Fiscal Year:	FY 2013	**Task Last Updated:**	FY 06/05/2013
PI Name:	Hargens, Alan R. Ph.D.		
Project Title:	Risk of Intervertebral Disc Damage after Prolonged Space Flight		
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) **Dynamic Loads**:Risk of In-Mission Injury and Performance Decrements and Long-term Health Effects due to Dynamic Loads (2) **IVD**:Concern of Intervertebral Disc Damage upon and immediately after re-exposure to Gravity [inactive] (3) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures (4) **Renal Stone**:Risk of Renal Stone Formation		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	92037-0863	**Congressional District:**	52
Comments:			
Project Type:	Flight	**Solicitation / Funding Source:**	2009 Crew Health NNJ09ZSA002N
Start Date:	07/01/2010	**End Date:**	06/30/2013
No. of Post Docs:	3	**No. of PhD Degrees:**	
No. of PhD Candidates:	1	**No. of Master' Degrees:**	1
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	2
No. of Bachelor's Candidates:	4	**Monitoring Center:**	NASA JSC
Contact Monitor:	Mullenax, Carol	**Contact Phone:**	281.244.7068
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Flight Program:	Pre/Post Flight		
Flight Assignment:	ISS NOTE: End date is 6/30/2013 per NSSC and PI (Ed., 9/25/13) NOTE: End date is 9/30/2013 per D. Risin/JSC (Ed., 7/11/13) NOTE: To be extended per J. Maher/JSC (Ed., 4/2013)		
Key Personnel Changes/Previous PI:			

COI Name (Institution):	Lotz, Jeffrey (University Of California, San Francisco) O'Neill, Conor (Self) Sayson, Jojo (Ola Grimsby Institute, San Diego) Chiang, Stephen (Methodist Hospital) Chang, Douglas (University Of California, San Diego) Allon, Moshe (Self) Parazynski, Scott (The Methodist Hospital Research Institute) Riascos-Castaneda, Roy (University of Texas Medical Branch)
Grant/Contract No.:	NNX10AM18G
Performance Goal No.:	
Performance Goal Text:	
Task Description:	Our proposal is a Flight Definition Study that will use state-of-the-art imaging technologies to quantify morphology, biochemistry, metabolism, and kinematics for lumbar discs of crew members before and after prolonged space flight. Importantly, we will correlate these data with low back pain that spontaneously arises in space so as to establish pain and disc damage mechanisms that will serve as basis for future countermeasure development. After successful completion of our investigation, we will deliver a comprehensive database of microgravity-induced intervertebral disc and vertebral changes (type and magnitude) and a prioritization of these changes as to their deleterious effects and risks for crew member injury based on clinical findings. We hypothesize that spontaneous space-flight back pain and disc herniation are due to biomechanical and biological pathomechanisms. First, microgravity leads to higher than normal physiologic disc swelling and increased disc height that may stiffen the lumbar motion segment and cause abnormal segmental movement patterns. These biomechanical changes increase risk for annular rupture, vertebral endplate microfracture, and facet joint capsule strain. Second, increased disc swelling may alter nuclear matrix osmotic pressure and nutrient transport from endplate capillaries in adjacent vertebra. These biological changes adversely affect disc cell metabolism, causing pain and inducing disc matrix degradation. Our project directly addresses the Critical Path Roadmap Risks and Questions for NASA regarding disc injury (IRP Gap-B4): Is damage to joint structure, intervertebral discs, or ligaments incurred during or following hypogravity exposure? The goal of this research is to characterize space-flight induced changes comprehensively in disc morphology, biochemistry, metabolism, and kinematics. These data will be correlated with measures of back pain intensity and disability. Crewmembers will be imaged pre-flight to establish baseline data and to characterize measurement repeatability. After long-term microgravity exposure (about 180 days on ISS), crewmembers will be studied while maintaining supine posture as soon as possible after return to 1-G in order to quantify the acute effects of prolonged space flight. Also, pre- and post-flight, they will be imaged supine and in standing upright posture at one body weight and again at 1.1 body weight so that MR images are obtained before and after axial body-weight loads. Pre-flight tests will be done within L-120 to L-60 days before the scheduled space flight. Post-flight tests will be undertaken1-7 days and 30-60 days after landing to investigate re-adaptation to 1-G and to distinguish immediate and longer-term recoveries. Our proposed measures represent a comprehensive set of tests that evaluate exposure severity, potential injury mechanisms, and pain generator localization. Our research will aid understanding of spinal pain and deconditioning during prolonged microgravity and of the higher incidence of disc prolapse or herniation following re-exposure to 1-G with a long-term view to prevent such spinal deconditioning with exercise or other physiologic countermeasures.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	We propose to use state-of-the-art, non-invasive imaging technologies to quantify morphology, biochemistry, metabolism, and kinematics for lumbar discs of crew members before and after prolonged space flight. Importantly, we will correlate these data with low back pain that spontaneously arises during prolonged microgravity and after re-adaptation to Earth gravity, so as to establish pathomechanisms that will serve as a basis for future countermeasure development. After successful completion of our investigation, we will deliver a comprehensive database of microgravity-induced intervertebral disc and vertebral changes (type and magnitude) and a prioritization of these changes as to their deleterious effects and risks for crew member injury based on clinical findings. Importantly, this research will have application to back-pain patients on Earth in general and specifically, to patients exposed to long-term bed rest or lack of mobility (spinal-cord injury patients as well as patients suffering lack of exercise, mobility and obesity). This research also has application to abnormal spinal curvature and pain suffered by children wearing heavy backpacks to and from school.
	We have made significant progress over the past 12 months improving our pre- and post-flight tests, consenting four more ISS crew members, updating IRB applications, submitting amendments and receiving approvals from the UCSD and NASA-JSC Institutional Review Boards (IRBs). In addition, we completed a series of ex vivo human cadaver studies that will be important for interpreting crew member data as well as for planning future countermeasures. Moreover, we also made significant progress with optimizing and validating our pre- and post-flight tests to maximize their scientific and clinical value and to minimize impacts and risks to ISS crew members. Importantly for this year, we performed our first, full Pre- and Post-Flight testing sessions for our first crew member for IVD. Also, we performed a second Pre-Flight testing session for our second crew member for IVD. Four more crew members will be tested in the near future after successful completion of our crew members this year and last. We were very successful in recruiting new crew members recently as evidenced by obtaining consent from all three crew members present at the March 2013 informed consent briefing. To improve our tests and protocol, we amended our JSC-CPHS Protocol 10-072 to include the cervical spine and to reduce the total scanning time for our upright MRI tests of ISS crews before and after flight. This modification reduces the risk (reducing overall scanning time from 80 min to 60 min and having the crew member sit in a fourth scan) and raises the benefit of our protocol by including the cervical spine which has the highest incidence of post-flight disc herniation. The risk of herniated vertebral discs was reported recently for 321 astronauts (Johnston et al., 2010). The incidence of disc herniation was the highest (41%) in the cervical spine, compared to 9% in matched controls. During pilot studies on the PI last year, we were able to streamline the upright MRI studies of the lumbar spine to less than the proposed 80 minutes. We were also able to add scans of my cervical spine for a total scanning time of 60 minutes.

Task Progress:	In January 2013, we renewed our IRB protocol successfully and submitted a minor amendment to our JSC-IRB Protocol 0303 “Risk of Intervertebral Disc Damage after Prolonged Space Flight” that was approved. In brief we moved our Biering-Sorensen test from JSC Building 261, Exercise Physiology Lab under the direction of Dr. Lori Ploutz-Snyder to UTMB Radiology Imaging Center - Victory Lakes 2240 Gulf Freeway South, League City, Texas 77573 (phone 409-772-7150), under the direction of Drs. Eric Walser and Roy Riascos-Castaneda. We believe this amendment will reduce crew time related to our pre- and post-flight testing of crew members. For each ISS increment over the past year, we have carefully reviewed the Experiment Summaries received prior to each increment. By reviewing the experiment summaries for all international space agency’s science teams, we developed a top-level understanding of the operations of other experiments requesting subjects in each increment. Thus, we were able to identify 1) conflicts that cannot be resolved by scheduling, 2) experiments that are mutually exclusive, and 3) conflicts that require further discussion during implementation. Over the past year with the help of our NASA Technical Monitors Steve Hing and Susan Torney, we have reviewed and re-reviewed the detailed Flight Experiment Requirements Document, Experiment Document for Risk of Intervertebral Disc Damage after Prolonged Space Flight. This was important to do after our first Pre- and Post-Flight testing sessions for our first crew member for IVD. Assessment of data retrieved from the first subject has been completed. Comparing the pre- and post- flight data, there was an observed: 1) Increase in lumbar IVD heights as demonstrated by morphological measures of the supine MRI scans, 2) Increased lumbar IVD compressibility with upright MRI scans, 3) Increased stiffness using Spinal Kinematics tests, and 4) Increased low back pain post-flight using the visual-analog scale. In terms of scientific progress, we now have a sample size of one after completing our first, full Pre- and Post-Flight testing sessions for our first crew member for IVD. Thus, it is not possible to make valid conclusions based on this preliminary sample size. However, the images we acquired are very high in quality and give us confidence that future tests will be very successful.
Bibliography Type:	Description: (Last Updated: 07/09/2025)
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