IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Medicine in Space and Extreme Environments (4)

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BRAIN OXYGENATION MONITORING IN A PARABOLIC FLIGHT USING PORTABLE FUNCTIONAL NEAR-INFRARED SPECTROSCOPY

Abstract

1 Abstract

1.1 Introduction

In this decade, we are experiencing a highly dynamic phase of space exploration, which highlights the urgent need to address medical challenges related to long-term missions. A key challenge addresses mitigation and monitoring strategies of cognitive impairments. In our previous study we could demonstrate the feasibility of portable functional near-infrared spectroscopy (fNIRS) to monitor brain oxygenation changes during cognitive demanding tasks under extreme environmental conditions such as high altitude. For future long-term missions, the next step involves the demonstration of brain monitoring in conditions such as simulated microgravity.

1.2 Objective

Our objective is to demonstrate the feasibility of assessing changes in brain oxygenation in a parabolic flight using portable fNIRS. The underlying hypothesis is based on the proposition that due to expected fluid shift during microgravity phase, blood circulation of the brain is increased and thus an increase in quantitative measurement of oxygenated hemoglobin in the prefrontal cortex can be observed while an increase in gravity as observed in the hypergravity phase is associated with a decrease in oxygen supply to the brain.

1.3 Method

Ten healthy, young study subjects took part in a parabolic flight training. During the flight all subjects were monitored using fNIRS while experiencing short duration phases of microgravity (6s) and hypergravity (3s) throughout eight parabolas. While five subjects were asked to remain relaxed and seated during the flight (control group), five subjects were asked to perform arithmetic problems displayed on an iPad (interventional group). Arithmetic tasks are commonly used to measure cognition in studies as they require a range of cognitive skills such as working memory, attention, and executive functions, all in all skills that can be assigned to the brain area of the prefrontal cortex (PFC). Oxygenated and deoxygenated haemoglobin were measured using two fNIRS sensors placed on the right and left forehead to measure brain oxygenation in the PFC. In addition, heart rate (HR) variations and peripheral oxygen saturation (SpO2) was monitored using a triode electrocardiogram (ECG) and a finger clip sensor.

1.4 Data analysis

For data analysis quantitative oxygenated [HbO] and deoxygenated [HbR] haemoglobin concentrations will be obtained throughout the Modified Beer-Lambert Law (MBLL).

1.5 Results

This study showcases the potential of portable fNIRS technology to measure changes in brain oxygenation during shifts in gravitational phases. Furthermore, the study explores the efficacy of using portable fNIRS to detect alterations in haemoglobin levels and detect physiological pattern while performing cognitive tasks under these extreme conditions.