Fiscal Year:	FY 2013	**Task Last Updated:**	FY 04/29/2013
PI Name:	Moore, Alan Ph.D.		
Project Title:	Maximal Oxygen Uptake (VO2max) and Submaximal Estimates of VO2max Before, During and After Long Duration International Space Station Missions		
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) **Aerobic**:Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Houston	**State:**	TX
Zip Code:	77058	**Congressional District:**	22
Comments:			
Project Type:	FLIGHT	**Solicitation / Funding Source:**	Directed Research
Start Date:	12/13/2007	**End Date:**	05/15/2013
No. of Post Docs:	0	**No. of PhD Degrees:**	1
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:	Norsk, Peter	**Contact Phone:**	
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Flight Program:	ISS		
Flight Assignment:	ISS 19, 20 NOTE: end date changed to 05/15/2013 per HRP MTL dtd 11/11/11 (Ed., 11/18/11) NOTE: change in start/end dates per JSC--now showing as 12/13/2007-12/17/2012 (previously 10/1/08-10/1/11)--2/2010 NOTE: Title change per JSC ; previous title: Evaluation of Maximal Oxygen Uptake (VO2max) During Long Duration International Space Station Missions (9/2009) NOTE: Start/end dates changed per JSC (4/27/2009)		
Key Personnel Changes/Previous PI:	April 2013 report: One of the original Co-Is, Frank McCleary, accepted employment in another field and is no longer participating as an investigator. Lori Ploutz-Snyder was added to the investigative team.		
COI Name (Institution):	Feiveson, Alan (Johnson Space Center) Lee, Stuart (Wyle Laboratories) Platts, Steven (Johnson Space Center) Evetts, Simon (European Astronaut Centre) Ploutz-Snyder, Lori (Universities Space Research Assoiciation)		

Grant/Contract No.:	Directed Research
Performance Goal No.:	
Performance Goal Text:	
Task Description:	Maximum oxygen uptake (VO2max, sometimes referred to as VO2peak)* is the standard measure of aerobic capacity and is directly related to the physical working capacity of an individual. Reduction in VO2max is commonly reported as a result of ground-based analogues of long duration spaceflight. Due to early concerns related to the safety of performing maximal exercise testing during or shortly after long duration flight, and until recently lack of a device to measure exercise VO2 on International Space Station (ISS), VO2max has never been directly measured over the course of or following long duration space flight. For operational purposes, for example, to assess crew member readiness to perform Extra Vehicular Activities during long missions, the heart rate (HR) response to submaximal exercise testing has been used to infer changes in aerobic capacity. Recent work by the investigators of this study has suggested that the validity of using the HR response to track changes in aerobic capacity during ISS flight is suspect, as a fundamental assumption underlying this technique (equivalence of preflight and in-flight submaximal VO2 per set exercise work rate), was demonstrated as questionable. The specific aims of this research are: 1. To directly measure VO2max during and following long duration ISS missions. 2. To examine the current method of estimating VO2max change during and following ISS missions, establish if it can used to validly track actual measures of VO2max and, if indicated evaluate alternative methods of tracking changes in VO2max. *- Exercise Physiology investigators will often refer to the maximum oxygen uptake value assessed in this study as “VO2peak” as repeated exercise tests are not used to verify the subject is truly at physiological maximum (not practical or even possible for certain time points of the study). For the purposes of this study and report, the investigators use the more familiar term “VO2max.”
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:	The application of the research findings of this investigation will be most relevant to space flight operations, addressing the questions of whether or not maximum testing will be required to accurately assess aerobic capacity during the course of long-duration missions and determining the time-course of VO2max changes during and following long-duration space flight. However, the findings of this research may also be applied to the clinical realm on Earth by quantifying the time-course of recovery of VO2max after long-term deconditioning. This would aide in the determination of how long rehabilitation would be required after extended periods of bed rest confinement or other severe deconditioning.
Task Progress:	The VO2max study team finished data collection following ISS Expedition 32/33, which returned to Earth in mid-November of 2012. In all, 14 astronaut subjects participated as subjects for the VO2max study. Data reduction and analysis has been ongoing. A draft of an internal NASA report, outlining the primary findings of the study, has been submitted to the management of the Exercise Physiology and Countermeasures project at NASA-JSC. This report is also a preliminary draft of the final report due next month to the Human Research Program. The investigators are in the process of preparing manuscripts of the study findings that will be submitted to peer-reviewed scientific journals over the next few months. The general findings of the study are: 1) Long duration ISS crewmembers typically experience a decline in peak oxygen uptake (VO2peak) which is evident within the first month of flight. VO2peak tends to slowly increase from the initially reduced levels during flight; however, the group data suggests that that VO2peak does not return to preflight levels. We speculate that the initial decrease in VO2peak is related to decreases in blood/plasma volume early in flight, and the upward trend following the initial decline is related to performance of in-flight exercise countermeasures. Immediately following flight, VO2peak is lower that preflight values, but recovers in the month following return to earth. The investigators note that there is a substantial amount of variation between subjects, with at least three subjects demonstrating no change during flight, however, the group data generally follows the description above. 2) The study data indicates that the method of using the heart rate (HR) response to submaximal exercise testing to track changes in VO2peak oftentimes conveys an erroneous impression of aerobic capacity, particularly when applied to an individual’s test results. This study objective was of particular interest to NASA Medical Operations because, although it generally recognized that maximal testing should provide the most accurate assessment of VO2peak, regular exercise tests being performed to maximal levels on ISS is undesirable for several reasons. These include the necessity of real-time ECG monitoring and down-link during maximal exercise tests conducted on ISS, which leads to resource constraints (both time and band-width constraints). Using the submaximal exercise data collected during the VO2max study tests, estimates of VO2peak are calculated using the HR data and assuming the VO2 for each of the submaximal stages are similar those measured preflight [this is the method currently used for NASA Medical Operations]. The estimates of VO2max derived from this technique have varied from actual measurements of VO2max by as much as 40%. When actual measurements of submaximal oxygen uptake obtained during flight are substituted in the method described above, instead of assuming equivalence to preflight submaximal VO2 data, there is less variation from measured VO2peak but still the amount of variability seems inappropriately high to find utility as a method to accurately assess crew aerobic fitness. 3) The data obtained for ancillary physiologic measurements collected during the exercise tests (e.g. the non-invasive cardiac output measurements) are in the process of being statistically examined to determine if they have utility in developing a more accurate submaximal estimate of VO2peak.

Bibliography Type:	Description: (Last Updated: 03/03/2016)
Abstracts for Journals and Proceedings	Moore AD Jr, Evetts SN, Feiveson AH, Lee SMC, Ploutz-Snyder L. "Peak oxygen uptake during and after long-duration spaceflight." 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. , Feb-2013
Articles in Peer-reviewed Journals	Moore AD, Downs ME, Lee SM, Feiveson AH, Knudsen P, Ploutz-Snyder LL. "Peak exercise oxygen uptake during and following long-duration spaceflight." J Appl Physiol (1985). 2014 Jun 26. [Epub ahead of print] http://dx.doi.org/10.1152/japplphysiol.01251.2013 ; PubMed PMID: 24970852 , Jun-2014