

Fiscal Year:	FY 2006	Task Last Updated:	FY 12/14/2006
PI Name:	Rubin, Clinton Ph.D.		
Project Title:	A Low Intensity Mechanical Countermeasure to Prohibit Osteoporosis in Astronauts During Long-Term Spaceflight		
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) 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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City:	Stony Brook	State:	NY
Zip Code:	11794-2580	Congressional District:	1
Comments:			
Project Type:	FLIGHT	Solicitation / Funding Source:	ILSRA 2001
Start Date:	03/15/2004	End Date:	03/15/2007
No. of Post Docs:	0	No. of PhD Degrees:	1
No. of PhD Candidates:	3	No. of Master' Degrees:	1
No. of Master's Candidates:	1	No. of Bachelor's Degrees:	0
No. of Bachelor's Candidates:	2	Monitoring Center:	NASA JSC
Contact Monitor:	McCollum, Suzanne	Contact Phone:	281 483-7307
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Flight Program:			
Flight Assignment:	In flight development phase (not yet manifested) NOTE: End date changed to 3/15/2007 (from 3/15/2009) for database validation reasons (6/2008)		
Key Personnel Changes/Previous PI:	0		
COI Name (Institution):	Judex, Stefan (State University of New York at Stony Brook) Qin, Yi-Xian (State University of New York at Stony Brook)		
Grant/Contract No.:	NNJ04HD87A		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	<p>Osteoporosis, the progressive loss of bone density and strength that cripples tens of millions on our planet, distinguishes itself as perhaps the greatest physiologic obstacle to an extended human presence in space. The principal objectives of this proposal are to establish the efficacy of a unique, mechanical countermeasure to inhibit bone loss - and muscle strength- in the lower appendicular skeleton of astronauts and payload specialists during International Space Station missions. Using a ground based model of microgravity, the tail-suspended rat, we have shown that brief exposure (10 minutes) to extremely low magnitude (0.25g, engendering <5 microstrain), high frequency (30-90 Hz) mechanical signals will inhibit the bone loss which typically parallels disuse, even though 10 minutes of full weightbearing failed to curb this loss. Longer-term experiments in sheep have shown this stimulus to be strongly anabolic, increasing bone mineral density, trabecular number and connectivity, and improving bone strength. Preliminary results in post-menopausal women and children with cerebral palsy indicate that this intervention can inhibit, and perhaps reverse, osteoporosis. To determine this intervention's ability to inhibit bone loss - and muscle strength - in people during prolonged space missions, we will subject astronauts, in single let stance, to brief exposures to the low level stimulus (10 minutes at 30 Hz, 0.3g), allowing the contralateral limb to serve as an intra-subject control. The proposal is structured to "piggy-back" onto ongoing flight studies, and thus the assays for efficacy will be determined by collaborative decisions between NASA teams studying the musculoskeletal system. At a minimum, DXA, QCT, and muscle strength measurements will be made both pre- and post- flight. This work represents a critical step in establishing a physiologically based, non-pharmacologic, non-invasive treatment for osteoporosis, for use on Earth or in space.</p>
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	<p>The intervention represents the basis for a non-pharmacologic interevent for the prevention and/or reversal of bone loss (osteoporosis) here on earth. Three clinical studies have been completed (post-menopausal women, children with cerebral palsy, young women w/ osteoporosis), each which supports the hypothesis that low-level mechanical signals can benefit the mass and morphology of the musculoskeletal system.</p>
Task Progress:	<p>The osteoporosis which develops in microgravity is one of the greatest hurdles to an extended human presence in space. Earth-based animal and human studies have demonstrated that extremely low magnitude mechanical loading, if imposed at a high frequency, is strongly anabolic to the skeleton, and can serve to inhibit the bone loss, which typically parallels disuse. This experiment is designed to evaluate the efficacy of this unique biomechanical countermeasure to inhibit the microgravity induced osteoporosis. To achieve this in a non-invasive, non-pharmacologic means would have tremendous impact not only in space, but would also address the bone loss which plagues over 20 million people world wide each year on earth.</p> <p>During extended missions ISS crewmembers will receive ten-minute daily doses of high frequency (30Hz), low magnitude (0.3g, or $3\text{m}\cdot\text{s}^{-2}$) mechanical accelerations. The subject will be secured to an oscillating plate by a shoulder harness, at 60% of their pre-launch body mass thus imparting sufficient force to allow the vibration of the platform to induce 0.3g accelerations to the lower appendicular and axial skeleton. The experimental equipment is designed such that it will not transmit vibration to the vehicular structure.</p> <p>Following flight durations of at least three months, the bone quantity and quality will be evaluated by comparing post-flight DEXA, QCT and ultrasound measurements to baseline (pre-flight measurements). The principal areas of interest will be R&L femora, tibia, calcaneus, the spine (L1-4), and non-dominant radius. Assays will evaluate bone density, trabecular and cortical bone density, cortical thickness, apparent bone quality, and bone mineral density. Muscle strength and postural stability will also be evaluated, again comparing pre and post-launch data.</p> <p>Differences from the baseline will be examined in terms of the ability of extremely low-level mechanical stimulation to inhibit the loss of bone quality and quantity. The preservation of muscle strength and postural stability, as based on these mechanical signals will provide a key to the regulatory stimulus in the maintenance of the musculoskeletal system.</p> <p>Efficacy will be determined as based on the ability of the signal to inhibit bone loss, prevent loss of muscle power and loss of postural stability. Given the ground-based evidence, we anticipate that treated crewmembers will retain bone density and muscle strength regardless of the deleterious consequences of the absence of gravity. Further, it is anticipated that bone loss in the axial skeleton (spine) will be reduced through exposure to the low-level mechanical signal. The experimental system is referred to as VIBE: Vibrational Inhibition of Bone Erosion.</p> <p>The experimental protocol and device hardware have been evaluated by a number of NASA committees, and the progress of the experiment continues on a path to flight.</p>
Bibliography Type:	Description: (Last Updated: 10/22/2009)
Abstracts for Journals and Proceedings	<p>Qin Y-X, Xia Y, Lin W, Mittra E, Gruber B, Rubin CT. "Trabecular bone density and strength assessment using non-invasive scanning confocal ultrasound imaging technology. " ASBMR-NIH (NIAMS) Bone Quality Workshop. Bone Quality: What is it and- can we measure it?, Washington DC, May 2005.</p> <p>ASBMR-NIH (NIAMS) Bone Quality Workshop. Bone Quality: What is it and- can we measure it?, May 2005. , May-2005</p>
Abstracts for Journals and Proceedings	<p>Judex S, Miller LM, Qin YX, Donahue LR, Rubin C. "Genetic and epigenetic influences on bone quantity and quality. " Symposium on "Comparative Animal Models for Studying Bone & Cartilage Morphogenesis & Growth." Experimental Biology 2005, San Diego, CA, April 2-6, 2005.</p> <p>Experimental Biology 2005, Program and Abstracts, Abstract #778.2, April 2005. , Apr-2005</p>