A Preliminary Assessment of Cognition and Fatigue during Simulated Lunar Surface Extravehicular Activities

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INTRODUCTION: Artemis astronauts will be required to complete more rigorous Extravehicular Activity (EVA) schedules than during ever before. While new spacesuits are designed to sustain high physical workloads during exploration EVAs (xEVA), crewmembers must also sustain cognitive performance throughout xEVA timelines. It is therefore necessary to characterize the effects of surface xEVA tasks and timelines on cognition and fatigue.

METHODS: This study utilized NASA Johnson Space Center's Active Response Gravity Offload System (ARGOS) to simulate lunar gravity and assess xEVA tasks and cognitive performance. Two subjects completed two ~5-hour EVAs in a pressurized Mark III spacesuit, completing simulated lander operations, cable routing, crew rescue, geology, payload relocation, and traverses. Subjects completed two cognitive assessments (Digit-Symbol Substitution Task (DSST) and Psychomotor Vigilance Task (PVT)) before the first and after the second simulated EVA to assess effects of xEVA tasks on processing speed and vigilant attention. Additionally, sleep (e.g., quality, duration, and efficiency) was monitored (Oura Ring) for ≥7 days prior to the simulated EVAs, as well as between each EVA, to account for possible effects of sleep decrements on cognitive metrics.

RESULTS: Cognitive performance changed minimally from pre to post EVA for both DSST (response time (RT): S1 Δ129.1ms, S2 Δ40.7ms; Accuracy: S1 preEVA = 1.0, S1 postEVA = 0.98, S2 preEVA = 1.0, S2 postEVA = 1.0) and PVT (S1 PVT RT Δ17.7 ms, S2 PVT RT Δ-2.7 ms). Subjects' sleep duration immediately prior to EVA showed minimal deviation from baseline (Δhrs; S1 preEVA1= + 0.67, S1 preEVA2 = -.03, S2 preEVA1 = - 1.1, S2 preEVA2 = -1.39) and efficiency (Δ%; S1 preEVA1 = 0.09, S1 preEVA2 = 9.54, S2 preEVA1 = 0, S2 preEVA2= 12). Notably, sleep waketime shifted earlier for one subject by ~1 hr which may have impacted performance.

CONCLUSION: Understanding the impacts of xEVA workloads on cognitive performance will be instrumental to future exploration mission planning and success. Future work will expand the subject pool and test new spacesuit designs to better characterize cognitive performance and impacts of sleep during simulated xEVA and inform modeling and prediction capabilities for future Artemis xEVA planning.