

EVALUATION OF AEROBIC CAPACITY IN RELATION TO SIMULATED LUNAR SURFACE EXTRAVEHICULAR ACTIVITIES

N.C. Strock¹, D. Frisco², P.N. Estep³, T. Schlotman¹, J. Norcross¹, B.J. Prejean¹, & K. Marshall-Goebel⁴
¹KBR, Houston, TX, USA; ²JES Tech, Houston, TX, USA; ³GeoControl Systems, Houston, TX, USA;
⁴NASA Johnson Space Center, Houston, TX, USA

INTRODUCTION

Astronauts will need to be physically prepared to successfully execute strenuous Extravehicular Activities (EVA) on the Lunar surface. Compared to Apollo missions, Artemis missions will include EVAs of increased physical demand, frequency, and duration, thus requiring adequate fitness to successfully and safely complete mission objectives and potential contingency scenarios. Currently, aerobic fitness standards for partial gravity (g) surface EVAs are not well supported by high-fidelity EVA analog data. This investigation aims to characterize metabolic demands from Lunar analog EVA simulations in relation to the current NASA standards for celestial partial-g aerobic fitness (aerobic capacity ($\text{VO}_{2\text{pk}}$) $\geq 36.5 \text{ ml/kg/min}$).

METHODS

To evaluate current Lunar EVA aerobic fitness requirements, a pilot study was performed to characterize metabolic rates during 6 hour simulated EVAs. The EVAs were performed in pressurized MKIII (n=2 male) and xEMU (n=3 female) spacesuits offloaded to 1/6 g in the NASA Active Response Gravity Offload System. $\text{VO}_{2\text{pk}}$ was assessed via graded exercise testing on a cycle ergometer and physical workload was quantified as percent of $\text{VO}_{2\text{pk}}$.

RESULTS

Four out of five subjects did not meet the current NASA celestial surface EVA aerobic standard (3 xEMU, 1 MKIII; $35.1 \pm 0.9 \text{ ml/kg/min}$). During simulated EVAs, subjects (xEMU: $35 \pm 1 \text{ ml/kg/min}$; MKIII: $44 \pm 10 \text{ ml/kg/min}$) worked at an average 36% $\text{VO}_{2\text{pk}}$ (xEMU) and 31% $\text{VO}_{2\text{pk}}$ (MKIII). For xEMU subjects, the tasks with the greatest average metabolic rates were 2km treadmill traverse (0% grade: 47.2% $\text{VO}_{2\text{pk}}$ [max 69.1%]), object relocation (45.2% $\text{VO}_{2\text{pk}}$ [max 60.5%]), and 1.5km traverse (0% grade: 45% $\text{VO}_{2\text{pk}}$ [max 59.7%]). For MKIII subjects, the tasks with the greatest average metabolic rates were 0.5km treadmill traverse (30% grade: 35.4% $\text{VO}_{2\text{pk}}$ [max 45.5%]), object relocation (31% $\text{VO}_{2\text{pk}}$ [max 40.8%]), and treadmill traverse (0% grade: 29.9% $\text{VO}_{2\text{pk}}$ [max 45.9%]).

CONCLUSIONS

While average metabolic rates for simulated Lunar EVA fall within sustainable work ranges of 30–40% $\text{VO}_{2\text{pk}}$ and life support system limitations, task-specific metabolic rates exceed this range and may indicate that greater fitness is necessary for more strenuous tasks expected to be performed on the Lunar surface. As few subjects met the standard, more data is needed to adequately evaluate the NASA 3001 standard.