Efficacy of Photobiomodulation for Attention Deficit Hyperactivity Disorder (ADHD): Case Studies.

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Abstract

Extensive research has now been conducted and published for the treatment of dementia or Alzheimer's disease, traumatic brain injury (TBI) and other brain disorders using photobiomodulation (PBM), also known as low-level laser therapy (LLLT). However, minimal information is available regarding the use of LLLT for the treatment of Attention Deficit Hyperactivity Disorder (ADHD). We have been using LLLT in our practice for over 15 years addressing chronic pain and injury issues. However, our work with brain injuries is more recent, and we have published three case studies, one describing a serious traumatic brain injury and two describing our success with dementia/Alzheimer's disease and PTSD. Currently there is very little published evidence regarding efficacious therapy for ADHD. The case studies presented here, suggest that LLLT can provide alleviation of these symptoms, with some improvement reported after just a single treatment, without any need for pharmaceutical intervention.

Key words: Photobiomodulation; Mitochondria; Attention Deficit Hyperactivity Disorder; Low level laser therapy (LLLT); Case studies

Introduction

According to the Center for Disease Control (CDC), attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder have become more prevalent in our society over the last 60 years. It was not until the 1960s that the American Psychiatry Association classified ADHD as a mental disorder. In 1980, it was referred to as "attention deficit disorder with or without hyperactivity". According to a 2016 report by the CDC, 6.1 million children between the ages of 2-17 are affected. Furthermore, children with ADHD showed significant behavioral or conduct problems. Moreover, 3 in 10 children with ADHD also have anxiety.

A complete understanding of the causes of ADHD is not currently available.[1] It is known that some cases of ADHD can be inherited, and having blood relatives, such as a parent or sibling, with ADHD or another mental health disorder is a risk factor. Exposure to environmental toxins, such as the lead found mainly in paint and pipes in older buildings could play a part. Maternal drug use, alcohol use, or smoking during pregnancy are also risk factors.[2]

While there is no known specific cause for ADHD, variations in neurotransmitter levels, such as dopamine, norepinephrine, and serotonin in the brain can contribute to the severity of the symptoms.[3] For example, because dopamine helps a person to focus and rewards the brain for completing tasks, the presence of lower dopamine levels in the brain means a person might have trouble maintaining focus on a task, or seeing it through to the end. It has been suggested that persons with ADHD have more dopamine transporter proteins due to genetic variations, which work to remove dopamine from the brain. If there are too many dopamine transporters in the brain, too much dopamine is being removed too quickly. It has also been proposed that ADHD is associated with changes in functional connectivity in resting state networks of the brain.[4] These networks could include the default mode network, as well as visual, sensory motor, attentional, frontal, central executive, and frontal networks. This is particularly relevant in the present case, because it has been shown that transcranial LLLT can produce beneficial modifications in the default mode network in patients suffering from chronic traumatic brain injury[5] and chronic stroke with aphasia.[6]

Treatment of ADHD has generally involved pharmacological administration of stimulants, such as methylphenidate (Ritalin) or amphetamine (Adderall).[7] However, in 2018 a study was published in the journal Pharmacy.[8] which concluded "Results revealed that Adderall had minimal, but mixed, effects on cognitive processes relevant to neurocognitive enhancement (small effects), and substantial effects on autonomic responses, subjective drug experiences, and positive states of activated emotion (large effects). Overall, the present findings indicate dissociation between the effects of Adderall on activation and neurocognition, and more importantly, contrary to common belief, Adderall had little impact on neurocognitive performance in healthy college students. Given the pilot design of the study and small sample size these findings should be interpreted cautiously. The results have implications for future studies and the education of healthy college students and adults who commonly use Adderall to enhance neurocognition."

The technology known as Low Level Laser Therapy (LLLT) delivers red and/or near-infrared light from a laser or a LED (light emitting diode) to a particular part of the body. LLLT initiates a process called photobiomodulation, which can in many circumstances provide physiological benefits lasting much longer than the duration of irradiation. LLLT has been widely employed for reducing pain, inflammation, preventing tissue damage, and the stimulation of healing of wounds or other types of injuries.[9] Because LLLT does not involve any drugs or invasive modalities, it is remarkably free of side effects, and has been generally recognized as safe by the FDA.

The first law of photobiology states that a photon must be absorbed by a specific molecular chromophore in order to have any biological effect. The chromophores that have been postulated to be useful in PBM, absorb at different wavelength regions of the electromagnetic spectrum (blue, green, red, NIR), and are shown in Figure 1.

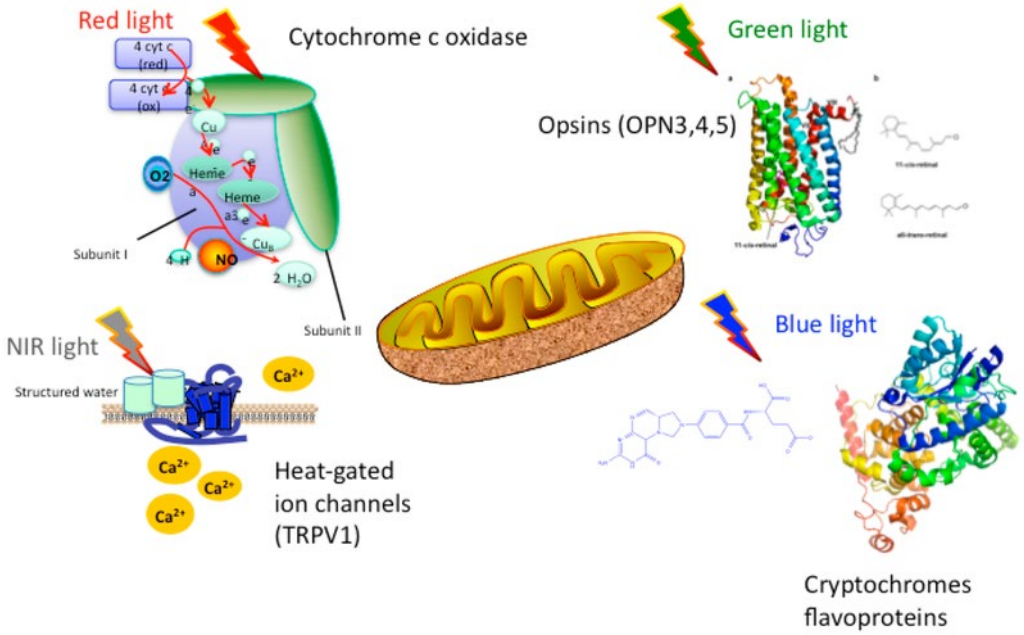

Figure 1. Proposed chromophores for PBM that can absorb different wavelengths of light. It should be noted that there is considerable overlap between the chromophores, and that the NIR absorbed by structured water is likely to be longer wavelength (>950 nm)

Cytochrome C oxidase (CCO) is the terminal enzyme (unit IV) in the electron transport chain situated in the outer mitochondrial membrane. The electron transport chain, through a series of redox reactions, facilitates the transfer of electrons across the inner membrane of the mitochondria. The net result of these electron transfer steps is to produce a proton gradient across the mitochondrial membrane that drives the activity of ATP synthase (sometimes-called unit V) that produces the high-energy adenosine triphosphate (ATP) from ADP. CCO mediates the transfer of electrons from cytochrome C to molecular oxygen. CCO is a complex protein, composed of thirteen different polypeptide sub-units, and contains two heme centers and two copper centers. Each of these heme and copper centers can be either oxidized or reduced, giving sixteen different oxidation states. Each of these oxidation states has a slightly different absorption spectrum, but CCO is almost unique amongst biological molecules in having a significant absorption in the near-infrared spectrum.

Regardless of the precise chromophore, all the evidence points to mitochondria playing a major role as the photo acceptors in LLLT and PBM (Figure 1). This is particularly relevant in the present case, because it has been shown that persons who suffer from ADHD also show evidence of mitochondrial dysfunction.[10]

In recent years, the application of LLLT to the head for treating many brain disorders and improving cognitive performance has attracted an exponentially increasing level of interest [11,12] Brain damage caused by stroke or traumatic brain injury, neurodegenerative diseases (Alzheimer's and Parkinson's), psychiatric disorders (depression, anxiety, insomnia, opiate addiction) have all been treated with transcranial LLLT.

Dr. Stephan and Mr. Banas have been using and "pioneering" this LLLT technology in their office for over 15 years, mainly for treating orthopedic injuries and reducing pain and inflammation. Howeve fo the last few years they have started to treat brain disorders, and so far have published three sets of case studies describing the benefits of transcranial LLLT. These comprise a serious case of traumatic brain injury [12], and two sets of cases in patients suffering from dementia and post traumatic stress disorder.[14,15]

Methods

The Theralase® TLC-2000 CLT laser head we used contained five superpulsed 905 nm diodes (200 nsec pulse duration) each with the ability to put out 200 mW average power, plus four 660 nm diodes each with the ability to put out 100 mW power. Patients were treated on four areas on the forehead over the pre-frontal cortex for two minutes 15 seconds per site. The power settings were 65 mW for the five 905nm diodes and 65 mW for the four 660 nm laser diodes. The energy delivered per site was 79 J, and the total energy delivered over four sites was 315 J. The patient was put in a supine position and protective eyewear was worn. No discomfort was reported by any patient

Case Studies/Testimonials

Case 1. A 46-year-old Carmelite nun was referred to us. She experienced positive results with a single treatment. All four patients received a second treatment, however she felt it was not necessary because a sufficient improvement was seen with the first treatment, the younger patients are receiving maintenance at 5-6 week intervals.

"I am a 46-year-old Carmelite nun. Since I was a very young teenager, I know I had trouble focusing. It was called ADHD. I would have trouble arranging my schedule and my thoughts to accomplish simple tasks It was suggested I go to the Brain Center where a good friend of mine had their three young boys treated. They were all in their twenties and they were able to focus much better after a single 5-minute treatment. I received two treatments consecutively due to the fact I had to leave town. I'm not sure I even needed the second because the initial treatment gave me the clarity and focusing ability which was necessary to be more efficient in my everyday activities. I have just started a new job where I am now taking on a new task and use a new program. I know this would have been much more challenging then it would have been before the therapy."

Case 2. The 22 year old son of the mother described in Case 1.

" I am Ben, I am 22 years old and I've had ADHD since I can remember. I had poor organization and task management problems. I finished school but it was a challenge. I could never focus on multiple things at once. My dad is a doctor and I have had conventional as well as alternative treatments which never really worked. There was always the crash. My mom discussed my problem with our primary care Dr. Stephan. Dr. Stephan keeps up on alternative medicine and said he has a colleague at The Brain Center who might be able to help. After the first treatment, I felt great right away! it's lasted for quite a few weeks and I did not need my Adderall. However, I am now scheduling for another treatment they call maintenance. I am looking to see how long it will last before needing another treatment"

Case 3. An 18-year-old male college student.

"I have been diagnosed with ADHD a while ago and really have a hard time trying to get organized and focus my duties. Although I am in college, I am doing okay but I struggle. After my first treatment, things became much clearer and I was able to figure out my schedule and have a better order in my life. I am very thankful for this treatment and I do have to get one every five or six weeks but is well worth it based on the improvement in my ability to make decisions and organize more clearly."

Case 4. A 21 year-old college student.

"I am Jim and a 21-year-old college student and I take a full 15 hours of classes weekly and I work 24 hours. It was a real struggle keeping organized with this much work but it was necessary. I was so surprised how much this cold laser treatment helped me! After just one treatment, I had to go back to school but now have my second treatment and within minutes, I feel the difference. I guess I will need a treatment every 4 to 5 weeks because it starting to wear off. This makes life much easier."

Conclusion

Currently there are many studies in progress seeking to test the benefits of photobiomodulation in a wide variety of brain disorders. Transcranial LLLT is certainly one of the biggest breakthroughs in therapeutic medicine over the last decade. However very little has been published regarding the use of LLLT in ADHD. The case studies reported here show that this could be a simple answer to the ADHD issue. The specific mechanisms responsible for the beneficial effects of LLLT, may well include improvements in mitochondrial function and increased functional connectivity in the default mode network. However, other beneficial effects including, the reduction of neuroinflammation, increased cerebral blood flow, reduction

of oxidative stress, and the stimulation of neuroplasticity and synaptogenesis, could also play a part. The simple and inexpensive procedure of transcranial LLLT suggests that a formal, controlled randomized clinical trial study should be undertaken as soon as possible. Moreover, recognized assessment scales such as the ADHD Rating Scale V for children [16] or the Cognition and Motivation in Everyday Life (CAMEL) Scale[17] should be used to quantify the improvements. At present, we are reaching out to local school systems to make them aware of this breakthrough, which could be administered to affected children at minimal cost and with no side effects.

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