Fiscal Year:	FY 2016	**Task Last Updated:**	FY 06/08/2016
PI Name:	Hargens, Alan R. Ph.D.		
Project Title:	Spinal Structure and Function after 90 Days Long-Duration Simulated Space Flight and Recovery		
Division Name:	Human Research		
Program/Discipline:			
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:	La Jolla	**State:**	CA
Zip Code:	92037-0863	**Congressional District:**	52
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2013 HERO NNJ13ZSA002N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	08/01/2014	**End Date:**	07/31/2017
No. of Post Docs:	2	**No. of PhD Degrees:**	
No. of PhD Candidates:	1	**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:	3	**Monitoring Center:**	NASA JSC
Contact Monitor:	Norsk, Peter	**Contact Phone:**	
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Ferguson, Adam Ph.D. (University of California at San Francisco) Lotz, Jeffrey Ph.D. (University of California at San Francisco) Macias, Brandon (NASA Johnson Space Center) Masuda, Koichi M.D. (University of California at San Diego)		
Grant/Contract No.:	NNX14AP25G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The vertebral bodies and flexible intervertebral discs are important, weight-bearing tissues that have adapted to gravitational stress. Consequently, the absence of gravitational axial loads during exposure to microgravity likely disrupts normal spine physiology. Throughout longer space flight missions, deconditioning of the intervertebral discs and spinal muscles poses a serious injury risk upon re-exposure to upright posture in a gravitational environment. We will use state-of-the-art technologies to quantify morphology, biochemistry, and kinematics of spines (including the vertebrae, intervertebral discs, and spinal muscles) of rats at defined time points as described in the NASA research announcement. After successful completion of our investigation, we will deliver a comprehensive database of simulated microgravity-induced spinal adaptations (type and magnitude). The overarching goal of these proposed studies are to develop a long-duration space flight ground based model of spine function and structure. In addition, this research project will afford the opportunity to examine possible gender differences in spinal structure and function. Our research group is in a unique position to leverage our past rodent space flight experience on STS-131, STS-133, STS-135, and BION M-1 missions and directly compare to this ground based model of simulated microgravity. Moreover, we are also uniquely positioned to compare this 90-days hindlimb suspension model to those changes that occur in our currently funded project to test crew members before and after 6-month International Space Station (ISS) missions. Our project directly addresses Critical Path Roadmap Risks and Questions regarding disc injury (IRP Gap-B4): Is damage to joint structure, intervertebral discs, or ligaments incurred during or following microgravity exposure? Our research will improve understanding of the underlying pathophysiology of spinal deconditioning induced by simulated microgravity, and mechanisms of spinal adaptation following re-exposure to 1-G. Our long-term goal is to prevent such spinal deconditioning with exercise or other physiologic countermeasures. The goal of this research is to comprehensively characterize 90-days simulated space flight and recovery induced changes in spinal tissue morphology, biochemistry, and biomechanics.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	To our knowledge, this study is the first to examine the effects of 90-days simulated space flight on spinal deconditioning in rats and to compare this model of simulated microgravity with actual space flight. The vertebral bodies and flexible intervertebral discs are important, weight-bearing tissues that have adapted to gravitational stress. Our research will aid understanding of spinal deconditioning during simulated 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. This research may aid understanding of spinal deconditioning during inactivity such as after spinal cord injury and bed rest in human patients on Earth.
Task Progress:	To date we have received 39 hind-limb suspension (HLS) spine samples. Currently, all 24 of the 90-day HLS and 90-day HLS + 28-day recovery samples have already been µCT scanned at 9 µm resolution. There are a total of 13 spines remaining to scan, which include samples in the 14-day and 28-day HLS groups. An abstract titled “90-Days Simulated Spaceflight Impairs Quality of Rodent Lumbar Intervertebral Disc and Bone” was presented at the Orthopaedic Research Society 2016 Annual Meeting in Orlando, FL. Data on the bone mineral density (BMD) and intervertebral disc (IVD) height changes in the 90-day HLS group was reported. BMD analysis reported significantly lower BMD in L1, L2, and L3 vertebral bodies compared to the weight-bearing controls (WC) (-20.6%, $p<0.0001$). BMD in L4-L5 in the HLS group was 10.3% lower; however, these decreases were not statistically significant. Overall, there was a 15.5% decrease in BMD in the HLS group compared to the WC group ($p<0.0001$). IVD height analysis found significantly decreased IVD height at L5/6 and L6/S1 by 6.4% ($p=0.0467$). However, IVD heights from Th13/L1 to L4/5 tended to be lower by 4.9%; but this was not statistically significant ($p=0.3031$). Across all levels, there was a 3.1% decrease in IVD height. Currently, bone morphological analyses are underway. The analyses will yield measures such as percent bone volume, trabecular separation, trabecular thickness, bone surface volume ratio, bone surface density, etc. Because of the large dataset due to the high resolution scans, an optimized analysis method utilizing Ct-Analyser (Bruker, Kontich, Belgium) and Matlab (Mathworks, Natick, MA) is currently being made. Other tests such as biomechanics and histomorphology will be delayed due to the unexpected slow arrival of samples.
Bibliography Type:	Description: (Last Updated: 10/31/2023)
Abstracts for Journals and Proceedings	Cheng K, Macias BR, Hargens A, Masuda K. "90-Days Simulated Spaceflight Impairs Quality of Rodent Lumbar Intervertebral Disc and Bone." Presented at 62nd Annual Meeting of the Orthopaedic Research Society, Orlando, FL, March 5-8, 2016. 62nd Annual Meeting of the Orthopaedic Research Society, Orlando, FL, March 5-8, 2016. Orthopaedic Research Society abstracts. Poster No. 0696. , Mar-2016
Articles in Peer-reviewed Journals	Berg-Johansen B, Liebenberg EC, Li A, Macias BR, Hargens AR, Lotz JC. "Spaceflight-induced bone loss alters failure mode and reduces bending strength in murine spinal segments." J Orthop Res. 2016 Jan;34(1):48-57. Epub 2015 Aug 31. http://dx.doi.org/10.1002/jor.23029 ; PubMed PMID: 26285046 , Jan-2016