

EFFECT OF SIMULATED SPACE CONDITIONS ON FUNCTIONAL CONNECTIVITY

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ABSTRACT

Long duration spaceflight missions can affect the cognitive and behavioral activities of astronauts due to changes in gravity. The microgravity significantly impacts the central nervous system physiology which causes the degradation in the performance and lead to potential risk in the space exploration. The aim of this study was to evaluate functional connectivity at simulated space conditions using an unloading harness system to mimic the body-weight distribution related to Earth, Mars, and International Space Station. A unity model with six directional arrows to imagine six different motor imagery tasks associated with arms and legs were designed for the Oculus Rift S virtual reality headset for testing. An Electroencephalogram (EEG) and functional near infrared spectroscopy (fNIRS) signals were recorded from 10 participants in the distributed weight conditions related to Earth, Mars, and International Space station using the g.Nautilus fNIRS system at sampling rate of 500 Hz. The magnitude squared coherence were estimated from left vs right hemisphere of the brain that represents functional connectivity. The EEG coherence was the higher which shows the strong functional connectivity and fNIRS coherence was lower shows weak functional connectivity between left vs right hemisphere of the brain, during all the tasks and trials irrespective of the simulated space conditions. Further analysis of functional connectivity needed between the intra-regions of the brain.

Keywords: Electroencephalogram (EEG), Functional near infrared spectroscopy (fNIRS), International space Station (ISS) etc.

INTRODUCTION

Over the last two decades, long-duration spaceflights were studied, showing that astronauts' cognitive and behavioral activities were impaired in space environments [1]. Long duration spaceflights cause changes in the sensorimotor systems which results in the difficulties experienced by astronauts with movements, postural control, and manual control. Microgravity is the leading cause of performance degradation in space exploration, and it poses a severe threat [2, 3]. Space flight and the microgravity environment significantly impacted astronaut central nervous system physiology [4]. This study evaluates human brain responses in distributed-weight conditions related to Earth, Mars, and International Space Station (ISS). This study used a harness system with a weight scale to distribute human body weight associated with Earth, Mars, and ISS. EEG and fNIRS signals were recorded to find the coherence during distributed weight conditions related to earth, mars, and ISS. EEG coherence measures the correlation coefficient that estimates the relative amplitude and phase consistency between any pair of signals at different frequency bands [5]. The functional connectivity was calculated by finding out the EEG and fNIRS coherence from the brain's left vs. right hemisphere.

MATERIALS & METHODS

Guger Technologies' g.Nautilus fNIRS wireless system was utilized because of its wireless capability and dual modality (EEG and fNIRS). The 500 Hz sampling rate was utilized during recording the signals. Figure 1 shows an unloading harness system where a participant is standing straight on the floor, partially lifted, and completely lifted to mimic body-weight distribution related to Earth, Mars, and ISS respectively.