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Acute Effects of Near Infrared Light Therapy on Brain State in Healthy Subjects as Quantified by qEEG Measures

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Abstract

Objective: Recent investigation suggests that near infrared (NIR) light may improve symptoms from mild traumatic brain injury. In addition, quantitative electroencephalography (qEEG) has shown measures correlating with concussion: P300, reaction time, and amplitude. The objective of this study was to determine whether NIR light treatment has an acute effect on brain state in healthy patients as measured by EEG. ***Methods:*** A total of 31 healthy volunteers, between the ages of 14 and 65, underwent qEEG event-related response tests before and after a 20-min NIR light head treatment. The treatment device is composed of 784 NIR GaAIAs LEDs covering 360 cm^2 on the head in a cap covering occipital, left temporal, right temporal frontal, and parietal lobes. The fluence rate was 1 $J/cm^2 \cdot min$ for a power density of 16.67 mW/cm^2. Peak spectral wavelength at steady-state temperature (42.2°C) is 903 nm. The device delivered a total dose of 20 J/cm^2. Two to four months later, 18 subjects returned for a second round of qEEG measurements, with a 20-min rest period in place of the NIR light treatment as a control arm. ***Results:*** Change in reaction time significantly differed between treated and control, with a mean of 23.8 msec improvement compared with controls ($p = 0.035$). Amplitude increased an average of 0.81 μV in treatment versus 0.22 μV in controls and did not reach significance. However, subanalysis of 14 treated subjects and 8 controls displaying initially low amplitude showed a mean increase in amplitude of 1.83 μV (30%) in treated subjects versus 0 μV in controls ($p = 0.08$). P300 measures did not show significant differences between groups. ***Conclusions:*** The data suggest that NIR light may have an acute effect on reaction time and amplitude in certain subject subsets. There were no adverse events registered across the 31 subjects in the treatment group, nor in the 18 evaluable control group subjects.

Keywords: brain stimulation, concussion, LED light therapy, light therapy, near infrared light, traumatic brain injury

Introduction

Concussion and mild traumatic brain injury

Concussion or mild traumatic brain injury (mTBI) is a headline issue in the world of sports and the military today. More than 250,000 service members suffered a TBI from 2000 to 2012 according to the Veterans Affairs Department.[1] mTBI is caused by sudden concussive impact events on the brain. Resulting damage includes severed neuron synapse connections, neuron apoptosis, microbleeding, and ischemia. Clinical manifestations of damage include cognitive impairment, mood disorders, headache, disrupted sleep patterns, and inappropriate behaviors.[2]

Concussion and mTBI have been shown to reduce blood flow to the brain.[3,4]

A correlation has been shown in studies between blood flow and brain function; impeded blood flow reduces the brain's ability to operate.[5] Estimates are that from 10% to 30% of concussion patients experience prolonged symptoms, described as postconcussion syndrome (PCS). Some PCS patients have persistent hypoperfusion in concussed areas of the brain as revealed by single-photon emission computed tomography.[6] Such hypoperfusion may impede neuronal function by starving cells of glucose and oxygen, thus impacting mitochondrial function and cell respiration.

TBI diagnosis and quantitative electroencephalography

The diagnosis of concussion is one of the main challenges faced by neurologists. Quantitative electroencephalography (qEEG) has been shown to be a viable tool for the diagnosis of concussion/mTBI based on several measurable factors. These measures include P300 brain speed, reaction time, and

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