Fiscal Year:	FY 2016	**Task Last Updated:**	FY 04/13/2016
PI Name:	Jagodnik, Kathleen Ph.D.		
Project Title:	Improving the Efficacy of Resistive Exercise Microgravity Countermeasures for Musculoskeletal Health and Function using Biomechanical 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:	None		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	44026	**Congressional District:**	10
Comments:	NOTE (Ed., May 2016): Administrative affiliation is Baylor College of Medicine, Center for Space Medicine, which administers the fellowship. Fellowship work is being performed at NASA Glenn.		
Project Type:	GROUND	**Solicitation:**	2014 NSBRI-RFA-14-02 First Award Fellowships
Start Date:	03/01/2015	**End Date:**	03/31/2017
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:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	2	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 3/31/2017 (previously 5/31/2017) per NSBRI (Ed., 4/1/17) NOTE: End date changed to 5/31/2017 per NSBRI (Ed., 3/8/17) NOTE: Start/End dates changed to 3/1/2015 and 2/28/2017, respectively (original start/end dates were 12/1/2014 and 11/30/2016, respectively) per NSBRI (Ed., 7/27/15)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Lewandowski, Beth Ph.D. (MENTOR/ NASA Glenn Research Center)		
Grant/Contract No.:	NCC 9-58-PF04105		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	POSTDOCTORAL FELLOWSHIP Original Project Aims/Objectives: This project aims to develop a biomechanical model of a human performing the deadlift exercise on the Hybrid Ultimate Lifting Kit (HULK) device in order to inform and ultimately optimize exercise prescriptions for astronauts so that their musculoskeletal health can be maintained during extended periods of spaceflight. To create this model, which has been developed using the OpenSim software platform, it was necessary to collect data (including motion capture, ground reaction force, and EMG) from human subjects performing the deadlift exercise. Trials using different combinations of load, load configuration, exercise cadence, and stance width were performed. Inverse kinematics and inverse dynamics analyses are in the process of being performed, and will be followed by residual minimization and static optimization. Key Findings: To date, we have collected motion capture, electromyography (EMG), force plate and load cell data from 2 human subjects performing 26 trials of the deadlift exercise with varying load, load configuration, stance width, and exercise cadence. We report the joint angle characteristics resulting from inverse kinematics analysis for selected joints in the biomechanical model, as well as the EMG results for all 16 muscles recorded. We are currently able to draw tentative conclusions about how the exercise configuration parameters affect the kinematic and muscle activation properties of the subject being modeled, but more extensive analyses of the collected data (and, potentially, additional data collection) will be necessary before stronger conclusions can be reached. Impact of Key Findings: As previously mentioned, the current set of key findings includes the kinematic and muscle activity properties of the human subjects being modeled as the deadlift load, load configuration, stance width, and cadence are varied. We are able to draw tentative relationships between these deadlift exercise parameters and the joint angles and EMG activities that result. This will eventually permit our Digital Astronaut Project team to make predictions about how particular exercise devices and prescriptions are likely to benefit the musculoskeletal health of the astronauts performing these exercises. This will assist us in optimizing exercise prescriptions for astronauts exposed to microgravity environments for extended periods. Research Plan for Coming Year: In the coming year, I will continue to conduct inverse kinematics (IK) analysis for the collected deadlift data. Subsequent to IK analysis, inverse dynamics (ID) analysis will be performed in order to determine the generalized forces that produce the deadlift exercise. This will allow the inference of how muscle groups are activated to produce this movement. Next, residual reduction will be performed to minimize errors associated with the modeling process. Static optimization analysis will follow, in which the calculated net joint moments are resolved into muscle forces at each time step based on the minimization of joint angle errors and muscle force magnitude. Sensitivity analyses will then be performed to determine how key parameters influence the behavior of the system as a whole. Data reports will be produced that describe these sensitivity analyses, as well as each preceding step in this project. Finally, verification and validation of the model, which is an ongoing process throughout the modeling effort, will be concluded in order to assess the credibility of this biomechanical deadlift model to optimize astronaut exercise prescriptions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Astronauts who are exposed to microgravity environments for extended durations during spaceflight experience declines in musculoskeletal health. Similarly, elderly and disabled people can experience losses of mobility that prevent them from participating in an active lifestyle that allows them to maintain optimal musculoskeletal health. Those who lack the balance or strength required for steady gait, who are bedbound, or who otherwise cannot remain sufficiently active, face a number of risks related to such inactivity. We are studying resistive exercises that serve to benefit not only astronauts during spaceflight, but inactive Earthbound individuals, as well. Our work aims to gain a solid understanding of the resistive exercise prescriptions required to maintain musculoskeletal health in the absence of gravity-based activity. Providing effective resistive exercise prescriptions for impaired Earthbound individuals will help them to optimize their health despite their existing physical limitations.
Task Progress:	Of the 10 steps listed in my proposed research, I completed Step 1, Collect Data using Human Subjects Performing Movements on the HULK Device, in collaboration with my lab members. Two human subjects performed the deadlift exercise for a variety of loads, load configurations, cadences, and stance widths; a total of 26 trials were collected. Data include motion capture, EMG, device load data, and force plate data; anthropometric measurements; and photographic and video data. I completed Step 2, Perform Data Processing and Reduction, on the collected data. This processing included data filtering, interpolation, tracking, and downsampling. Subsequently, in Step 3, in consultation with my lab members, I developed a biomechanical model of the human body performing the deadlift exercise, using the OpenSim software platform. Further development of the model is currently being performed to improve shoulder stability of the model and to optimize efficiency. Using that model, in Step 4, I scaled this model by matching the model's virtual markers to the collected motion capture data. In Step 5, I have been performing inverse kinematics analysis to yield the descriptive kinematics of the subject-specific model performing the deadlift exercise on the HULK device. This work is ongoing, as it needs to be performed for each of the trials collected. For selected trials, I have also started work on Step 6, inverse dynamics analysis, which involves formulating and solving the system's equations of motion, to determine the generalized forces (e.g., net joint forces and torques, ground reaction forces, and residual forces and moments on the pelvis) that produce the deadlift exercise; this will permit the inference of how muscle groups are activated in order to produce this movement. I have not yet started on Step 7, minimizing the residuals (errors resulting from the process of computational modeling) of the system, nor have I undertaken Step 8, performing static optimization. Step 9, performing sensitivity analysis and creating data reports, will follow once I have completed the preceding steps. Finally, Step 10 involves conducting verification and validation (V&V) analyses for this modeling effort. I have created a detailed verification and validation plan for this project, which will be implemented as the stages of the project are completed. My lab members plan to use this V&V plan for the deadlift exercise as a reference for their own V&V planning work when studying other exercises.
Bibliography Type:	Description: (Last Updated: 09/01/2017)

Abstracts for Journals and Proceedings	Jagodnik KM, Thompson WK, Gallo CA, Crentsil L, Funk JH, Funk NW, Perusek GP, Sheehan CC, Lewandowski BE. "Biomechanical Modeling of the Deadlift Exercise on the HULK Device to Improve the Efficacy of Resistive Exercise Microgravity Countermeasures." 2016 Human Research Program Investigators' Workshop, Galveston, Texas, February 8-11, 2016. 2016 Human Research Program Investigators' Workshop, Galveston, Texas, February 8-11, 2016. , Feb-2016