VALIDATION OF A SENSORIMOTOR DISORIENTATION GROUND ANALOG

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INTRODUCTION

Simulating the sensorimotor disorientation effects of gravity transitions after prolonged stays in microgravity is exceedingly challenging on Earth. In a previous study [1], a Sensorimotor Disorientation Analog (SDA) was developed based on subjective feedback from previously flown astronauts. The purpose of this study was to validate this SDA by comparing performance in movement tasks that have a wealth of spaceflight data against task performance while using the SDA.

METHODS

Thirty healthy non-astronaut subjects (17 males, 13 females; Mean ± SD, Age: 33.5 ± 7.2 years, Height: 68.0 ± 3.4 in, Weight: 164 ± 26 lbs.) volunteered to participate in this study. Subjects performed three movement tasks: computerized dynamic posturography (CDP), obstacle walk, and tandem walk. For CDP, subjects maintained an upright stance for 20s with eyes closed on an unstable pitch sway-referenced platform with head erect (sensory organization test (SOT)-5) and with head pitch ±20° to an auditory cue (SOT-5M). The obstacle walk involved a sit-to-stand with 10s of quiet stance followed by walking to and around a cone placed 4m away while navigating a 30cm obstacle to the cone and back. The tandem walk involved walking heel-to-toe for approximately 10-12 steps with eyes open and eyes closed. Subjects performed the three movement tasks under three levels of the SDA replicating different time points of recovery: none (preflight), low (Return (R)+24-48hours), and high (R+0-24hours). The SDA included galvanic vestibular stimulation (GVS) to disorient the vestibular system and a weighted suit (trunk, wrists, and ankles) to alter proprioceptive feedback and replicate subjective heaviness.

RESULTS

As the SDA magnitude increased, overall performance outcomes decreased. However, the ability of the SDA to replicate the range of astronaut postflight performance was task dependent. CDP SOT-5 performance across SDA levels closely replicated astronaut performance at all time points. SOT-5M, however, had minimal performance changes across SDA levels and was unable to replicate astronaut performance. The obstacle walk showed performance changes across SDA levels and matched astronaut performance preflight and at R+24-48hrs (low). Obstacle walk performance at the high SDA level was reduced in comparison to the low level; however, it was not replicative of astronaut performance immediately after landing. Last, tandem walk had distinct groupings of performance across SDA levels and was able to elicit a high level of disorientation consistent with R+0-24 hours (high) postflight performance for eyes open and eyes closed. The low SDA level for both eyes open and eyes closed was more disruptive than previous crewmember performance at the R+24-48 hours timepoint.

CONCLUSION

The SDA was developed to replicate postflight sensorimotor disruptions. However, it is well-known that immediately post-landing, astronauts can experience motion sickness, dehydration, fatigue, orthostatic intolerance, illusory sensations, lumbar pain, etc. This multi-system response to return to 1G varies widely across astronauts and, as such, it was not unexpected that the extreme ends of responses in the R+0-24hrs time period were the most difficult to replicate. These results suggest that the SDA levels are able to elicit distinct performance groupings and, although not able to perfectly replicate R+0-24hrs, the SDA did replicate a large range of performance after return to Earth.

[1] S.C. Moudy et al. (2023) *NASA HRP IWS 2023*. "Development of a Sensorimotor Ground Analog…"