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An 808-nm Diode Laser with a Flat-Top Handpiece Positively Photobiomodulates Mitochondria Activities

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Abstract

Objective: Photobiomodulation is proposed as a non-linear process. Only the action of light at a low intensity and fluence is assumed to have stimulation on cells; whereas a higher light intensity and fluence generates negative effects, exhausting the cell's energy reserve as a consequence of a too strong stimulation. In our work, we detected the photobiomodulatory effect of an 808-nm higher-fluence diode laser [64 J/cm^2–1 W, continuous wave (CW)] irradiated by a flat-top handpiece on mitochondria activities, such as oxygen consumption, activity of mitochondria complexes I, II, III, and IV, and cytochrome c as well as ATP synthesis. ***Materials and methods:*** The experiments are performed by standard procedure on mitochondria purified from bovine liver. ***Results:*** Our higher-fluence diode laser positively photobiomodulates the mitochondria oxygen consumption, the activity of the complexes III and IV, and the ATP production, with a P/O = 2.6. The other activities are not influenced. ***Conclusions:*** Our data show for the first time that even the higher fluences (64 J/cm^2–1 W), similar to the low fluences, can photobiostimulate the mitochondria respiratory chain without uncoupling them and can induce an increment in the ATP production. These results suggest that the negative effects of higher fluences observed to date are not unequivocally due to higher fluence *per se* but might be a consequence of the irradiation carried by handpieces with a Gaussian profile.

Keywords: diode laser, paramecium, photobiomodulation

Introduction

In the past decade, thanks to repeated and continuing clinical and research studies by reputed investigators, the merits of photobiomodulation (PBM) as a genuine medical therapy have been established.[1,2] In animal studies, PBM improved the outcome in retinal damage due to methanol or rotenone toxicity,[3,4] traumatic brain injury,[5] or spinal cord injury and induced analgesia in dorsal root ganglion neurons.[6] PBM has improved the survival and function of rat neuronal cells exposed to MPP+.[7] In the human brain, transcranial laser therapy (delivery of near-infrared laser light through the scalp and skull) has been used to successfully treat complex neurological conditions such as ischemic stroke[8] as well as in model human dopaminergic neuronal cells, PBM can increase axonal transport, thus suggesting PBM as a novel treatment to improve neuronal function in patients with Parkinson disease.[9] Enthusiastic medical specialists successfully utilized, for example, PBM in treating healing-resistant wounds and ulcers and in pain management.[1,2,10]

Usually, PBM uses low-powered laser light in the range of mW, at wavelengths from 600 up to 1000 nm, and at a low fluence around 1–5 J/cm^2 or less,[2,11,12] to stimulate a biological response. PBM works on the principle that when light hits certain molecules called chromophores, the photon energy causes electrons to be excited and to jump from low-energy orbits to higher-energy orbits. PBM is not an ablative or thermal mechanism, but it is rather a photochemical effect comparable to photosynthesis in plants whereby the light is absorbed and exerts a chemical change.[2]

Scrupulous researchers support the idea that, in animal cells, PBM stimulates components in the mitochondria,[13] increasing redox capacity, protein electrochemical potential,[14] oxygen consumption, phosphate potential, and energy charge,[15] stimulating the proton pumping activity,[16] or activating cytochrome c oxidase (complex IV).[17,18] Moreover, increased ATP production in both irradiated normal and dysfunctional cells has been proved.[14,19]

Recently, a variety of diseases have definitively been demonstrated to depend on mitochondria functions: This

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