

DEVELOPMENT AND VALIDATION OF SENSORIMOTOR ASSESSMENT TASKS USING SPACEFLIGHT ANALOGS

S.C. Moudy¹, B.T Peters², T.K. Clark³, M.C. Schubert⁴, H.M. Weiss², S.J. Wood⁵

¹Aegis Aerospace, ²KBR, ³University of Colorado Boulder, ⁴Johns Hopkins University, ⁵NASA JSC

INTRODUCTION

Exploration class missions will require a new level of crew autonomy to self-assess and treat their sensorimotor dysfunction around periods of gravitational transition, where sensorimotor disturbances are at their highest. There is a need to define sensorimotor assessment thresholds that indicate when performance in early extravehicular activities (EVAs) might be impacted or unsafe. The purpose of this study was to develop and validate a set of assessment tasks using sensorimotor spaceflight analogs including the Sensorimotor Disorientation Analog (SDA) [1] and +3G_x sustained centrifugation.

METHODS

For the SDA, forty-one healthy non-astronaut subjects (21 males, 20 females; Mean \pm SD, Age: 34.0 ± 7.8 years) volunteered to participate in this study. Subjects attended two testing sessions: 1) familiarization to the tasks and baseline data collection, and 2) tasks completed under two levels of sensorimotor disorientation. Subjects performed a series of seven sensorimotor assessment tasks followed by two operationally relevant EVA analog tasks. The sensorimotor assessments tasks, ordered from least to most provocative of the sensorimotor system, included: postural stability, step test, prone/supine recovery from fall (RFF), four-square-step-test, obstacle negotiation with turns (OTT), kneel-and-reach, and augmented reality full-body coordination. The operational analog tasks included a top-hatch capsule egress and a 5-minute EVA traversal. Disorientation was applied via the SDA which utilized galvanic vestibular stimulation and weighted trunk, wrists, and ankles to target the vestibular and proprioceptive systems such that performance while wearing the SDA mimicked astronaut postflight performance at R+0 and R+1.

Sixteen healthy non-astronaut subjects (10 males, 6 females; Age: 35.0 ± 9.5 years) completed +3G_x 60-minute sustained centrifugation as an established spaceflight analog replicating the vestibular disruptions seen postflight. Subjects completed a pre-session which included familiarization to the tasks and a 5-minute centrifuge spin. The data collection session included, in order, a baseline data collection, 60-minute centrifuge spin, immediate post-centrifuge data collection, 45-minute seated recovery, and a final data collection. The same assessment and operational analog tasks were conducted as described above.

RESULTS

Pearsons' correlation r -values were calculated between assessment and operational analog tasks. The two assessment tasks with the strongest correlations to the operational analog tasks were the RFF (SDA: $r \geq 0.57$, Centrifuge: $r \geq 0.55$) and OTT (SDA: $r \geq 0.66$, Centrifuge: $r \geq 0.49$). For brevity, repeated measures ANOVA with follow-up paired t -tests are discussed for these two assessment tasks. The SDA found significant differences between all three levels of disorientation for both RFF and OTT ($p < 0.001$). Significant differences were also found between baseline and immediate post centrifuge testing for both the RFF ($p \leq 0.011$) and OTT ($p = 0.001$). Additional results are forthcoming for both disorientation paradigms.

DISCUSSION

These validation studies provide evidence for down-selection of the assessment tasks that were able to distinguish between levels of sensorimotor disorientation and correlate to performance in operationally relevant tasks for use in upcoming Artemis missions.

ACKNOWLEDGEMENTS

The authors acknowledge the support in conducting the centrifuge runs from KBR Aerospace and Environment Protection Lab at Brooks City Base in San Antonio, TX. This project is funded by the NASA Human Research Program.

[1] Moudy et al. (2024) *Front Physiol* 15:1369788