Fiscal Year:	FY 2009	**Task Last Updated:**	FY 07/10/2009
PI Name:	Bloomfield, Susan A. Ph.D.		
Project Title:	Maintaining Musculoskeletal Health in the Lunar Environment		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Musculoskeletal Alterations Team		
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		
PI Email:	sbloom@tamu.edu	**Fax:**	FY 979-862-1692
PI Organization Type:	UNIVERSITY	**Phone:**	979-845-2871
Organization Name:	Texas A&M University		
PI Address 1:	Department of Health & Kinesiology		
PI Address 2:	400 Harvey Mitchell Pkwy, Suite 300		
PI Web Page:			
City:	College Station	**State:**	TX
Zip Code:	77843-4375	**Congressional District:**	17
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2007 Crew Health NNJ07ZSA002N
Start Date:	06/01/2008	**End Date:**	05/31/2012
No. of Post Docs:	1	**No. of PhD Degrees:**	0
No. of PhD Candidates:	2	**No. of Master' Degrees:**	2
No. of Master's Candidates:	4	**No. of Bachelor's Degrees:**	3
No. of Bachelor's Candidates:	6	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Braby, Leslie (Texas Engineering Experiment Station) Hogan, Harry (Texas A&M University) Fluckey, James (Texas A&M University)		
Grant/Contract No.:	NCC 9-58-MA01602		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The over-arching purpose of this project is to determine if the usual bone and muscle loss observed during spaceflight will be mitigated by the moon's partial (1/6 g) gravity, if radiation exposure exacerbates bone/muscle loss at this reduced loading level, and if exercise is effective in mitigating such losses under these conditions. This requires an effective model of the Lunar environment, simulating conditions during Lunar outpost missions. We will use a novel partial gravity mouse model to first determine the independent impact of 1/6 g on multiple bone and muscle outcomes, including direct determinations of bone breaking strength and other mechanical properties. We will then test the additional impact of low dose radiation modeling galactic cosmic radiation (GCR) during partial gravity conditions by exposing these mice to one acute dose, or 4 fractionated doses on a weekly basis, of ionizing radiation. Data from these experiments will be used to justify expanded experiments at the Brookhaven NASA Space Radiation Laboratory utilizing heavy iron ions to simulate galactic cosmic radiation. Finally, the impact of the Lunar environment (partial gravity plus modeled space radiation) on the musculoskeletal response to exercise countermeasures. Experiments supporting Specific Aim 1 [does partial weightbearing (~1/6 g) mitigate losses observed with full unloading (~ 0 g)] are just concluding in early June 2009, hence we are not yet able to report on key findings. We have made a "course correction" in the design of those first experiments. To simulate the additional loadbearing incurred by crew members locomoting on the Lunar surface due to the weight of EVA spacesuits, we elected to add one additional group of animals designated "1/3 g" (since current spacesuit design is roughly equivalent to one body weight, hence doubling the load bearing in the 1/6 g environment). This is easily accommodated by our partial g mouse model, since weightbearing can be titrated to whatever fraction of 100% body weight is desired. We are concurrently preparing to start Experiment 2 (supporting Specific Aim 2: does low-dose radiation exposure change the bone or muscle response to partial gravity). This is a dose-response study utilizing reference x-ray radiation to assess responses of bone and muscle at early (~3 days), "delayed" (~21 days) and "recovery" (~56 days) time points. To achieve the best sensitivity possible, we have added cell culture studies to this experiment at the earlier timepoints to assess the impact on osteoprogenitor cell populations in the marrow. Pilot experiments are in progress to verify our procedures with primary cell culture. Year 2 of this project will hence start with Experiment 2 (beginning July 2009) utilizing 108 mice (12 groups of 9 each) to test responses at the 3 time points listed above at 3 different radiation exposures. We will choose the lowest radiation dose producing detectable change in muscle protein synthesis and bone formation rate to use in the subsequent Experiment 3, commencing in February 2010, which will test the effects of x-ray exposure on the response to simulated partial gravity; in this experiment, mice subjected to 1/3 g (and weightbearing control mice) will be exposed to one acute dose of x-ray (low LET) radiation as well as 3 fractionated doses. Results of Experiment 2 will also be critical to constructing a beam time proposal for a repetition of Experiment 3 at Brookhaven National Lab during Year 3 of this project. The project PI (S. Bloomfield) is attending NASA's Space Radiation Summer School at Brookhaven National Laboratory in June 2009. Both the conceptual and practical knowledge gained will prove invaluable for the later preparation of a beam time proposal as well as preparing for the logistics of conducting 3-week long experiments with live animals at the NASA Space Radiation Laboratory facility.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Defining the impact of partial weightbearing (as opposed to complete removal of weightbearing) has potentially important implications for rehabilitative strategies applied to stroke or spinal cord-injured patients. Should the 1/6 body weight load bearing of our experimental animals (simulating the Lunar environment) prove to mitigate the dramatic loss of mass and strength of both muscle and bone tissues seen with zero load bearing (mimicking the zero gravity conditions of spaceflight), then harness systems allowing for even minimal load bearing might help mitigate the profound changes seen in muscle strength and bone integrity in these patient populations. Our experiments focusing on the effect of chronic exposure to low-dose radiation on musculoskeletal structure and function will provide unique and novel data about the potential degenerative effects experienced by those humans living in areas with high natural background radiation (e.g. Ramsar, Iran), DOE/nuclear industry workers accumulating occupational exposures, and patients accumulating large exposures with multiple medical procedures.
Task Progress:	The first few months of this project year were dominated by planning activities and interviewing of post-doctoral fellow candidates; an outstanding candidate with 4 years of post-doctoral experience and a rich background in bone biology (Dr. Florence Lima) was successfully hired and joined the lab as of September 1, 2008. Our laboratory hosted a visit by our consultant, Dr. Erika Wagner of MIT, in August of 2008 to train our lab personnel in the logistics of the partial gravity mouse model critical to our specific aims. Multiple pilot experiments in the fall of 2008 confirmed effective doses of fluorochrome labeling (for bone formation rate) and the minimal amount of muscle tissue needed for assessing protein synthesis rates. Experiments supporting Specific Aim 1 (does simulated Lunar gravity protect against those bone and muscle decrements observed with simulated zero gravity) are nearly complete, with the final animals being euthanized the week of June 8, 2009. We added an additional group of animals to simulate the additional loading imposed by EVA spacesuits (approximately doubling effective body weight for an average weight crew member); given that this produces 1/3 body weight (~ 1/3 g), these data will also yield interesting clues about the impact of Martian gravity conditions on musculoskeletal integrity. While these experiments were still running, work has begun on Specific Aim 2 (determine impact of low-dose radiation exposure on muscle/bone integrity in modeled Lunar gravity); in particular, we have been planning for Experiment 2, the preliminary dose-response experiment with reference x-ray radiation Multiple consultations with other team PIs and with Dr. Marcelo Vasquez (NSBRI HQ) helped us refine our specific exposure doses and time of animal sacrifice relative to exposure day. Our post-doctoral fellow, skilled in primary cell culture work, has added osteoprogenitor cell differentiation and proliferation assays to our outcomes from these experiments. Pilot studies started in May 2008 to confirm viability and lack of contamination of primary cultures derived from mouse bone marrow samples are thus far successful. We plan to begin Experiment 2, testing 3 x-ray exposure doses and three times of sacrifice after exposure, no later than July of 2009.
Bibliography Type:	Description: (Last Updated: 05/28/2021)

Abstracts for Journals and Proceedings	Hogan HA, Swift JM, Nilsson MI, Bloomfield SA. "Effects of simulated resistive exercise on cortical bone in the tibia mid-diaphysis of hindlimb unloaded rats." 30th Annual Meeting of the American Society of Bone and Mineral Research, Montreal, Canada, September 12-16, 2008. J Bone Miner Res. 2008 Sep;23 (Suppl 1):S232. , Sep-2008
Abstracts for Journals and Proceedings	Swift JM, Bouse SD, Nilsson MI, Bloomfield SA. "High intensity muscle stimulation has an anabolic effect on unweighted tibia and maintains ankle plantar-flexor muscle strength." 2008 APS Intersociety Meeting: The Integrative Biology of Exercise V, Hilton Head, SC, September 24-27, 2008. 2008 APS Intersociety Meeting: The Integrative Biology of Exercise V, Hilton Head, SC, September 24-27, 2008. Meeting Program and Abstracts, p. 40. , Sep-2008
Abstracts for Journals and Proceedings	Swift JM, Swift SN, Bloomfield SA. "Beta-adrenergic receptor agonist administration during hindlimb unloading effectively mitigates reductions in cancellous bone formation rate." 30th Annual Meeting of the American Society of Bone and Mineral Research, Montreal, Canada, September 12-16, 2008. J Bone Miner Res. 2008 Sep;23(Suppl 1):S231. , Sep-2008
Articles in Peer-reviewed Journals	Baek K, Barlow AA, Allen MR, Bloomfield SA. "Food restriction and simulated microgravity: effects on bone and serum leptin." J Appl Physiol. 2008 Apr;104(4):1086-93. PMID: 18276897 , Apr-2008
Articles in Peer-reviewed Journals	Baek K, Bloomfield SA. "Beta-adrenergic blockade and leptin replacement effectively mitigate disuse bone loss." J Bone Miner Res. 2009 May;24(5):792-9. PMID: 19113907 , May-2009
Articles in Peer-reviewed Journals	Prisby RD, Swift JM, Bloomfield SA, Hogan HA, Delp MD. "Altered bone mass, geometry and mechanical properties during the development and progression of type 2 diabetes in the Zucker diabetic fatty rat." J Endocrinol. 2008 Dec;199(3):379-88. PMID: 18755885 , Dec-2008
Articles in Peer-reviewed Journals	Swift JM, Nilsson MI, Sumner LR, Jeffery JM, Hogan HA, Bloomfield SA. "Simulated resistance training during hindlimb unloading abolishes disuse bone loss and maintains muscle strength." Journal of Bone and Mineral Research. Submitted, 2009. , Jun-2009
Dissertations and Theses	Lucas MW. "A novel method for the evaluation of mechanical properties of cancellous bone in the rat distal femur." Thesis (MS), Texas A&M University, August, 2009. , Aug-2009