Fiscal Year:	FY 2012	**Task Last Updated:**	FY 03/08/2012
PI Name:	Hanson, Andrea M Ph.D.		
Project Title:	Enhancing the Efficacy of Musculoskeletal Countermeasures Using Computer Simulation (Postdoctoral Fellowship)		
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) **Aerobic**:Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity (2) **Muscle**:Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Organization Name:	NASA Johnson Space Center		
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City:	Houston	**State:**	TX
Zip Code:	77058	**Congressional District:**	36
Comments:	NOTE: formerly at University of Washington		
Project Type:	GROUND	**Solicitation / Funding Source:**	2010 NSBRI-RFA-10-01 Postdoctoral Fellowships
Start Date:	11/01/2010	**End Date:**	10/31/2011
No. of Post Docs:	1	**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:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: NSBRI March 2012 submission shows 10/31/2011 end date (Ed., 3/8/2012) NOTE: End date change to 10/30/2011 per HRP Master Task List information dated 11/11/11 and PI (Ed., 1/27/2012)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Cavanagh, Peter Ph.D., D.Sc. (MENTOR/University of Washington)		
Grant/Contract No.:	NCC 9-58-PF02302		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	POSTDOCTORAL FELLOWSHIP The proposed project addresses the short-coming in musculoskeletal maintenance by examining the current ISS exercise protocols through computer simulation. Specifically, this model will be used to characterize how ARED-like exercises impact hip joint contact forces with the LifeMOD/MD Adams biomechanics simulation software. The hip is a region of the skeleton that experiences the greatest loss in bone mineral density (1.2-1.5%/month) and strength during long-duration missions in microgravity. This study aims to examine why current exercise countermeasures are not sufficiently maintaining bone health and to characterize the hip loading forces during ARED-like exercise. Characterizing the hip forces experienced during ISS exercise protocols assigned to crews will provide a baseline from which to adjust exercises to better protect the hip. Ultimately the study will result in a recommendation of more efficacious exercise protocols with the goal of increasing loading forces to better protect the hip joint based on computer simulations. In addition to ISS exercise, an examination of similar exercises in reduced gravity environments will also be performed. The project has three specific aims: Aim 1: Characterize the hip joint contact forces that result during ARED-like exercise through computer simulation. Aim 2: Examine how the use of gravity replacement loads affect hip joint forces in microgravity and partial gravity environments. Aim 3: Perform a sensitivity analysis to examine and optimize the contributions of muscle forces to joint forces. The proposed project fulfills the following anticipated deliverables from the Musculoskeletal Alterations Team at NSBRI: 1) Ground-based simulation of on-orbit exercise devices; 2) Specific exercise prescriptions tailored to individual astronauts; 3) Designing improved exercise devices. Additionally, gender specific models can be developed to address the questions of gender specific effects of bone loss and exercise countermeasures outlined throughout the Human Research Program's Integrated Research Plan.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	While this work is focused on maintaining bone health in reduced gravity environments and reducing the risk of fracture when exploring new terrain on distant planetary surfaces, there is a direct benefit to the patient population afflicted with osteoporosis, sarcopenia, and musculoskeletal injury here on Earth. The computer models developed in this project will help to provide input to develop more effective bone strengthening exercises, particularly targeting the hip joint, for these at-risk populations. The exercises being modeled in this project can be replicated using exercise equipment found in a strength training facility or even in a home setting, and subject specific simulation can be derived. Methods used to optimize muscle recruitment patterns to develop high fidelity musculoskeletal simulations will directly benefit Earth-based modeling efforts. The computer models may also be a useful tool for clinicians to demonstrate to their patients the benefits of performing specific exercises targeted at strengthening individual joints and muscle groups.
Task Progress:	The specific aims of this project include: Aim 1: Characterize the hip joint contact forces that result during ARED-like exercise through computer simulation. Aim 2: Examine how the use of gravity replacement loads affect hip joint forces in microgravity and partial gravity environments. Aim 3: Perform a sensitivity analysis to examine and optimize the contributions of muscle forces to joint forces. Four milestones were outlined in the proposal: MILESTONE 1 - Hip Joint Contact Force Model of ARED-like Activity. MILESTONE 2 - Model Validation and Optimization. MILESTONE 3 – Recommend Enhanced Exercise Program. MILESTONE 4 - Apply for Funding to Launch Independent Research Program. Each aim has been addressed in the initial development of the LifeMod simulations in Year 1 of the project. Milestones 1 & 2 have been met for simulation of the squat exercise. An application to the University of Washington Internal Review Board for the use of human subjects has recently been approved. This will allow for additional data collection to continue modeling ARED-like exercises as originally proposed. Specifically, hip abduction, hip adduction, single legged squat, dead-lift, and heel raises will be examined. These future ARED exercise models will be optimized using the combinatorial and Monte Carlo methods developed in the initial simulations. A final report with recommendations for an enhanced exercise program on the ARED will be submitted at the completion of the project. In the last year, the trainee submitted a grant proposal to initiate independent research and received a strong evaluation and score of 82, but was not recommended for funding. The concerns of the reviewers were addressed and a resubmission of the grant proposal was recently submitted. The trainee is a co-investigator on a successful institutional research award granted through the Coulter Translation Research Foundation. The trainee has participated in professional growth and academic career enhancement seminars offered through the Institute of Translation Health Sciences, the UW Postdoctoral Association, and an Academic Careers Workshop series offered through the UW Career Center. Additionally, the trainee has organized and participated in STEM outreach activities in the greater Seattle area and remotely co-presented on Outreach and Mentoring during the NSBRI Summer Institute.
Bibliography Type:	Description: (Last Updated: 03/19/2019)
Abstracts for Journals and Proceedings	Hanson AM, Lang TF, Cavanagh PR. "Enhancing Efficacy of Exercise in Reduced Gravity Environments through Computer Simulation." 57th Annual Meeting of the Orthopaedic Research Society, Long Beach, CA, January 13-16, 2011. 57th Annual Meeting of the Orthopaedic Research Society, Long Beach, CA, January 13-16, 2011. 2011 Abstract Book, January 2011. , Jan-2011

Abstracts for Journals and Proceedings	Hanson A, Lee E, Absher B, Streeper T, Lang T, Cavanagh P. "Wireless Monitoring and Data Management During Exercise Countermeasures In Spaceflight." 82nd Annual Scientific Meeting, Aerospace Medical Association, Anchorage, AK, May 8-12, 2011. Aviat Space Environ Med, 2011 Mar:82(3):231-2. http://www.ingentaconnect.com/ , Mar-2011
Articles in Peer-reviewed Journals	Reed EB, Hanson AM, Cavanagh PR. "Optimising muscle parameters in musculoskeletal models using Monte Carlo simulation." Comput Methods Biomech Biomed Engin. 2015;18(6):607-17. Epub 2013 Sep 19 when Published online. https:// ; PubMed PMID: 24050838 , Sep-2015
Awards	Hanson A. "AsMA Fellows Scholarship, December 2010." Dec-2010
Awards	Hanson A. "NASA Group AchievEment Award for the NSBRI Monitoring Bone Health Project, June 2011." Jun-2011