Fiscal Year:	FY 2016	**Task Last Updated:**	FY 03/10/2016
PI Name:	Lau, Anthony G Ph.D.		
Project Title:	Whole Joint Health: Investigating Modeled Spaceflight Changes in Mice		
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		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	08618-1104	**Congressional District:**	12
Comments:	NOTE: As of Fall 2015, Dr. Lau is at The College of New Jersey. Previously at University of North Carolina at Chapel Hill while NSBRI postdoc.		
Project Type:	Ground	**Solicitation / Funding Source:**	2012 NSBRI-RFA-12-02 Postdoctoral Fellowships
Start Date:	11/01/2012	**End Date:**	10/31/2015
No. of Post Docs:	1	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	2
No. of Bachelor's Candidates:	4	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 10/31/2015 per NSBRI submission (Ed., 12/12/14)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Bateman, Ted (MENTOR/ University of North Carolina)		
Grant/Contract No.:	NCC 9-58-PF03003		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	POSTDOCTORAL FELLOWSHIP Original Aims Aim 1: Further develop the image analysis technology for assessing changes to mouse knee joint soft tissue with microCT, including cartilage, meniscus, ligaments, and tendons. Aim 2: Assess whole-joint changes in the knee, including bone and soft tissues, from both unloading and reloading using the established hindlimb unloading (HLU) model. This will be accomplished with two studies: Aim 2a: Study the effects of HLU on integrated joint properties, mimicking the STS-135 Space Shuttle flight profile. Hypothesis: Degradation of bone strength, as assessed by computational finite element analysis (FEA), will be similar to that observed in mice flown on STS-135 (13-days of unloading). Similarly, degradation of meniscus volume and density will also be observed with few changes in tendon and ligaments. Aim 2b: Study the effects of longer-term unloading followed by reloading on whole-joint structural and functional properties. Hypothesis: Longer periods of unloading cause greater degradation in bone volume and strength, as well as larger changes in the connective soft tissues. There will be limited recovery after 4-weeks of reloading. Key Findings Analysis of the proximal tibia from skeletally mature mice flown on SPX-4, Rodent Research-1, found that ~21 days of spaceflight resulted in a decline in trabecular bone volume fraction (-45%) and total bone volume (-20% for combined cortical and trabecular bone) in the proximal tibia. Finite Element modeling of this region found this corresponded to a decline in compressive structural stiffness (-28%) which corresponded to a 12% decline in bone structural efficiency. Separation of the cortical and trabecular bone compartments found the majority of loss in the bone strength was in the cortical compartment. These findings are consistent with those observed from FE Analysis of the mouse proximal tibia from STS-135 as well as the complementary Hind Limb Unloading study, which were both previously reported. Results from the HLU study had similar overall trends that were observed in spaceflight. One major difference is that while both HLU and spaceflight caused a 17% decline in proximal tibia bone volume, HLU caused a 22% decline in bone strength, compared to the 34% decline from spaceflight. Impact of Key Findings The use of skeletally mature mice and having the mice sacrificed while in orbit reduce the confounding factors of reloading as well as skeletal growth of the animal during the study. Thus, the majority of the observed decline in bone can be attributed to the microgravity conditions, with some possible loss due to aging. Even in skeletally mature mice (32 weeks old), the 21 days of spaceflight caused a decline in proximal tibia structural efficiency. Using older mice could better model spaceflight related bone loss in astronauts, as the average astronaut has achieved skeletal maturity. The FE modeling provides a more detailed assessment of bone health compared to the traditional microCT analysis and should be considered in future assessments of bone quality. Proposed research plan for the coming year While the post-doctoral fellowship has ended, Dr. Lau is planning on applying the computational techniques developed over the past 3 years in a collaboration with Dr. Jeff Willey at Wake Forest to look at bone strength changes in some of his animal studies.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Research Impact: MicroCT and computational modeling provide important information about bone strength changes beyond that of traditional bone density and microCT bone morphometric parameters. These models found that in skeletally mature mice, long duration spaceflight resulted in a decline bone strength which were greater than the bone volume, resulting in a loss of bone structural efficiency. Earth Benefits: The techniques developed to perform a detailed analysis of bone strength changes in spaceflight are being adapted to study human tissues. The continued development of these techniques will benefit the population on Earth to better study bone strength changes in pathological bone diseases.
Task Progress:	This past year, we performed finite element modeling at the proximal tibia skeletal site for mice undergoing 21-days of spaceflight on SPX-4. Unlike the previous two studies, which used young mice, these were skeletally mature mice, which reduce any confounding effects of the animals still growing during the study. These findings were compared to results from mice flown on Space Shuttle Mission STS-135 for 13 days as well as the parallel HLU study (13-days). Post-Doctoral Training: In addition to research this past year, I participated in science outreach, undergraduate and graduate student mentoring, and teaching. For community outreach, I was a Judge for the NC Science and Engineering Fair, a presenter at the Creekside Elementary School Science Night, and also participated in our Lab's exhibit booth at the UNC Science Expo. I mentored one graduate student, who was previously my undergraduate research student that graduated and returned to the lab for her PhD. I also mentored 4 undergraduate research students. Two of these were previous research students, who was a Biology Student from Meredith College and the BME Lucas Scholar, who performed her Honor's Thesis Project with me. The first of the new research students was a BME major, who joined the lab in the Fall Semester of 2014. The 2nd research student was a Biology Major from UNC and joined the lab in the Fall semester of 2014. I also took the opportunity to gain additional teaching experience through the Joint Department of Biomedical Engineering at UNC. In the Spring of 2015, I was a co-instructor of the biomechanics course with Dr. Ted Bateman. My experimental biomechanics module was about 4 weeks of the course. I have completed my post-doc and am now an Assistant Professor of Biomedical Engineering at the College of New Jersey.
Bibliography Type:	Description: (Last Updated: 03/30/2016)

Articles in Peer-reviewed Journals	Lau AG, Kindig MW, Salzar RS, Kent RW. "Micromechanical modeling of calcifying human costal cartilage using the generalized method of cells." Acta Biomaterialia. 2015 May;18:226-35. Epub 2015 Feb 21. http://dx.doi.org/10.1016/j.actbio.2015.02.012 ; PubMed PMID: 25712387 , May-2015