Fiscal Year:	FY 2023	**Task Last Updated:**	FY 12/08/2022
PI Name:	Bouxsein, Mary Ph.D.		
Project Title:	Time Course of Spaceflight-Induced Adaptations in Bone Morphology, Bone Strength and Muscle Quality		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
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) **Muscle**:Risk of Impaired Performance Due to Reduced Muscle Size, Strength and Endurance (3) **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:	02215-5400	**Congressional District:**	7
Comments:			
Project Type:	FLIGHT	**Solicitation / Funding Source:**	2017-2018 HERO 80JSC017N0001-BPBA Topics in Biological, Physiological, and Behavioral Adaptations to Spaceflight. Appendix C
Start Date:	02/17/2019	**End Date:**	07/31/2034
No. of Post Docs:	0	**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 7/31/2034 per NSSC information (Ed., 2/8/22) NOTE: End date changed to 6/16/2022 per NSSC information (Ed., 9/21/21) NOTE: End date changed to 6/16/2021 per NSSC information (Ed., 7/24/20)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Sibonga, Jean Ph.D. (NASA Johnson Space Center)		
Grant/Contract No.:	80NSSC19K0567		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The rate and extent of musculoskeletal changes during long-duration spaceflight remain uncertain. In particular, a critical question is whether bone mass and bone strength declines continue at the same rate as seen during the first 6 months of spaceflight or whether the body will adapt to its new environment, and bone loss will slow or stop during longer duration exposure to microgravity. To address this key gap in knowledge, we propose to conduct 3D computed tomography (CT) scans prior to launch and after landing in astronauts participating in the One-Year Mission Project. Using CT-based finite element analysis (CT-FEA), prior work using older imaging technology in 16 astronauts found average declines in femoral and vertebral bone strength of 1.1 to 2.6% per month during 4 to 6 month International Space Station (ISS) missions, though some astronauts experienced much higher losses. The declines in estimated bone strength exceeded the declines in bone mass as assessed by 2D dual-energy X-ray absorptiometry (DXA) scans. Moreover, the declines in strength were not predicted by the DXA-based bone mass measures, indicating the need to use 3D CT measures to accurately assess bone changes. Thus, we propose to employ state-of-the-art CT imaging to assess spaceflight-induced changes in cortical and trabecular bone density and morphology, along with changes in femoral and vertebral bone strength from Food and Drug Administration (FDA)-approved CT-FEA. In addition, to assess the risk of fracture, in secondary analyses, we will compare the bone strength values to the estimated loads applied to the skeleton during flight and on the ground using validated, subject-specific multibody musculoskeletal models. Finally, we will assess changes in muscle quality via pre- and post-flight analysis of fatty infiltration of the trunk and lower extremity musculature from the same CT scans. In addition, we will perform in vivo, non-invasive electrical impedance myography pre- and post-flight to supplement function assessments of muscle being conducted as part of the standard measures in the integrated One-Year Mission Project. In addition, to understand astronaut variability in adaptation to spaceflight, we will relate the muscle, bone structure, and bone strength measurements to pre- and post-flight serum indices of bone and muscle metabolism, as well as dietary patterns and physical activity logs while on station. Altogether, by examining bone and muscle changes following 2, 6, and 12 months of spaceflight, this work should provide critical and novel information regarding the temporal pattern of musculoskeletal changes during spaceflight, including their impact on maintenance of human health and performance and will inform the design of future long-duration deep space missions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Improved understanding of the time course of musculoskeletal changes in spaceflight will provide new insights for how to prevent and treat disuse-related osteoporosis and sarcopenia on Earth.
Task Progress:	The rate and extent of musculoskeletal changes during long-duration spaceflight remain uncertain. In particular, a critical question is whether bone mass and bone strength declines continue at the same rate as seen during the first 6 months of spaceflight or whether the body will adapt to its new environment, and whether bone loss will slow or stop during longer duration exposure to microgravity. To address this key gap in knowledge, we propose to conduct 3D computed tomography (CT) scans prior to launch and after landing in astronauts participating in the One-Year Mission Project. Using CT-based finite element analysis (CT-FEA), prior work using older imaging technology in 16 astronauts found average declines in femoral and vertebral bone strength of 1.1 to 2.6% per month during 4-to 6 month International Space Station (ISS) missions, though some astronauts experienced much higher losses. The declines in estimated bone strength exceeded the declines in bone mass as assessed by 2D dual-energy X-ray absorptiometry (DXA) scans. Moreover, the declines in strength were not predicted by the DXA-based bone mass measures, indicating the need to use 3D CT measures to accurately assess bone changes. Thus, we propose to employ state-of-the-art CT imaging to assess spaceflight-induced changes in cortical and trabecular bone density and morphology, along with changes in femoral and vertebral bone strength from Food and Drug Administration (FDA)-approved CT-FEA. In addition, to assess the risk of fracture, in secondary analyses, we will compare the bone strength values to the estimated loads applied to the skeleton during flight and on the ground using validated, subject-specific multibody musculoskeletal models. Finally, we will assess changes in muscle quality via pre- and post-flight analysis of fatty infiltration of the trunk and lower extremity musculature from the same CT scans. In addition, we will perform in vivo, non-invasive electrical impedance myography (EIM) pre- and post-flight to supplement function assessments of muscle being conducted as part of the standard measures in the integrated One-Year Mission Project. In addition, to understand astronaut variability in adaptation to spaceflight, we will relate the muscle, bone structure, and bone strength measurements to pre- and post-flight serum indices of bone and muscle metabolism, as well as dietary patterns and physical activity logs while on the station. Altogether, by examining bone and muscle changes following 2, 6, and 12 months of spaceflight, this work should provide critical and novel information regarding the temporal pattern of musculoskeletal changes during spaceflight, including their impact on maintenance of human health and performance and will inform the design of future long-duration deep space missions. Accomplishments During Project Period 1) Work with NASA staff and other CIPHER (Complement of Integrated Protocols for Human Exploration Research) investigators to develop an integrated protocol 2) Submitted and received approval for continuing review of JSC IRB (Johnson Space Center Institutional Review Board) protocol 3) Participated in CIPHER principal investigator briefings 4) Participated in virtual informed consent briefing sessions 5) Finalized manual of procedures for CT scan collection and data transfer, trained study staff in all procedures 6) Purchased the EIM device 7) Held bi-weekly project team meetings 8) After purchasing the EIM device, conducted and passed a Technology Readiness Review (TRR) for the use of the EIM device 9) Creating Training materials for EIM device, conducted in-person training for study staff at JSC 10) Performed baseline data collection for one subject; data transferred to Beth Israel Deaconess Medical Center (BIDMC) Goals & Milestones for Next Funding Period 1) Conduct a reproducibility study for the EIM device 2) Continue to participate, as needed, in virtual informed consent briefings 3) Perform additional data collection as subjects are enrolled 4) Renew IRB approval via continuing review, as needed 5) Hold bi-weekly meetings with study team
Bibliography Type:	Description: (Last Updated: 02/21/2024)