Fiscal Year:	FY 2011	**Task Last Updated:**	FY 03/09/2011
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		
PI Email:	alan.d.moore@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	281 483-3749
Organization Name:	NASA Johnson Space Center		
PI Address 1:	Code SK32/KRUG		
PI Address 2:	2101 NASA Road 1		
PI Web Page:			
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:**	0
No. of PhD Candidates:	1	**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:**	
Contact Email:	Peter.norsk@nasa.gov		
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:			
COI Name (Institution):	Feiveson, Alan (Johnson Space Center) Lee, Stuart (Wyle Laboratories) McCleary, Frank (Wyle Laboratories) Platts, Steven (Johnson Space Center) Evetts, Simon (European Astronaut Centre)		
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 have 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, and establish if it can used to validly track actual measures of VO2max. 3. To determine if the addition of a non-invasive cardiac output measures during exercise will improve the accuracy of estimating changes in VO2max during and following ISS missions. *- 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:	Task Progress: The VO2max study continues to progress well. Seven subjects have now completed the study on board ISS, with the eighth currently on board. In addition, informed consent has been obtained for the remaining subject complement. An internal NASA Mid-Study Review was conducted for the management of the Human Research Program (HRP) and the Human Health Countermeasures Element (HHC) in February, 2011. This review recommended continuing the study for the full complement of subjects. The general interim findings of the study are: 1) Long duration ISS crewmembers typically experience a decline in VO2max which is evident within the first month of flight. VO2max tends to slowly increase from the initially reduced levels during flight; however, the group data suggests that that VO2max does not reach preflight levels. We speculate that the initial decrease in VO2max 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, VO2max 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 one subject demonstrating no change during flight, however, the group data generally follows the description above. 2) We continue to examine the accuracy of estimating VO2max, and tracking changes in VO2max, using the heart rate (HR) response to submaximal exercise. This study objective is of particular interest to NASA Medical Operations because, although it generally recognized that maximal testing should provide the most accurate assessment of VO2max, 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 VO2max 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 28%. Thus, it is highly likely that we will conclude that this technique in not a desirable one for Medical Operations to continue to utilize. We also perform a similar calculation using the measured VO2 values for submaximal exercise, instead of assuming equivalence to preflight values. The differences from actual measurements of VO2max are reduced, with the maximal difference being approximately 14%. Thus, there is increased precision in using this technique but it still may be too variable to recommend for accurate assessment of aerobic fitness. 3) Ancillary measurements taken during the exercise tests (e.g. the cardiac output measurements) have been obtained. Determination of their utility in developing a more accurate submaximal estimate of VO2max is ongoing.

Bibliography Type:	Description: (Last Updated: 03/03/2016)
Abstracts for Journals and Proceedings	Moore AD, Lee SMC, McCleary FA, Evetts SN, Feiveson AH. "Oxygen Consumption and Heart Rate Responses in Graded Exercise during Long-Duration Space Flight. " Presented at the 57th Annual Meeting of the American College of Sports Medicine, Baltimore MD, June 1-5, 2010. Med Sci Sport Exerc. 2010 May;42 (5 Suppl):515. http://dx.doi.org/10.1249/01.MSS.0000385173.96698.e6 , May-2010