"Photobiomodulation of the Brain: Shining Light on Alzheimer's and Other Neuropathological Diseases"

Journal of Alzheimer Disease

Guest Editors:

Michael R. Hamblin, PhD

1. Wellman Center for Photomedicine, Massachusetts General Hospital, Boston, MA, USA
2. Laser Research Centre, Faculty of Health Science, University of Johannesburg, Doornfontein 2028, South Africa (hamblin.lab@gmail.com)

Farzad Salehpour, MSc

1. *College for Light Medicine and Photobiomodulation, Starnberg, Bavaria, Germany*
2. *ProNeuroLIGHT LLC, Phoenix, AZ, USA* (farzadsalehpour1988@gmail.com)

Abstract

Photobiomodulation therapy refers to the non-thermal use of visible to near-infrared light (400 to 1100 nm) to stimulate many biological processes. Nowadays, the applications of photobiomodulation therapy are extremely diverse in modern medicine, so that this light-driven modality has gained considerable credibility among the available therapeutic strategies. Photobiomodulation therapy has been shown to be an effective strategy to promote microcirculation, cellular proliferation and regeneration, and to ameliorate pain, edema, oxidative stress, and inflammation in many traumatic, acute, and chronic diseases. Given this, there are numerous well-known medical applications where photobiomodulation therapy has a significant role to play, such as wound healing, muscle and tendon repair, autoimmune diseases, arthropathies, and rheumatoid arthritis. The underlying molecular and cellular mechanisms of photobiomodulation therapy, rely on the absorption of photons by

cytochrome c oxidase (CCO, the terminal enzyme in the mitochondrial inner membrane respiratory chain) causing a redox change in the enzyme, leading to increased ATP synthesis and associated effects on cAMP and Ca^{2+}, release of nitric oxide, and a burst in reactive oxygen species (ROS). This, in turn promotes a cascade of secondary events such as ROS-mediated activation of key transcription factors like AP-1 and NF-kB and subsequent effects on transcription of genes involved in cellular processes such as proliferation and survival as well as cell migration.

Brain photobiomodulation therapy is a promising modality by which red to near-infrared light derived from lasers or LEDs is delivered to the scalp to stimulate neural cells and brain function. It is well-known that photons in this wavelength range are able to penetrate the scalp/skull and partially reach the brain tissue. Brain photobiomodulation therapy is safe, simple, pain-free, inexpensive, easy to administer, and well-tolerated by the patients in almost all clinical studies. There is plenty of evidence suggesting efficacy of photobiomodulation therapy in three major types of brain conditions; traumatic events (stroke, global ischemia, and traumatic brain injury), degenerative diseases (dementia and Parkinson's disease), and neuropsychiatric disorders (major depression, bipolar disorder, anxiety, and post-traumatic stress disorder). Furthermore, in recent years, photobiomodulation is gaining increasing interest as a brain-boosting strategy in healthy young and old individuals. Brain photobiomodulation therapy has been shown to increase cerebral blood flow and also augment cerebral metabolic capacity. Moreover, there is growing preclinical evidence to support that brain photobiomodulation therapy could ameliorate neuronal oxidative stress, neuroinflammation, and apoptosis and could stimulate neurogenesis and synaptogenesis. In addition to the aforementioned beneficial effects at the neuronal level, there is also evidence of changes occurring at the neurobehavioral level such as cognitive improvement (in various domains, e.g., learning and memory, executive function, concentration, and attention), antidepressant-like effects, and improved sleep quality. In terms of delivered light dosage, output powers used are normally in the range of a few hundred mW to several Watts spread over a large area, irradiance ranges from 0.005 to 6 W/cm^2, with fluence ranges from 0.03 to 20 J/cm^2 at the neuronal tissue level or a monolayer of neuronal cells. In humans the total

energy delivered to the head can be several thousand Joules. Of note, mitochondrial cytochrome c oxidase has peaks in the action spectrum at the specific wavelengths of 630–670 nm and 800–880 nm. Keeping this in mind, the specific wavelengths of 600-670 nm, 800-870 nm, 980 nm, and 1064-1080 nm appear to be superior for brain photobiomodulation therapy.

As discussed above, photobiomodulation therapy has the potential to revolutionize the treatment and prevention of brain diseases including traumatic events (stroke, traumatic brain injury, and global ischemia), degenerative diseases (dementia, Alzheimer's and Parkinson's), and psychiatric disorders (depression, anxiety, post-traumatic stress disorder). The aim of this Special Issue in the Journal of Alzheimer Diseases is to present the current state of the art in the application of photobiomodulation therapy for the aforementioned brain conditions. The Guest Editors encourage the submission of original research and review papers on topics related to the photobiomodulation, including but not limited to:

- Biomarkers, imaging and other indices of the effects of NIR and red light
- Highly innovative reports on clinical cases
- Preventative applications
- Impacts of PBM on healthy aged/young brain
- Procognitive benefits of PBM in neurodegenerative diseases (MCI, AD, PD)
- Brain PBM for traumatic injuries (stroke, TBI)
- Therapeutics role of PBM in neuropsychiatric disorders
- Neuroimaging methods for assessing brain PBM
- Impacts of systemic PBM on the brain
- Tolerability, short-term and long-term safety
- Models to simulate the penetration of red and NIR light
- Optical simulation researches for brain PBM
- Conceptual and review papers on PBM and neurodegenerative diseases