. p. 687-705. http://dx.doi.org/10.1007/978-1-4939-2001-3_41 (originally reported as 'in press, as of July 2014.'), Jan-2015
NASA Technical Documents	Smith SM, Zwart SR, Heer M. "Human Adaptation to Spaceflight: The Role of Nutrition." Houston, TX : National Aeronautics and Space Administration Lyndon B. Johnson Space Center, 2014. (NP-2014-10-018-JSC). ISBN:9780160926297. http://www.nasa.gov/sites/default/files/human-adaptation-to-spaceflight-the-role-of-nutrition.pdf ; accessed 3/31/2015. , Dec-2014
NASA Technical Documents	Smith SM, Zwart SR, Douglas GL, Heer M. "Human adaptation to spaceflight: The role of food and nutrition. Second edition." Houston, TX: NASA Lyndon B. Johnson Space Center, 2021. 255 p. NP-2021-03-003-JSC. https://www.nasa.gov/sites/default/files/atoms/files/human_adaptation_2021_final.pdf , Apr-2021