Fiscal Year:	FY 2013	**Task Last Updated:**	FY 08/28/2013
PI Name:	De Witt, John Ph.D.		
Project Title:	Biomechanical Analysis of Treadmill Locomotion on the International Space Station		
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) **Muscle**:Risk of Impaired Performance Due to Reduced Muscle Size, Strength and Endurance		
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:	Flight	**Solicitation / Funding Source:**	Directed Research
Start Date:	07/13/2009	**End Date:**	05/15/2013
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:	ISS		
Flight Assignment:	ISS NOTE: End date changed to 5/15/2013 per JSC and PI (Ed., 7/11/2011)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Ploutz-Snyder, Lori (USRA/NASA Johnson Space Center) Guilliams, Mark (Wyle/NASA Johnson Space Center) Fincke, Renita S (Wyle/ NASA Johnson Space Center)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	There are many factors that may contribute to the deconditioning that occurs during long-term microgravity exposure. Countermeasures hardware limitations, suboptimal exercise programming, and alterations in gait biomechanics may all contribute to physiological losses. During the NASA International Space Station (ISS) Exercise Prescription Workshop in October 2008, internal and external experts identified a need to better quantify specific physiological responses to exercise in microgravity. Knowledge of resistance exercise biomechanics while on ISS will provide insight as to why bone, muscle and cardiovascular health are lost during long duration spaceflight. There have been no rigorous evaluations of locomotion biomechanics during exercise in microgravity on the ISS. The installation of the Second-Generation Treadmill (T2) on the ISS will allow the measurement of ground reaction forces (GRF) during exercise. Quantification of these forces is vital to understanding the musculoskeletal benefits of treadmill exercise. GRF data used in combination of joint motion data obtained from video can be used to quantify the joint torques that occur during exercise, which will give critical information regarding exercise efficacy. It is probable that variables such as speed, external load (EL) applied to the waist-shoulder harness, and vibration-isolation affect locomotive biomechanics, which could influence exercise prescription efficacy. The objective of this evaluation is to collect biomechanical data from crewmembers during treadmill exercise prior to and during flight. The goal is to determine if locomotive biomechanics differ between normal and microgravity environments and to determine what combination of subject load and speed optimizes joint loading during in-flight treadmill exercise. Up to 8 crewmembers will be assessed during nominal exercise sessions on the T2 during long duration ISS mission. Data will be collected from up to 6 sessions per crew member, spaced approximately 30 days apart. Video data will be collected using a standard high-definition video camera, and GRF data will be collected directly from the T2. Data will be downlinked from ISS for post processing. Video will be digitized and joint position throughout exercise will be determined using a two-dimensional direct linear transformation analysis. Position data will be used to determine joint kinematics, and position data will be used with GRF data in an inverse dynamic analysis to determine joint torques. Prior to flight, video and GRF data will be collected in the lab for use in comparisons between gravitational levels. The data will be used to determine if locomotive biomechanics differ between microgravity and normal gravity. The data will also be used to determine how differences in speed, EL, and the interaction of speed and EL affect locomotive biomechanics. Obtaining these data will help to determine if specific speed and EL conditions exist that maximize joint torques, and thus increase exercise efficacy.
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.
Research Impact/Earth Benefits:	The primary intent of this activity is to create an operational benefit for crewmember exercise prescriptions. The techniques used to collect and assess data are those typically used during Earth-based evaluations. There are benefits to life on Earth in comparing motion between microgravity and normal gravity because of implications on vestibular system impact on control, and there are substantial benefits for crewmembers.
Task Progress:	This task is complete. All data have been collected and initial analyses completed. Journal manuscripts are in preparation. The purpose of this investigation was to examine the biomechanics of running on the second generation treadmill on the International Space Station as it is used during normal exercise. Kinematic and ground reaction force data were collected in the lab prior to flight and throughout the missions of seven subjects. In-flight data were collected during up to six exercise sessions for each subject spaced throughout their mission. Hip, knee, and ankle sagittal motion trajectories, gait temporal kinematics, and ground reaction force parameters were compared between exercise sessions in 1G and 0G. The effects of speed and bungee load on ground reaction force parameters were also examined. We found that joint motion trajectories and gait temporal kinematics remained relatively consistent between 0G and 1G at a given speed. Ground reaction force parameters, however, were significantly decreased in 0G, but did increase with increased speed and bungee load. Furthermore, the relationship between peak ground reaction forces and speed and bungee load were subject-dependent, suggesting that individual variations exist in adaptation strategies to the microgravity environment. Our data suggest that subject-specific relationships can be developed that allow practitioners to prescribe exercise that may more effectively recreate 1G-like ground reaction forces, and that subjects performing exercise at higher speeds obtain ground reaction forces similar to exercising at lower speeds on Earth. Take Home Message for Exercise: Crewmembers have similar running motions in 0G as they do in 1G, but develop lower ground reaction forces. Running faster will increase the ground reaction forces and increase exercise benefits. Take Home Message for Motor Control: Running motion does not change in the absence of gravity, but force generation is scaled to approximately the same relative level as in 1G. Control mechanisms that depend on gravity must be secondary to those that are gravity-independent.
Bibliography Type:	Description: (Last Updated: 02/11/2021)
Abstracts for Journals and Proceedings	De Witt JK, Ploutz-Snyder LL, Fincke RS, Guilliams ME. "Biomechanical analysis of treadmill locomotion on the International Space Station." 2nd Annual International Space Station (ISS) Research and Development Conference, Denver, CO, June 16-18, 2013. 2nd Annual International Space Station (ISS) Research and Development Conference, Denver, CO, June 16-18, 2013. , Jun-2013
Abstracts for Journals and Proceedings	De Witt JK, Fincke RS, Guillams ME, Ploutz-Snyder L. "Biomechanics of treadmill locomotion on the International Space Station." 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
Abstracts for Journals and Proceedings	De Witt JK, Fincke RS, Guillams ME, Ploutz-Snyder L. "Biomechanical analysis of treadmill locomotion on the International Space Station." 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. , Feb-2012

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Articles in Peer-reviewed Journals	De Witt JK, Ploutz-Snyder LL. "Ground reaction forces during treadmill running in microgravity." J Biomech. 2014 Jul 18;47(10):2339-47. Epub 2014 Apr 30. http://dx.doi.org/10.1016/j.jbiomech.2014.04.034 ; PubMed PMID: 24835563 , Jul-2014
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