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PI Name:	Norcross, Jason M.S.		
Project Title:	Metabolic Assessment of Suited Mobility using Functional Tasks		
Division Name:	Human Research		
Program/Discipline:			
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) **EVA**:Risk of Injury and Compromised Performance due to EVA Operations (IRP Rev F)		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	77058-3711	**Congressional District:**	36
Comments:			
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No. of Bachelor's Candidates:	1	**Monitoring Center:**	NASA JSC
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Key Personnel Changes/Previous PI:			
COI Name (Institution):	McFarland, Shane M.S. (NASA Johnson Space Center)		
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Task Description:	Existing methods for evaluating extravehicular activity (EVA) suit mobility and verifying requirements have typically relied on measurement techniques such as motion capture and joint torque measurements looking at several isolated joint range of motions. These methods are straightforward and can be clearly defined, but they have little to do with how well a crewmember can actually perform in an EVA suit. EVA tasks often rely on the movement of several joints concurrently to complete the task. This proposal seeks to evaluate alternate methods of evaluating suited mobility through measurement of metabolic rate and time to completion of functional tasks. The product of this research will be inputs to suit mobility requirements, possibly new suit requirements based on metabolic assessment of functional task, and risk characterization inputs for the Integrated Research Plan (IRP) gap EVA 7.		

	Traditional joint torque and isolated joint range of motion measurements may be quantifiable and measurable, but they do not provide information that describes how the EVA suit as a whole allows the crewmember to function. We propose that by focusing on crewmember physiological performance of functional tasks, we can define metrics that verify that a suit is meeting suit mobility requirements.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	An end result of this research may be a functional requirement and verification process for spacesuit mobility enabling more effective exploration extravehicular activities (EVAs).
Task Progress:	Existing methods for evaluating extravehicular activity (EVA) suit mobility have typically focused on isolated joint range of motion or torque, but these techniques have little to do with how well a crewmember functionally performs in an EVA suit. PURPOSE: To evaluate suited mobility at the system level through measuring metabolic cost (MC) of functional tasks. METHODS: Six male subjects completed 2-3 trials of 5 functional tasks (walk, side step, stair climb, and upper body and full body object relocations) in each of 3 different space suits including 2 prototype planetary EVA suits, the Mark III (64 kg) and Rear Entry I-suit (REI, 43 kg), and a modified intravehicular activity suit (Demonstrator, 27 kg) with enhanced mobility for contingency EVA. All tasks were performed in 1g. Rate of carbon dioxide (CO_2) production was determined by measuring suit inlet flow and outlet CO_2 concentration. Respiratory exchange rate was assumed to be 0.85 for the conversion to kcal. Mixed-effects regression methods were used to compare metabolic cost across the three different space suits, incorporating random intercept terms to accommodate the within-subjects experimental design, and random variance terms to accommodate the observed heterogeneity of variance among the three suits. Five separate models were evaluated; one per functional task. RESULTS: The MC of all functional tasks was significantly higher in the Demonstrator suit, averaging 33-62% more depending on task. The Mark III and REI suits elicited similar MC, except in response to the side step and stair climb tasks. In these tasks, MC was significantly lower in the REI relative to the Mark III. DISCUSSION: Although the Demonstrator is the lightest space suit evaluated here, it required the highest MC to complete functional tasks, suggesting poor relative functional mobility. Differences between the Mark III and REI were evident on tasks that required vertical travel, with REI suit having lower MC for side step and stair climb. When normalizing MC results to system mass (subject + suit), then MC per kg favors the Mark III; therefore, these small differences in MC at 1g may not be as evident on the moon or Mars. The method of quantifying and comparing suited mobility and performance as a function of metabolic cost should continue to be evaluated as a possible replacement or supplement for traditional isolated-joint range of motion/torque evaluations. In addition, it potentially offers a means of developing requirements more tied to functional, complex motions and a method for developing a single scoring metric should be further investigated.
Bibliography Type:	Description: (Last Updated: 01/06/2022)
Abstracts for Journals and Proceedings	Norcross JR, McFarland SM, Ploutz-Snyder R. "Metabolic assessment of suited mobility using functional tasks." American College of Sports Medicine 63rd Annual Meeting, Boston, MA, May 31-June 4, 2016. American College of Sports Medicine 63rd Annual Meeting, Boston, MA, May 31-June 4, 2016. Hypoxia/Altitude/Dive/Space Physiology Session, Poster 211. , Jun-2016
Papers from Meeting Proceedings	McFarland SM, Norcross JR. "Development of an Objective Space Suit Mobility Performance Metric Using Metabolic Cost and Functional Tasks." 46th International Conference on Environmental Systems, Vienna, Austria, July 10-14 2016. 46th International Conference on Environmental Systems, Vienna, Austria, July 10-14 2016. Paper ICES-2016-278. , Jul-2016