Fiscal Year:	FY 2013	**Task Last Updated:**	FY 05/02/2013
PI Name:	Sibonga, Jean Ph.D.		
Project Title:	Astronaut Bone Medical Standards Derived from Finite Element [FE] Modeling of QCT Scans from Populations Studies		
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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Zip Code:	77058	**Congressional District:**	22
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	06/27/2012	**End Date:**	12/30/2014
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: Extended to 12/30/2014, per M. Covington/ JSC HRP (Ed., 7/3/14) NOTE: End date is 9/30/2014 per PI (Ed., 4/24/14) NOTE: Gap changes per IRP Rev E (Ed., 1/27/14)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Orwoll, Eric M.D. (Oregon Health and Sciences University) Khosla, Sundeep M.D. (Mayo Clinic) Amin, Shreyasee M.D. (Mayo Clinic) Lang, Thomas Ph.D. (University of California, San Francisco) Keyak, Joyce Ph.D. (University of California, Irvine) Keaveny, Tony Ph.D. (University of California Berkeley) Cody, Dianna Ph.D. (University of Texas MD Anderson Center)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	A Research and Clinical Advisory Panel [RCAP] met in 2010 (Bone Summit) to review medical and research data of long-duration astronauts in order to make recommendations for the risk management for early onset osteoporosis in long duration astronauts. In its assessment, the RCAP stated that the guidelines using bone mineral density [BMD] T-scores as diagnostic criteria for osteoporosis have minimal clinical utility for the younger aged (< 50 years), predominantly male, astronaut cohort following exposure to prolonged spaceflight. In addition, NASA's research data have revealed that DXA measurement of hip BMD does not capture all of the effects of spaceflight that influence bone strength (Keyak et al., Bone 2009; 44(3):449-53) The Bone Summit RCAP recommended that NASA explore emerging population studies that use hip bone strength, as estimated from Finite Element models of QCT [quantitative computed tomography] scans, to supplement DXA bone mineral density [BMD] as a combined standard for bone health (Orwoll et al. J Bone Miner Res 2013; 28(6):1243-1255). To this aim, the Bone Discipline Lead (named as PI), convened a Task Group of US principal investigators and FE modelers of those QCT population studies, along with one non-advocate FE modeler, to propose a FEM-based method by which bone medical standards could be modified. The FE strength cutoffs that are generated by this proposed method will be reviewed, modified if required, and accepted for recommendation by the FE Task Group as a bone health medical standard specific for astronauts exposed to the spaceflight environment. Specific Aims NASA's Bone medical standards establish the "operating bands for bone health" that: a) qualify an astronaut for long duration spaceflights, b) establish the non-permissible outcome for a spaceflight mission, c) provide a level of efficacy for countermeasures as well as d) qualify an applicant for the astronaut corps. The current Bone medical standards are based upon the diagnostic criteria for a terrestrial population known to be at risk for osteoporosis, i.e., perimenopausal and postmenopausal women and men over the age of 50. As a follow-up to the Bone Summit RCAP recommendation, the FE Task Group proposes the following Specific Aims to accomplish the task of generating of FE-based medical standards: 1) Develop a dataset of FE hip strengths from human subjects: with ages covering the age range of the astronauts and for which fracture outcome data have been collected. a. The Rochester Bone Health Study (as authorized by Drs. Sundeep Khosla and Shreyasee Amin) will provide QCT scans from ~408 persons to Dr. Joyce Keyak who will develop FE models and estimate hip bone strength using the FE modeling developed at UCI (Keyak, 2005). b. FE data from 1a (above) will be combined with FE data generated from other applications of Keyak FEM to QCT scans from additional study cohorts, which include ISS astronauts. 2) Determine FE strength cutoffs from to be used as a decision-tool by Space Medicine for the following scheduled decision points (a-d): a. to qualify a sub-set of applicants for astronaut candidacy (those who currently are not qualified due to hip T-score between -1 and -1.5) for further medical testing b. to qualify an astronaut for a long-duration (LD) mission c. to qualify a veteran LD astronaut for a second LD mission d. to establish responsibility by occupational space medicine for a post-mission fracture or osteoporosis diagnosis. 3) Present, review, and finalize the generated FE strength cutoffs with FE Task Group (along with the inclusion of cohort biostatisticians) to recommend to Human Health Countermeasures as a deliverable to Space Medicine and Office of Chief Health and Medical Officer. (Ed. note: revised version, per PI. 8/27/2013)
Rationale for HRP Directed Research:	This research is directed because it contains highly constrained research, which requires focused and constrained data gathering and analysis that is more appropriately obtained through a non-competitive proposal. Bone Medical standards provide the index by which the effects of spaceflight, the efficacy of countermeasures and the restoration of skeletal health following long-duration missions are all evaluated. Consequently, it is important and urgent to increase the sufficiency of our current bone medical standards in order not to risk underestimating the fracture or osteoporosis risks or the effectiveness and timing of strategies to mitigate the risk (e.g., in-flight countermeasures, selection criteria, flight certification). The Bone Summit RCAP of 2010, which made the recommendation to modify the BMD-based bone medical standards to be more relevant to the target population (i.e., long-duraiton astronauts), was composed of leaders in the International Society of Clinical Densitometry [ISCD] – This society formulates the positions by which BMD is used in clinical practice in terrestrial medicine and currently by the JSC Bone and Mineral Laboratory for Med Volume b and for required astronaut medical evaluation.
Research Impact/Earth Benefits:	A successful demonstration will showcase how Finite Element Models could enhance the ability to determine fracture probability in terrestrial populations.
	1) Develop a dataset of FE hip strengths, of human subjects, that have all been generated by the same FE model; human subjects span ages of the astronauts population and for which fracture outcome data have been collected. a. The Rochester Bone Health Study will provide QCT scans from 408 persons to Dr. Joyce Keyak who will estimate hip bone strength using her developed FEM at UCI (Keyak, 2005). The contract with UCI was set up in June 2012 and this work is in progress. b. FE data from 1a (above) will be combined with FE data generated from other applications of Keyak FEM to QCT scans of cohorts from UCSF studies, which include ISS astronauts. The full FE Strength database is expected to be complete in November 2013. 2) Determine FE strength cutoffs to be used for decision-making by Space Medicine for the following scheduled decision points (below, a-d) – using conventional biostatistical approaches (receiver operating characteristic [ROC] and area under the curve [AUC]) to be performed by NASA/JSC Biostatisticians and working with representatives of Space

Task Progress:	and Clinical Operations [SD]: a. Qualifying an applicant for astronaut candidacy b. Qualifying an astronaut for a long-duration (LD) mission c. Qualifying a previously-flown LD astronaut for a second LD mission d. Assuming responsibility by occupational space medicine for a post-mission fracture or osteoporosis diagnosis. 3) Present generated FE strength cutoffs to FE Task Group (with inclusion of cohort biostatisticians from UCSF, Mayo, and JSC) for review and possible modification. Recommend finalized FE strength cutoffs to Human Health Countermeasures to process through Transition-to-Operations [TTO].
Bibliography Type:	Description: (Last Updated: 05/24/2021)
Abstracts for Journals and Proceedings	Sibonga JD. (on behalf of Finite Element [FE] Strength Task Group.) "How do we develop medical standards for bone health that are relevant to spaceflight? Astronaut Bone Medical Standards Derived from Finite Element [FE] Models of QCT Scans from Population Studies." 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. , Feb-2013
Articles in Peer-reviewed Journals	Orwoll ES, Adler RA, Amin S, Binkley N, Lewiecki EM, Petak SM, Shapses SA, Sinaki M, Watts NB, Sibonga JD. "Skeletal health in long-duration astronauts: Nature, assessment and management recommendations from the NASA bone summit." J Bone Miner Res. 2013 Jun;28(6):1243-55. http://dx.doi.org/10.1002/jbmr.1948 ; PubMed PMID: 23553962 , Jun-2013
Articles in Peer-reviewed Journals	Sibonga JD. "Spaceflight-induced bone loss: Is there an osteoporosis risk?" Curr Osteoporos Rep. 2013 Jun;11(2):92-8. http://dx.doi.org/10.1007/s11914-013-0136-5 ; PubMed PMID: 23564190 , Jun-2013