

METABOLIC ASSESSMENT OF SUITED MOBILITY USING FUNCTIONAL TASKS

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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 (CO₂) production was determined by measuring suit inlet flow and outlet CO₂ 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.

Space Suit	Metabolic Cost (kcal • rep ⁻¹)				
	Walk	Side Step	Stair Climb	Up Body Obj Relo	Full Body Obj Relo
Demonstrator	1.75 ± 0.11	1.64 ± 0.29	1.57 ± 0.32	2.68 ± 0.67	4.20 ± 0.78
Mark III	1.32 ± 0.12	1.19 ± 0.14	1.17 ± 0.13	1.66 ± 0.33	3.01 ± 0.68
REI	1.31 ± 0.16	1.03 ± 0.13	1.04 ± 0.10	1.66 ± 0.30	2.84 ± 0.39

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.