

Fiscal Year:	FY 2011	Task Last Updated:	FY 07/14/2011
PI Name:	De Witt, John Ph.D.		
Project Title:	Ground-based Biomechanical Analyses of Resistance Exercise Using the Advanced Resistive Exercise Device		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:	TechPort:	Yes	
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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City:	Houston	State:	TX
Zip Code:	77058	Congressional District:	22
Comments:			
Project Type:	Ground	Solicitation / Funding Source:	Directed Research
Start Date:	07/13/2009	End Date:	10/29/2010
No. of Post Docs:	0	No. of PhD Degrees:	1
No. of PhD Candidates:	0	No. of Master' Degrees:	2
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: Received extension until 10/29/2010, per PI; original end date was 7/02/2010 (Ed., 10/7/10)		
Key Personnel Changes/Previous PI:	Rachel Logan, M.S., NSBRI intern participated in the data collection; Renita S. Fincke, MBA, participated as support personel during all phases of the project.		
COI Name (Institution):	Ploutz-Snyder, Lori (USRA/NASA Johnson Space Center) English, Kirk (NASA Johnson Space Center) Guilliams, Mark (Wyle/NASA Johnson Space Center) Fincke, Renita S (Wyle/NASA Exercise Physiology and Countermeasures Project) Logan, Rachel (Midwestern University, Chicago College of Osteopathic Medicine)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	<p>The new integrated resistance and aerobic training study (SPRINT) exercise prescription is being designed using ground-based evidence with the intent of increasing the loads experienced by the musculoskeletal system during in-flight exercise. Prescription optimization is dependent upon a complete understanding of exercise biomechanics in order to include exercises that are most beneficial to increasing crewmember health. Furthermore, variations in exercise biomechanics of specific exercises, such as the range of motion during the performance of the parallel squat, could have large influences upon the loads experienced by the musculoskeletal system. A detailed biomechanical analysis is required to determine which variations lead to the greatest site-specific joint loading forces and can be used to inform the optimal exercise prescription. The objective of this project was to determine the joint loads that occur during exercise in microgravity on the Advanced Resistive Exercise Device (ARED). The goal is to determine the best exercises for use during crewmember exercise during long-term missions.</p> <p>There are various complexities with performing in-flight investigations. In order to maximize the potential for the most relevant data to be collected with minimal impact on crew time, we propose a two-phase program. Biomechanical analyses need to occur during actual exercise in microgravity to ensure optimal application of the results. However, since crew time is limited, ground-based evaluations should occur prior to in-flight data collection to ensure that the analyses performed on International Space Station (ISS) are completed as efficiently as possible. We propose to complete the analysis in three phases. Phase 1, which is detailed in this study, involved a detailed data collection on ground while subjects performed variations of squat and deadlift exercises on the ARED. Variations of each exercise included placement of the feet, speed of the lift, and range of motion and were examined. A computational model was used to compute joint loads and torques during each exercise. Six subjects (3 M/3 F) of small, medium, and large body types as described by NASA anthropometric standards were tested. The purpose of this investigation was to quantify the joint loading that occurred during typical resistance exercise on the ARED. The goal was to better understand the kinematic and kinetic similarities between exercise variations and to determine a subset of exercises that will be included in a future proposal that will include a biomechanical analysis of exercise on the ISS using the subset of exercises determined during phase 2.</p>
Rationale for HRP Directed Research:	<p>Resistance exercise is a common activity performed by individuals wishing to increase muscular strength and bone health. Crewmembers perform squat and deadlift exercise to load the lower extremity and core musculature and the axial skeleton. Each exercise is fundamentally similar in that a subject performs hip, knee, and ankle flexion and extension as a load is lowered and raised. During the lowering phase, musculature primarily acts eccentrically, while during the raise musculature primarily acts concentrically. Squat and deadlift exercises are common activities performed in exercise programs used by athletes and during rehabilitation from injury.</p> <p>Each exercise can be modified by increasing or decreasing stance width, movement velocity, and/or range of motion. Although the fundamental movement remains the same, these variations or combinations thereof may result in differences in long-term training effects. In order for practitioners to better understand and utilize these variations in creating optimal exercise programs, the joint motions and loads need to be quantified. This research, because it was performed in normal gravity, is beneficial to strength coaches, rehabilitation personnel, and scientists who use squat and deadlift exercise as a part of their exercise programs. In addition, this is the first study to quantify the hip joint motions in the frontal and transverse planes, which is important in differentiating between exercise variations and better understanding why slight variations load the musculoskeletal system differently.</p>
Task Progress:	<p>This investigation was completed in 2010, and a final report was submitted to NASA.</p> <p>The purpose of this investigation was to quantify the joint kinematics and kinetics that occur during squat and deadlift exercise on the ARED to inform a future proposal that will include a biomechanical analysis of exercise on the ISS. Six subjects (3m/3f) were tested while performing single legged squats, normal squats, increased range of motion squats, wide stance squats, fast squats, reduced range of motion squats, normal deadlift, and sumo deadlift. Ground reaction force (GRF) and motion capture data were collected as each subject performed a single repetition using a load that approximated their 10 repetition maximum. Testing loads were determined during an earlier training session. Three dimensional joint kinematics and kinetics were computed using a standard inverse dynamics approach. GRF data indicated that peak loads were dependent upon exercise type and that the peak GRF did not always occur at the same time during a repetition depending upon the exercise. Bilateral joint kinematics were generally symmetrical; however, hip adduction and rotation displayed increased bilateral asymmetry. Joint kinetics differed between exercise types although there were no specific trends across all variables. In general during the downward motion, work was performed on the hip and knee extensors for all exercises, and work was performed by the hip and knee extensors during the upward motion. Positive and negative work for hip adduction/abduction, hip internal/external rotation, and ankle flexion varied across exercises. Bilateral joint kinetics were asymmetrical, which may reflect a property of ARED that needs further study.</p> <p>Based on our results, we suggest that the exercises included in a future flight study include, along with the justification:</p> <ol style="list-style-type: none"> 1) Normal Squat: A baseline measure 2) Single Legged Squat: Increased net hip torque and only exercise inducing hip adduction 3) Wide Normal Squat: Hip adduction and rotation kinematics suggest femoral head loading differences 4) Normal Deadlift: Baseline measure, but with different kinematics than the squat <p>Furthermore, we suggest the following:</p> <ol style="list-style-type: none"> 1) Increasing the subject size of the current study to allow for standard statistical analyses 2) Retest of current subjects bilateral symmetry using a free weight condition 3) Further study of the FS condition relative to free weights to better understand joint kinetic differences <p>Although IR (increased range of motion) squats had larger kinetic values than others, variation was also increased because of between subject differences. We did not recommend this lift because of the larger subject variation, but this lift should also be considered in a future study.</p>

Bibliography Type:	Description: (Last Updated: 02/11/2021)
Abstracts for Journals and Proceedings	De Witt JK, Fincke RS, Logan RL, Guilliams ME, Ploutz-Snyder LL. "Kinematics and kinetics of squat and deadlift exercises with varying stance widths." Presented at the 34th National Strength and Conditioning Association Conference, Las Vegas, NV, July 6-9, 2011. Program and Abstracts. 34th National Strength and Conditioning Association Conference, Las Vegas, NV, July 6-9, 2011. http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110007993.pdf ; accessed 2/11/2021. , Jul-2011
Abstracts for Journals and Proceedings	De Witt JK, Fincke RS, Logan RL, Guilliams ME, Ploutz-Snyder LL. "Load variation influences on joint work during squat exercise in reduced gravity." Presented at the 35th Annual Meeting of the American Society of Biomechanics, Long Beach, CA, August 10-13, 2011. 35th Annual Meeting of the American Society of Biomechanics, Long Beach, CA, August 10-13, 2011. , Aug-2011
Articles in Peer-reviewed Journals	De Witt JK, English KL, Crowell JB, Kalogera KL, Guilliams ME, Nieschwitz BE, Hanson AM, Ploutz-Snyder LL. "Isometric mid-thigh pull reliability and relationship to deadlift 1RM." J Strength Cond Res. 2018 Feb;32(2):528-33. Epub ahead of print 2016 Aug 18. https://dx.doi.org/10.1519/JSC.0000000000001605 ; PubMed PMID: 27548797 , Feb-2018