Fiscal Year:	FY 2009	**Task Last Updated:**	FY 09/15/2009
PI Name:	Lang, Thomas F. Ph.D.		
Project Title:	An Integrated Musculoskeletal Countermeasure Battery for Long-Duration Lunar Missions		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Musculoskeletal Alterations Team		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Bone Fracture**:Risk of Bone Fracture due to Spaceflight-induced Changes to Bone (2) **Osteo**:Risk Of Early Onset Osteoporosis Due To Spaceflight		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	94143-0649	**Congressional District:**	8
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2007 NSBRI-RFA-07-01 Human Health in Space
Start Date:	09/01/2007	**End Date:**	08/31/2011
No. of Post Docs:	0	**No. of PhD Degrees:**	9
No. of PhD Candidates:	0	**No. of Master' Degrees:**	1
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Bloomberg, Jacob (NASA JSC) Grodsinsky, Carlos (ZIN Technologies, Inc.) Sibonga, Jean (USRA) Mulavara, Ajitkumar (USRA) Lee, Stuart (Wyle Integrated Sciences and Engineering Group) Cavanagh, Peter (University of Washington)		
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Task Description:	The degree to which the musculoskeletal system will maintain its integrity during prolonged sojourns in the reduced gravity of the lunar surface is presently unknown. It is, however, likely that without countermeasures there will be adaptive changes in muscle strength, bone mineral density, bone geometry, and sensorimotor status. When the combined effects of these changes are considered in the context of the construction and exploration tasks that will be performed at the lunar base or at other lunar sites, the risk of injury secondary to a fall is likely to be elevated. To address this fundamental problem, we have constructed a compact platform that integrates a time efficient integrated battery of countermeasures that can be conducted in the confines of the lunar habitat to minimize the risk of musculoskeletal injury. Ultimately, we expect that this battery of countermeasures will be validated using a 10° head-up bedrest simulation of a lunar mission, although it could also be tested in the standard 6 degree head down simulation. The specific objectives of the countermeasure battery are: to preserve muscle strength and cardiovascular fitness; to minimize decrements in postural stability, dynamic balance, and the ability to make corrective actions prior to a fall; to preserve functional performance on mission relevant tasks; and to minimize bone loss in the proximal femur. To accomplish these objectives, we have constructed a unique multi-functional countermeasure device which integrates cardiovascular, balance control, and resistance training functions. The stepper system provides cardiovascular exercise. When the stepper is locked down, the device may be utilized for lower body strengthening exercises such as squats, leg extensions and abductor/adductor exercises. To facilitate balance training, the stepper/resistive system is mounted on a Stuart Platform allowing 3D translations with a range of +/- 10 cm and pitch/yaw/roll of +/-10 degrees. As a next step, we are carrying out a training study to quantify, in the 1-g setting, increases in cardiovascular function (VO2 max) and lower body strength in volunteers characteristic of the population of the Flight Analog Project Bedrest study. Also, in the coming year, we plan to carry out a substudy testing the balance training function of our device in subjects with sensorimotor deficits. We believe that this study will establish that the gains is muscle strength and VO2max, when the device is used with an exercise prescription simulating its function in bedrest and spaceflight, will be comparable to historical studies in which resistive and cardiovascular exercises have been performed in parallel. We hypothesize that the combined effect of this multifaceted intervention will be to significantly reduce the risk of a work-related falls and subsequent injury. Ultimately, we expect to test our hypothesis in a bedrest study by randomizing half of our subjects to a group which will undergo the integrated countermeasure and the other half to a control group. Pre- and post-bedrest, we will compare indices of balance, muscle strength, and skeletal density and function using a combination of functional and strength tests, serum and urine bone markers and CT and DXA imaging of the hip, spine and tibia.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Outside of the space medicine community, there is a growing appreciation of the importance of an integrated musculoskeletal approach towards prevention of age-related skeletal fractures. Hip fractures, which represent the most serious manifestation of osteoporosis, rarely occur without falls, and the exercise strategies developed here could potentially be adapted to an older demographic, with the same compact exercise and balance countermeasures geared towards reduction of falls and bone loss in the growing population of elderly. We believe that the compact characteristics of the CCD which are optimal for the spaceflight environment will also fulfill the needs for an in-house exercise device or for a nursing home. It is well known that impaired balance is associated with aging and with an increased risk of falling. Balance training exercise in the elderly has been shown to reduce risk of falls. In particular, resistive exercise has been shown to increase muscle strength in the elderly, and increases in muscle strength and balance are associated with improvements in performance and mobility, which are important determinants of quality of life in the elderly. Finally, by focusing on resistive exercise in the abductor and adductor muscle groups, this device is expected both to improve lateral balance and reduce the rate of age-related bone loss by stressing those muscle groups that attach at the hip and thus provide significant mechanical loads on the proximal femur.
Task Progress:	In November 2008, the Combined Countermeasure Device (CCD) was installed at the PI's laboratory at UC San Francisco. The CCD combines cardiovascular exercise, neurovestibular stimulation, and lower body strength exercise into a single compact design of 32" diameter. Resistive exercise employs cables attached to Subject Loading Devices to provide resistance for squats, leg extensions and flexions, hip adduction and abduction and ankle plantar flexion. Cardiovascular stimulus is obtained by stepping exercise. The platform used for the resistive and stepping exercise is integrated onto a Stewart platform offering ten degrees of pitch, roll and yaw and translation in three dimensions. The balance exercise is designed to be carried in combination with visual stimulation provided by changing scenes projected onto a stationary screen. The current year of the study, ending 8/31/09, was devoted to starting a training study to demonstrate that cardiovascular and resistive exercise could improve measures of muscle strength and endurance. The study components included training on the CCD at our facility and pre- intermediate and post training testing at the Exercise Laboratory at the Clinical Research Center (CRC) of the UCSF Clinical and Translational Science Institute. We have made considerable progress: 1) The CCD was installed in 12/2008. We also brought new personnel onto the project so that the training study could be carried out at UCSF. Mr. Tim Streeper, an Exercise Physiologist, was brought in to lead the training study. Dr. Lynda Frassetto, Medical Director of the CRC, joined as our Study Physician. Dr. Kathleen Mulligan, director of the CRC Exercise Lab, became a co-investigator. Drs. Frassetto and Mulligan have been instrumental in use of the CRC for the pre and post training strength and VO2max testing. 2) We carried out pilot studies to reveal issues with the study logistics and operation of the CCD. These pilot studies revealed multiple technical issues with the operation of the device in strength training and stepping mode. These problems were identified and fixed in the first part of 2009, which delayed the projected start of the training study from March to May 2009. 3) We started the training study in May 2009. As of time of this report, three subjects have finished the full twelve week study, with four more subjects in initial and intermediate phases of the study. By the end of the project period, four subjects will have completed training. 4) Initial results are positive. On average, with three subjects complete, VO2max increases by an average of 7%, and leg press strength by 60%. Hip abductor and adductor strength increase by 20 and 68% respectively. Given that the technical problems associated with the early part of the study have been addressed, we expect to make considerable progress towards completing the study in the coming year.

Bibliography Type:	Description: (Last Updated: 03/20/2017)