

<b>Fiscal Year:</b>	FY 2010	<b>Task Last Updated:</b>	FY 05/21/2010
<b>PI Name:</b>	Adams, Gregory R. Ph.D.		
<b>Project Title:</b>	Integrated Endurance and Resistance Exercise Countermeasures Using a Gravity Independent Training Device		
<b>Division Name:</b>	Human Research		
<b>Program/Discipline:</b>	NSBRI		
<b>Program/Discipline--Element/Subdiscipline:</b>	NSBRI--Musculoskeletal Alterations Team		
<b>Joint Agency Name:</b>	<b>TechPort:</b>	Yes	
<b>Human Research Program Elements:</b>	(1) <b>HHC:</b> Human Health Countermeasures		
<b>Human Research Program Risks:</b>	(1) <b>Aerobic:</b> Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity (2) <b>Muscle:</b> Risk of Impaired Performance Due to Reduced Muscle Size, Strength and Endurance		
<b>Space Biology Element:</b>	None		
<b>Space Biology Cross-Element Discipline:</b>	None		
<b>Space Biology Special Category:</b>	None		
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<b>City:</b>	Irvine	<b>State:</b>	CA
<b>Zip Code:</b>	92697-0001	<b>Congressional District:</b>	48
<b>Comments:</b>			
<b>Project Type:</b>	GROUND	<b>Solicitation / Funding Source:</b>	2007 Crew Health NNJ07ZSA002N
<b>Start Date:</b>	06/01/2008	<b>End Date:</b>	05/31/2012
<b>No. of Post Docs:</b>	1	<b>No. of PhD Degrees:</b>	0
<b>No. of PhD Candidates:</b>	0	<b>No. of Master' Degrees:</b>	0
<b>No. of Master's Candidates:</b>	0	<b>No. of Bachelor's Degrees:</b>	0
<b>No. of Bachelor's Candidates:</b>	0	<b>Monitoring Center:</b>	NSBRI
<b>Contact Monitor:</b>	<b>Contact Phone:</b>		
<b>Contact Email:</b>			
<b>Flight Program:</b>			
<b>Flight Assignment:</b>			
<b>Key Personnel Changes/Previous PI:</b>			
<b>COI Name (Institution):</b>	Baldwin, Kenneth ( University of California, Irvine ) Caiozzo, Vincent ( University of California, Irvine )		
<b>Grant/Contract No.:</b>	NCC 9-58-MA01601		
<b>Performance Goal No.:</b>			
<b>Performance Goal Text:</b>	Extended space flight as well as existence on the Moon and Mars will require exercise equipment and training protocols designed to maintain physical fitness and general health. NASA has determined that current flight rated exercise hardware is not appropriate for use on the future Crew Exploration Vehicle (CEV) (JSC SAT Report 12/06). Studies will investigate protocols designed to maintain both cardiovascular and musculoskeletal fitness using a gravity independent multi-mode exercise device (M-MED), which has been identified by NASA as potential flight hardware. M-MED can provide either high resistance strength- or low resistance endurance-mode exercises. Phase 1 -ground based integrated strength & CV exercise training under normal weight bearing conditions. Phases 2&3 - application of this protocol with progressive levels of inactivity. Measurements - total body physical work capacity, muscular mass, strength and sustained muscle endurance (i.e., EVA related issues). CV-related exercise using M-MED "aerobic" mode configuration		

<b>Task Description:</b>	<p>designed to minimize the time spent in exercise using high power output, short duration interval training. On alternate days, the M-MED will be configured for strength training which has been shown to result in increased muscle strength and size. These studies will validate the efficacy of concurrent endurance and strength training as a high economy approach to flight crew physical fitness, using a scientifically proven exercise modality that has a high probability for use during prolonged spaceflight missions. This work directly addresses primary requirements in the NSBRI RFA:</p> <ol style="list-style-type: none"> <li>1. "New, innovative exercise hardware for deployment on CEV, lunar and Martian surfaces that provide efficient means for maintenance of aerobic capacity, bone and muscle strength, and endurance with sufficient reserve for contingencies".</li> <li>2. "New, innovative exercise protocols that minimize in-flight crew time necessary to maintain aerobic capacity and muscle strength and endurance, and facilitate reserve for contingencies on lunar and Martian missions".</li> </ol>
<b>Rationale for HRP Directed Research:</b>	
<b>Research Impact/Earth Benefits:</b>	<p>The data collection associated with this study includes extensive cellular and molecular analysis that will provide information on the mechanisms by which skeletal muscle adapts. This information will contribute to the basic science necessary to understand regulatory processes in muscle. A number of disease states result in changes in skeletal muscle at the cellular level. The fundamental information developed in the current studies will contribute to the knowledge base necessary to understand these processes. Specific questions, such as the potential for cross- talk or interference between endurance and resistance mode exercise also have high relevance in the area of rehabilitation medicine as well as occupational and sports performance. The M-MED itself represents a single stand alone system that can be used for a wide variety of exercises. As such it can provide a useful platform for either rehabilitation and/or health maintenance in circumstances wherein access to a number of much larger devices is limiting.</p>
<b>Task Progress:</b>	<p>It has been established that long term residence in an environment with effective gravity loading significantly lower than earth normal will cause deconditioning of the cardiovascular, skeletal and skeletal muscular systems. Resistance and endurance mode exercise will be required to counter these deconditioning effects. The multi-mode exercise device or M-MED is gravity independent and is designed to provide both the high force concentric (muscles shorten against resistance) and eccentric (muscles resist lengthening due to an external load) and low force rowing type resistance. This allows the M-MED to be used for both low repetition high force strength training and high repetition low force endurance mode training. The aims of this study are to validate the effectiveness of M-MED exercise as countermeasures to physical deconditioning. To date the results indicate that foot forces in resistance mode exercise on M-MED are similar to those seen using free weight exercises. Similarly, electromyography (EMG) studies demonstrate that similar activation levels are seen in key agonist muscles during either M-MED based or free weight resistance exercise. These findings indicate that the gravity independent M-MED is a viable option for resistance mode exercise during flight and/or planetary exploration. Results also show that, when configured for endurance mode exercise, the thigh, leg and arm muscles are robustly activated. Thus M-MED endurance mode exercise may have the added benefit of maintaining and, possibly, improving strength and endurance of arm muscles of flight crews. Endurance mode exercise was also found to stimulate recruitment of the muscles which support the spine indicating that M-MED based exercise may promote the maintenance of lower back stability and loading during flight and planetary exploration. Year 2 training studies involve eight weeks of subject participation and are conducted in serial campaigns. To date, three eight week campaigns have been completed. A total of sixteen subjects have completed training. In addition, nine subjects are currently participating in campaign number four. Data analysis is ongoing. Interim results indicate that subjects completing the combined interval endurance plus heavy resistance training protocol experienced significant increases in: VO2 max (12%), 3RM (18%) and myofiber cross sectional area (14.5%). These results indicate that training on the M-MED device has the potential to address two critical risks: 1) cardiovascular deconditioning; 2) Decreased muscle strength and size (atrophy). Additional deliverables from year 2 include cross validation of VO2 testing results between the M-MED device and laboratory standard cycle ergometry based testing protocols (<math>r=0.95</math>, <math>p&lt;0.0001</math>; <math>n=16</math>). These results indicate that the M-MED device can be used for both training and physical work capacity testing providing a platform for in-flight assessment.</p>
<b>Bibliography Type:</b>	Description: (Last Updated: 03/23/2018)
<b>Articles in Peer-reviewed Journals</b>	<p>Adams GR. "Insulin-like growth factor I signaling in skeletal muscle and the potential for cytokine interactions." Med Sci Sports Exerc. 2010 Jan;42(1):50-7. <a href="http://dx.doi.org/10.1249/MSS.0b013e3181b07d12">http://dx.doi.org/10.1249/MSS.0b013e3181b07d12</a> ; PubMed <a href="https://pubmed.ncbi.nlm.nih.gov/20010130/">PMID: 20010130</a> , Jan-2010</p>