Fiscal Year:	FY 2015	**Task Last Updated:**	FY 09/30/2015
PI Name:	Barstow, Thomas Ph.D.		
Project Title:	Standardized 'Pre-flight' Exercise Tests to Predict Performance during Extravehicular Activities in a Lunar Environment		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:		**TechPort:**	Yes
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) **Muscle**:Risk of Impaired Performance Due to Reduced Muscle Size, Strength and Endurance		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	66506-0109	**Congressional District:**	1
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2009 Crew Health NNJ09ZSA002N
Start Date:	07/01/2010	**End Date:**	06/30/2015
No. of Post Docs:	0	**No. of PhD Degrees:**	2
No. of PhD Candidates:	2	**No. of Master' Degrees:**	3
No. of Master's Candidates:	3	**No. of Bachelor's Degrees:**	5
No. of Bachelor's Candidates:	4	**Monitoring Center:**	NASA JSC
Contact Monitor:	Loerch, Linda	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: Extended to 6/30/2015 per PI and NSSC information (Ed., 5/19/14) NOTE: New end date is 9/2/2014 per NSSC information (Ed., 5/9/2013)		
Key Personnel Changes/Previous PI:	May 2012 report: Chris Lewis, Ph.D. has left Kansas State University and is no longer on the project. We are actively pursuing a replacement engineer.		
COI Name (Institution):	Warren, Steven (Kansas State University) Schinstock, Dale (Kansas State University)		
Grant/Contract No.:	NNX10AK60G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The original Apollo missions and more recent extravehicular activities on the International Space Station have provided basic information that can be applied to activities that may occur during future long-duration lunar missions. However, despite these previous efforts, significant gaps remain in our understanding of the more complex physiological costs of different activities in a true lunar environment. Recently a ground-based simulation of a 10-kilometer Lunar Walkback was conducted to better understand the physical capabilities of a suited astronaut in partial gravity. Unfortunately, this study was limited because of the use of a stationary treadmill that did not accurately simulate the lunar environment (i.e., landscape and terrain). To date this overall lack of physiologic data collected during true lunar activities or their accurate simulation has limited the ability of NASA physicians and scientists to predict if an astronaut candidate is physically capable of completing the multiple lunar activities that may be required during long-duration missions. Therefore, the goals of this proposal are to 1) develop a mobile testbed to accurately simulate partial-gravity lunar activities, and 2) determine subject performance and the concomitant physiological responses to these activities, which will allow us to 3) create a series of standardized tests that can be performed in a pre-flight setting to determine the readiness of the astronaut to perform physically demanding activities during a lunar mission.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The results of these studies will help identify which key components of physical fitness are required to perform different physical tasks. These results will, therefore, be applicable in a wide variety of settings, from rehabilitation to athlete evaluation, to determining the relative preparedness of astronauts for in-flight and destination extravehicular activity (EVA). These insights will be especially important when astronauts return to a gravitational environment, either on Earth or at their destination. These results will provide target information regarding minimum required strength and endurance from which in-flight and destination exercise countermeasures can be based. The strategy employed here can also function as a template for approaching the establishment of field tests for other occupations in which there is a demand for minimal physical performance, such as what has been done for firefighters and police officers.
Task Progress:	The proposed projects have been completed and most of the data has been published. General findings include: Project 1: The purpose was to evaluate the relationships between tests of fitness and several activities that simulate components of Lunar- and Martian-based extravehicular activities (EVAs). Seventy-one subjects completed four field tests: 1) a physical abilities test which consisted of 6 stations -- stair climbing, forward-backward zigzag, ladder climb and descent, horizontal rock wall, lifting heavy objects, and side step duck/step over; 2) a 10 km Walkback test; 3) material transport field test requiring the loading, transport, and unloading of geological samples; and 4) a device operations field test consisting of tasks associated with equipment set-up and the operations of controls and valves. The relationships between test times for each of these tests and the following parameters were determined: running: O2max, gas exchange threshold (GET), speed at O2max (s- O2max), highest sustainable rate of aerobic metabolism [critical speed (CS)]; arm cranking: O2peak, GET, critical power (CP). Important Findings: A) Across the 4 tests, CS, running O2max, s- O2max, and arm cranking O2peak had the highest correlations. CS and to a lesser extent O2max are most strongly associated with tasks that simulate aspects of EVA performance, highlighting CS as a method for evaluating astronaut physical capacity. B) Arm cranking tests are strongly associated with upper-body dependent tasks, highlighting that the nature of mission tasks needs to be considered when evaluating astronaut physical capacity. C) When comparing arm to leg responses, as expected arm responses were lower than those seen with leg exercise. There was a significant correlation between arm-cranking and lower body O2max, GET, and the O2 at LCS. Backward stepwise regression analyses revealed that arm-cranking physical fitness could explain 67%, 40%, and 49% of the variance in lower body O2max, GET, and CS, respectively. Discussion: Results suggest arm-cranking exercise can be used to obtain an approximation of lower body aerobic capacity. Project 2: The purpose of the second project was to determine the physiological parameters associated with the ability to complete simulated exploration type tasks at metabolic rates which might be expected for Lunar and Martian ambulation. Two simulated extravehicular activity field tests were completed in 1-g at two intensities designed to elicit metabolic rates of ~20.0 and ~30.0 ml kg-1 min-1, which are similar to those previously reported for ambulation in simulated Lunar- and Martian-based environments, respectively. Important Findings: A) All subjects were able to complete the field test at the Lunar intensity, but 28% were unable to complete the field test at the Martian intensity (non-Finishers). B) During the Martian field test there were no differences in O2 between Finishers and non-Finishers, but the non-Finishers were performing at a greater % O2max compared to Finishers. C) Logistic regression analysis revealed fitness thresholds for a predicted probability of 0.5, at which Finishing and non-Finishing are equally likely, and 0.75, at which an individual has a 75% chance of Finishing, to be a O2max of 38 ml kg-1 min-1 and 40 ml kg-1 min-1, both significantly greater than the current minimum standard of ~32 ml kg-1 min-1 for the astronaut corps. D) Logistic regression analysis also revealed that the expected % O2max required to complete a field test could be used to successfully predict performance (X2=19.3). Project 3: the purpose of the current project was to develop an offload hoist system that is able to simulate the gravitational environments of expected future mission destinations that may be used to determine insightful physiological variables and responses to monitor in an astronaut in order to assess mission readiness and EVA performance. Important Findings: A) The offload system was successfully designed, implemented, and tested. B) Proof-of-concept data were collected for ambulatory activities in Earth (1-g), Martian (3/8-g), and Lunar (1/6-g) simulated gravitational environments. Metabolic and ventilatory measurements were collected during ambulation at constant-speeds in each of the gravitational environments.

	C) Metabolic and cardiovascular responses were greatest in 1-g and least in Lunar microgravity. While responses for Martian gravity were lower than for 1-g Earth, they were substantially greater than for Lunar gravity. These data emphasize the need for careful consideration of critical mission tasks and the minimum fitness required for astronaut safety and mission success.
Bibliography Type:	Description: (Last Updated: 01/23/2020)
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