MS NON-PHARMACOLOGICAL COUNTERMEASURE TO DECREASE LANDING SICKNESS AND IMPROVE FUNCTIONAL PERFORMANCE WHILE DISORIENTED

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Upon return from spaceflight, a majority of crewmembers experience motion sickness (MS) symptoms. The interactions between crewmembers' adaptation to a gravitational transition, the performance decrements resulting from MS and/or use of promethazine (PMZ), and the constraints imposed by mission task demands could significantly challenge and limit an astronaut's ability to perform functional tasks during gravitational transitions. No operational countermeasure currently exists to mitigate the risks associated with these sensorimotor disturbances. Stochastic resonance (SR) can be thought of simply as "noise benefit" or an increase in information transfer by a system when in the presence of a non-zero level of noise. We have shown that low levels of stochastic vestibular stimulation (SVS) improve balance and locomotor performance due to SR (Goel et al. 2015, Mulavara et al. 2011, 2015). Additionally, a study in a 6-hydroxydopamine (6-OHDA) hemi-lesioned rat model of Parkinson's disease demonstrated improvements in locomotor activity after low-level SVS delivery possibly due to an increase in nigral gamma-aminobutyric acid (GABA) release in a dopamine independent way (Samoudi et al. 2012). SVS specifically increased GABA release on the lesioned, but not the intact side. These results suggest that SVS can cause targeted alterations of GABA release to affect performance of functional tasks. Activation of the GABA pathway is important in modulating MS and promoting adaptability (Cohen 2008). Magnusson et al. (2000) supported this finding by showing that the administration of a $GABA_B$ agonist caused a reversal of the symptoms that is normally seen after unilateral labyrinthectomy. Thus, GABA could play a significant role in reducing MS and promoting adaptability. We have taken advantage of the SR mechanism as a modulator of neurotransmitters to develop a unique SVS countermeasure system to mitigate MS symptoms and improve functional performance after landing.

Healthy subjects (n=20) participated in two test sessions, one in which they received ±400 µA of SVS and one where they received no stimulation (0 µA); the study design was counterbalanced. Subjects began by performing a series of four functional tasks 3-5 times as baseline measurements of task performance. Then, to induce MS, subjects walked an obstacle course with up-down reversing prisms. If they completed the course before achieving our pre-determined level of MS, they were asked to read a poster while making large up-down head movements to a metronome while still wearing the reversing prism goggles. Subjects were stopped every two minutes and asked to report their MS symptoms. Using the Pensacola Scale for motion sickness, test operators evaluated the level of MS of each subject. Once a subject reached an 8 on this scale, which is equivalent to mild malaise, or 30 minutes had passed since the start of the MS induction, this protocol was stopped. Finally, immediately after MS induction, subjects were asked to complete the four functional tasks again. Although, 100% of our subjects experienced at least one MS symptom, only 55% of our subjects experienced stomach awareness to any degree. Without SVS, only 40% of subjects lasted the full 30-minute MS induction protocol, while 65% of subjects lasted the full 30 minutes with SVS, which is nearly a significant increase (p=0.056). In addition, subjects showed significant improvement from baseline when performing a tandem walk and a prone-to-stand test immediately after the MS induction protocol was stopped but the stimulation level was continued. The results are promising and future work includes comparing MS progression between PMZ and SVS directly in subjects that are provoked to a minimum of nausea. Low levels of SVS stimulation may serve as a non-pharmacological countermeasure to replace or reduce the PMZ dosage requirements and concurrently improve functional performance during transitions to new gravitational environments after spaceflight.

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