Fiscal Year:	FY 2009	**Task Last Updated:**	FY 04/09/2009
PI Name:	Bloomberg, Jacob J. Ph.D.		
Project Title:	Physiological Factors Contributing to Postflight Changes in Functional Performance (Functional Task Test)		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:		**TechPort:**	No
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Human Research Program Risks:	(1) **Sensorimotor**:Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	77058-3607	**Congressional District:**	36
Comments:			
Project Type:	FLIGHT	**Solicitation / Funding Source:**	Directed Research
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No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
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Flight Program:	Shuttle/ISS		
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Key Personnel Changes/Previous PI:			
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Performance Goal Text:	
Task Description:	During space flight astronauts experience alterations in multiple physiological systems due to exposure to microgravity. These physiological changes include sensorimotor disturbances, cardiovascular deconditioning, loss of muscle mass and strength. These changes lead to disruption in the ability to ambulate and perform functional tasks during the initial reintroduction to a gravitational environment and may cause significant impairments in performance of operational tasks immediately following landing on a planetary surface. To date, changes in functional performance that result from physiological changes have not been systematically documented. The objective of this study is to identify the key underlying physiological factors that contribute to performance of functional tests that are representative of critical mission tasks for lunar and Mars operations. We will test astronauts on an integrated suite of functional and physiological tests before and after short and long-duration space flight. This study will 1) identify functional tasks and physiological changes that relate to and are predictive of human performance following space flight on return to planetary gravity; 2) map physiological changes to alterations in functional performance and 3) aid in the design of countermeasures that specifically target the physiological systems responsible for impaired functional performance. The functional test battery was designed to address high priority tasks identified by the Constellation program as critical for mission success. The set of functional tests making up the FTT include the: 1) Seat Egress and Walk Test, 2) Ladder Climb Test, 3) Recovery from Fall/Stand Test, 4) Rock Translation Test, 5) Jump Down Test, 6) Torque Generation Test, and 7) Construction Activity Board Test. Corresponding physiological measures include assessments of postural and gait control, dynamic visual acuity, fine motor control, plasma volume, orthostatic intolerance, upper and lower body muscle strength, power, fatigue, force control and neuromuscular drive. Crewmembers will perform both functional and physiological tests before and after short (Shuttle) and long-duration (ISS) space flight. Data will be collected on R+0 (Shuttle only), R+1, R+6 and R+30. Using a multivariate regression model we will identify which physiological systems contribute the most to impaired performance on each functional test. This will allow us to identify the physiological systems that play the largest role in decrement in functional performance. Using this information we can then design and implement countermeasures that specifically target the physiological systems most responsible for the altered functional performance associated with space flight.
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:	This research will provide a better understanding of the underlying physiological mechanisms that contribute to changes in functional performance. In the elderly population activities of daily living are often impaired by mutifactorial physiological causes. The information obtained from this interdisciplinary study will aid in identifying the relative contributions of sensorimotor, cardiovascular and muscle function on comprehensive performance outcomes. This has direct application in the design of clinical interventions and rehabilitation programs that can target specific systems responsible for decline in functional performance.
	We have conducted a series of studies to investigate the reliability of a subset of test measures that were designed specifically for this study. Two studies are summarized below: Functional Tests The objective of this pilot study was to examine the reliability of our set of functional tests. To achieve this objective, 14 normal subjects were tested on the battery of functional tests on three separate sessions with a preceding familiarization session at least 2 days apart to determine if the performance metrics obtained from these functional tests display variations between the sessions that are within limits to detect a change after space flight. The duration of the reliability study was seven weeks and a total of 56 test sessions were completed. In addition to the primary data measures collected during the sessions, subjects were equipped with hardware that recorded electrocardiogram (EKG), blood pressure, electromyography (EMG), and body position data. These functional tests will become part of a larger suite of tests that include corresponding physiological measures that include assessments of vestibular function, dynamic visual acuity, fine motor control, postural and locomotor stability, plasma volume, orthostatic intolerance, upper and lower body muscle strength, power, fatigue, control and neuromuscular drive. The following functional tests were conducted: 1) Seat Egress and Walk Test The ability to egress from a seat, ambulate and avoid obstacles following landing will be assessed with the Seat Egress and Walk Test. For this test subjects were required to unbuckle a harness while in a seat and stand up. Testing occurred under two initial conditions: 1) with the seat upright; 2) with the seat positioned with its back to the floor. Immediately following egress from the seat, subjects walked through the obstacle course. After negotiating the portal and pylons, subjects walked up and down a sloped surface inclined at 18 degrees. The primary performance metric was time to complete the course. 2) Recovery from Fall/Stand Test Impairment in the ability to get up from a prone position is one of the strongest independent risk factors associated with serious fall related injuries. For this test, subjects, were asked to lie down on a mat face down and then asked to stand up again as quickly as possible when a start command was given. The primary performance metric was time elapsed between presentation of the start command and the completion of the stand. We have integrated into this test, a three-minute Stand Test designed to assess orthostatic intolerance in an operational context and gain physiological data describing underlying changes in cardiovascular function that contribute to orthostatic intolerance. Immediately upon standing up, subjects performed the Stand Test by taking a step onto the solid floor and maintained a quiet standing position for three minutes. Previous results from landing day tilt/stand tests indicate that three minutes should provide a reasonable measure of orthostatic tolerance while remaining within a non-syncopal period even for long-duration crewmembers. Continuous blood pressure was acquired with a Portapres

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(TNO Medical, Netherlands) ambulatory blood pressure monitor. High fidelity, 12-lead EKG was acquired with a Holter monitor (Mortara Instrument, Milwaukee, WI).

3) Rock Translation Test

While on the planetary surface astronauts will be required to carry objects (tools, equipment, rock samples) from one point to another. To simulate this task requirement subjects picked up one of three weights (6, 10, 20 lbs) that have handles to grip (CorBall, Power Systems Inc. Knoxville, TN) and carried the weight a distance of eight feet and placed it in a receptacle positioned at twenty inches above the floor. This procedure was repeated until all three weights were individually transferred to the receptacle. Then the subject returned each weight one-by-one to its original location. The primary performance metric was time to complete the entire task.

4) Torque Generation Test

Performance on the Torque Generation Test was assessed with the use of the BTE PrimusRS System (BTE Technologies, Hanover, MD). A wheel attachment was affixed to the PrimusRS to simulate a hatch-opening task. Subjects stood on the floor while performing the task under both isometric and isotonic conditions. For the isometric evaluation the wheel attachment was fixed and subjects were asked to apply as much torque as possible to rotate the wheel assembly. The PrimusRS recorded the torques during the session. In the isotonic portion of the assessment, a constant resistance was applied to the wheel attachment and the wheel was allowed to rotate. The resistance applied by the system was equal to 50% of the average peak torque obtained from the isometric trial. The subject was asked to turn the wheel as quickly as possible for a total time of 20 seconds. The primary performance metrics were peak torque and number of wheel turns in 20 seconds.

5) Ladder Climb Test

The ability to climb a ladder is an essential functional task related to entering or exiting into a planetary landing vehicle. Current landing vehicle designs (i.e. Lunar Surface Access Module) include ladders that extend from 20-28 rungs, so ladder climbing will be an early task performed by astronauts soon after landing on a planetary surface. To gain a better understanding of ladder climbing ability, we developed the Ladder Climb Test. To perform the Ladder Climb Test, subjects climbed a passive treadmill ladder (Jacobs Ladder, LLC, North Tonawanda, NY) at a self-generated pace until they completed 40 rungs. The primary performance metric was time to completion.

6) Construction Activity Board Test

To assess changes in the ability to perform manual assembly and repair tasks each subject completed a standard EVA training task. This task has been used previously to evaluate space suit designs and is used to train astronauts participating in actual EVA activities. While standing, subjects performed a variety of standard construction and assembly tasks including connecting hoses to receptacles. Subjects also used a cordless power tool to tighten bolts on a handle assembly. The primary performance metric was time to complete the entire set of manual tasks.

7) Jump Down Test

Astronauts may be required to jump down from landing vehicles, habitats and on uneven terrain during exploratory extravehicular activities (EVAs). Changes in this ability can lead to increased incidence of falling. Given the previously described changes in control of jumping and landing and the highly relevant operational nature of this task we designed a functional test to investigate jump down performance.

During the Jump Down Test, subjects used a two-footed hop to jump from a height of 30 cm and landed on a force plate to measure the peak vertical impact force on landing. (Kistler, model 9286A, Kistler Instruments, Winterthur, Switzerland). Force transducers, one under each foot, were used to determine the time that the subject leaves the platform. EMG was collected using a system developed by Delsys, Inc. (Bagnoli EMG systems, Delsys Inc., Boston, MA). Electrodes were placed on the major postural muscles (medial and lateral gastrocnemius, soleus, and anterior tibialis) on the subject's left leg.

The first performance metric for the Jump Down Test was the Settling Time. This metric provides a measure of how quickly the postural control system can bring the body to steady state after impact following the jump. The other performance metric was the peak resultant force following landing. These metrics provide an overall indication of the efficacy of intersegmental coordination and muscular control mechanisms to produce an appropriate response to compensate for impact forces following landing. The two main EMG parameters obtained were: 1) the preparatory response latency with respect to the time the subject leaves the platform and, 2) Functional Stretch Reflex latency with respect to force plate impact. This test was repeated for total of three trials.

Conclusions

1) The main performance metrics obtained from the FTT functional tests were within limits to detect a change associated with space flight. Therefore, the functional test performance metrics are reliable indicators of postflight performance.

2) The signals obtained from the body motion sensors, EMG electrodes and the force plate were within the physiological range expected and the signal quality is such that the desired parameters can be extracted for analysis.

3) Excellent quality blood pressure data were obtained for the portions of the FTT that were designed to evaluate an orthostatic challenge. Additionally, heart rate data, and its derivatives were satisfactorily obtained for all but the Torque Generation Test.

Muscle Performance Tests

The goal of this pilot study was to examine the reliability of the muscle performance measures used in this study. Ten subjects completed a battery of lower- and upper-body neuromuscular performance tests on three separate occasions, with each session separated by at least 48 hours. The battery consisted of tests in the following order: 1) knee extension central activation; 2) knee extension force steadiness; 3) leg press maximal strength; 4) leg press maximal power; 5) leg press power endurance; 6) bench press maximal strength; 7) bench press force steadiness; 8) bench press maximal power; and 9) bench press power endurance. We determined that the muscle performance test battery could quickly and reliably assess diverse indices of neuromuscular performance.

Bibliography Type:	Description: (Last Updated: 05/21/2021)
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