Paper ID: 68762
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IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Human Physiology in Space (2)

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TRANSCRANIAL PHOTOBIOMODULATION MODULATES METABOLISM IN THE HUMAN BRAIN AS MEASURED BY PHOSPHORUS MAGNETIC RESONANCE SPECTROSCOPY

Abstract

PURPOSE

Although techniques for non-invasive brain stimulation are under intense investigation, an approach that has received limited attention is transcranial photobiomodulation (tPBM), the delivery of near-infrared light to the brain with a laser or light-emitting diode (LED) directed at the scalp. Previous investigations have shown tPBM modulates cognitive performance, mood, brain waves, and hemodynamic activity. Whether tPBM modulates energy metabolism directly hasn't been tested in the human brain. This is the first study to measure phosphorus metabolites, including ATP, during tPBM in humans using magnetic resonance spectroscopy (MRS). These results haven't been presented at a previous meeting.

METHODOLOGY

We performed tPBM in n=14 healthy astronaut-like adult participants. Participants received stimulation to the right frontal pole (Fp2). Stimulation was delivered for 10 minutes with a monochromatic laser at a wavelength of 808 nm and an intensity of 318 mW/cm2. The total incident light energy was 150 J. We recorded the concentration of phosphorus metabolites before, during, and after tPBM. We computationally modeled the distribution of light absorption in the human brain when illuminating the scalp.

RESULTS

The PCr/ATP ratio was decreased significantly both during and after tPBM in regions predicted to absorb the bulk of the delivered photons, indicating that the concentration of ATP increases when stimulated with light.

CONCLUSIONS

Our findings provide the most direct evidence to date for the capability of tPBM to increase energy availability in the human brain. The concentration of ATP increases during active stimulation, relative to sham, indicated by a decrease in the PCr/ATP ratio. Cerebral bioenergetics and cognitive performance are closely linked. These results pave the way for investigating tPBM as a cognitive enhancement tool in healthy adults.

DISCUSSION

During sham sessions the PCr/ATP ratio increased, which may indicate a shift in the brain state of our subjects during the 30-minute MRS scan. Other phosphorus metabolites measured in our MRS signals are currently being investigated. A similar study was performed on canines anesthetized with isoflurane where no changes were found during tPBM lasting 4 minutes, and the PCr/ATP ratio increased two weeks following tPBM. These different results may be due to differences in the metabolism or neuronal excitability of an anesthetized brain and an awake brain, or due to differences in tPBM stimulation time.