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Impact of photobiomodulation on human skin melanocytes

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In this study, we assessed the impact of PBM using blue light on melanocytes. Blue light wavelength belongs to the shorter wavelength range in the electromagnetic spectrum and is the nearest one to UV radiation. The effects of UV radiation on the skin has been studied in great depth, but in the last decade, the focus has started to shift towards understanding the role of the shorter wavelength range on the human body and even other wavelengths belonging to VIS light spectrum. VIS light represents almost half of the solar light coming on the earth. It has been shown that low levels of VIS and NIR light can have beneficial effects, and therefore, it is being used to treat various conditions and diseases in the medical field. In the past, the use of this therapy has progressed but still, there is a lot that needs to be studied to unravel the cellular and molecular mechanisms involved to assess the effects as a whole. From the literature search, it was noted that in the skin, the consequences of blue light on keratinocytes and fibroblasts have been explored more as compared to melanocytes. Wide ranges of inhibitory and stimulatory effects on biological processes have been reported. At the same time, these outcomes might not be the same for every cell type as different irradiation parameters can bring out different impact and every cell has own mechanisms to deal with varied type and amount of stimuli. Hence, this study aimed to evaluate the effects of blue light wavelength (453 nm) on melanocytes.

In vitro experiments were carried out using NHEM cells with the application of different doses of blue light to assess the dose-effect, which resulted in a biphasic dose-response curve. Next, blue light was tested in NHEM cells for its response on melanin production following 90 min of irradiation with a dose of 64.8 J/cm2, the cells were harvested 48 hours after irradiation and an increased melanin concentration was noted. The same results occurred in all the three pigmented skin phototype of NHEM cells. Further, this dose was selected, and other parameters were evaluated, for example, possible induction of apoptosis, influence on ATP level and consequences on the redox status of the cells. No significant apoptosis was induced, and an increase in the ATP level was identified as well as the ROS production increased with a sudden burst immediately after irradiation and later with time, it shifted to basal levels.

Finally, gene expression analysis was performed, which revealed an array of genes and pathways explaining the other in vitro data. Pathways like glycolysis and oxidative phosphorylation were up-regulated, reflecting the results of ATP measurements. Moreover, the overall pattern for the pathways related to cell growth and death was down-regulated, and apoptosis pathway itself was not significantly regulated, which is reflected by the FACS analysis where no significant apoptosis was observed.

Additionally the caspase cascade was slightly down-regulated. The utmost important gene CYP1B1 was strongly significantly up-regulated. This gene belongs to ‘AHR gene battery’, involved in the production of phase I and phase II enzymes of xenobiotic metabolism. They are well known for their role in preventing damage due to oxidative stress. This outcome is in line with the observation obtained from ROS measurements. Thus, an increase in ROS levels activates the ‘AHR gene battery’ triggering the anti-inflammatory response as also downstream pathways like the steroid hormone synthesis. Furthermore, an increase in the melanogenesis pathway and tyrosine metabolism was noted, which is in agreement with the increase in melanin content assay. Moreover, gene expression profiles revealed an up-regulation of tyrosinase enzyme, AHR pathway as well as tryptophan metabolism. All these findings suggest the possible role of AHR as a potential regulator of xenobiotic effects in human melanocytes on exposure to blue light dose (64.8 J/cm2) via photo-oxidation of tryptophan and possibly mediating pigmentation by modulating the melanogenic enzymes.