Fiscal Year:	FY 2018	**Task Last Updated:**	FY 09/19/2018
PI Name:	Ploutz-Snyder, Lori L. Ph.D.		
Project Title:	Integrated Resistance and Aerobic Training Study (Sprint)		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Aerobic**:Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity (2) **Bone Fracture**:Risk of Bone Fracture due to Spaceflight-induced Changes to Bone (3) **Muscle**:Risk of Impaired Performance Due to Reduced Muscle Size, Strength and Endurance (4) **Osteo**:Risk Of Early Onset Osteoporosis Due To Spaceflight		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Ann Arbor	**State:**	MI
Zip Code:	48109-2013	**Congressional District:**	12
Comments:	Previously at Universities Space Research Association/NASA Johnson Space Center until July 2016.		
Project Type:	FLIGHT	**Solicitation / Funding Source:**	Directed Research
Start Date:	10/01/2016	**End Date:**	01/31/2019
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
Contact Monitor:	Norsk, Peter	**Contact Phone:**	
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Flight Program:	ISS		
Flight Assignment:	ISS NOTE: End date changed to 1/31/2019 per NSSC information and J. McFather/JSC (Ed., 7/8/19)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Ploutz-Snyder, Robert Ph.D. (University of Michigan) Downs, Meghan Ph.D. (Wyle Laboratories, Inc./NASA Johnson Space Center)		
Grant/Contract No.:	NNX16AO74G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	ED. NOTE (October 2016): Continuation of "Integrated Resistance and Aerobic Training Study (Sprint)," which was an internal project at Universities Space Research Association/NASA Johnson Space Center, while Principal Investigator was affiliated there. Current exercise countermeasures are insufficient to prevent muscle atrophy, cardiovascular deconditioning, and bone loss associated with long-duration spaceflight. A known limitation has been the inability of the International Space Station (ISS) exercise hardware to provide sufficient loads to the human body that are required for maintaining physiological function. New flight exercise hardware, including the advanced resistance exercise device (ARED) and 2nd generation treadmill (T2), are designed to provide astronauts with the ability to exercise at higher intensity. This opens an array of new possibilities for exercise programming in long-duration spaceflight. While the ability to do resistance exercises at heavier loads, the ability to run faster and potentially with more body loading are obvious improvements in exercise capabilities, the details of how this new equipment should be used are not so obvious. Towards this end, two workshops were held, the NASA Muscle Workshop in June 2008 and the NASA International Space Station Exercise Prescription Workshop in October 2008. Intramural and extramural experts concluded that using higher intensity resistance exercises and interval aerobic exercise would help to maintain physiological function while simultaneously decreasing total exercise time and volume. The panel then recommended that this evidence-based approach to the development of a novel exercise prescription for use on ISS should immediately be proposed. Therefore the purpose of this research is to evaluate the efficacy of a new integrated resistance and aerobic training (iRAT) program designed to minimize loss of muscle, bone, and cardiovascular function during ISS missions. Highlights of the iRAT include an increase in the intensity and a reduction in the volume of resistance exercises, inclusion of very short, but high intensity interval-type aerobic exercises, and starting the exercise countermeasures as early as possible in the flight, preferably in the first week. Pre-, in-, and post-flight testing, and data sharing with selected on-going medical assessment tests, will be used to assess the effectiveness of this candidate prescription. Tests include detailed measurements of lower body muscle structure and function (MRI, ultrasound, muscle performance testing, shared muscle medical tests), maximal aerobic capacity, ventilatory threshold, left ventricular mass and cardiac contractility, and bone mineral density. Twenty (20) long duration crewmembers will be recruited as active subjects in iRAT; and 20 will be asked to serve as controls that perform the standard care exercise prescription and the pre-post flight testing. This proposal is sponsored by the Exercise Physiology and Countermeasures Project and directly addresses the Human Research Program (HRP) Integrated Research Plan (IRP) Risks of Impaired Performance Due To Reduced Muscle Mass, Strength and Endurance and Risk of Reduced Physical Performance Capabilities Due To Reduced Aerobic Capacity, and Risk of Accelerated Osteoporosis. This proposal addresses Gap M7: Can the current in-flight performance be maintained with reduced exercise volume? The proposal addresses IRP Gap M8 (What is the minimum exercise regimen needed to maintain fitness levels for operationally relevant tasks?) and Gap M9 (What is the minimum set of equipment needed to maintain those (M8) fitness levels?).
Rationale for HRP Directed Research:	This research is directed because it contains highly constrained research, which requires focused and constrained data gathering and analysis that is more appropriately obtained through a non-competitive proposal.
Research Impact/Earth Benefits:	Development of more efficient exercise programs could be used on Earth. A more thorough understanding of how cardiovascular, skeletal muscle, and bone health is affected by exercise.
Task Progress:	Long-duration spaceflight causes wholesale physiologic deconditioning including decrements in muscle mass, muscle strength and function, aerobic capacity, and bone mineral density. Even the performance of near-daily exercise countermeasures is largely inadequate to prevent this degradation. Current exercise hardware on the International Space Station (ISS) employed to combat these maladaptations consists of a cycle ergometer (CEVIS), the second-generation treadmill (T2), and advanced resistive exercise device (ARED); crewmembers on the ISS have used these systems and previous legacy devices to exercise 6 d per week with 2.5 h per day allotted to exercise countermeasures. This represents a significant time commitment and reduces crewmembers' availability to perform other important mission tasks. Higher intensity/lower volume aerobic intervals have been incorporated into ISS exercise prescriptions; however, velocity restrictions on the first ISS treadmill curtailed their usage and individual crewmember preferences limited ubiquitous implementation. Similarly, resistance exercise on the ISS was performed at lower intensities due to the loading limitations of the original resistive exercise device until the 2009 deployment of ARED which provides up to 272 kg of resistance; subsequently, up to 6-repetition maximum loads have been used. The effectiveness of high intensity/low volume training (HIT) has been extensively documented in populations ranging from elite athletes to clinical patients. In addition to the time savings of shorter exercise sessions, there is evidence to suggest that HIT may elicit superior physiologic adaptations compared to traditional lower intensity/higher volume training. For instance, over a 6-week period (5 d/wk), Tabata et al. compared 60 min bouts of continuous exercise (70% VO2peak) to 7-8 intervals (20 s at 170% VO2peak /10 s rest). Despite cumulative exercise time of only ~2 h compared to 30 h for the continuous group, the HIT group increased both aerobic and anaerobic capacity whereas the continuous, high volume group only improved aerobic capacity. Somewhat longer duration intervals of 2-4 min have been shown to maintain or improve aerobic capacity during bed rest unloading and athletic training. In light of the potential for similar if not superior physiologic protection despite diminished exercise volume, the purpose of this investigation was to compare physiologic outcomes after long-duration (~six months) spaceflight on the ISS in crewmembers who performed exercise countermeasures consisting of either 1) lower intensity/higher volume exercise (6 d/wk resistance exercise and 6 d/wk aerobic exercise) or 2) high intensity/lower volume exercise (3 d/wk resistance exercise and 6 d/wk aerobic exercise). Tabata I, Nishimura K, Kouzaki M et al. Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO2max. Med Sci Sports Exerc. 1996;28(10):1327-30.
Bibliography Type:	Description: (Last Updated: 04/29/2023)

Articles in Peer-reviewed Journals	De Witt JK, English KL, Crowell JB, Kalogera KL, Guilliams ME, Nieschwitz BE, Hanson AM, Ploutz-Snyder LL. "Isometric midthigh pull reliability and relationship to deadlift one repetition maximum." Journal of Strength and Conditioning Research. 2018 Feb;32(2):528-33. https://journals.lww.com/nsca-jscr/Abstract/2018/02000/Isometric_Midthigh_Pull_Reliability_and.28.aspx ; PubMed PMID: 27548797 , Feb-2018
Articles in Peer-reviewed Journals	Dillon EL, Sheffield-Moore M, Durham WJ, Ploutz-Snyder LL, Ryder JW, Danesi CP, Randolph KM, Gilkison CR, Urban RJ. "Efficacy of testosterone plus NASA exercise countermeasures during head-down bed rest." Medicine and Science in Sports and Exercise. 2018 Sep;50(9):1929-39. https://doi.org/10.1249/MSS.0000000000001616 ; PubMed PMID: 29924745; PubMed Central PMCID: PMC6095739 , Sep-2018
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