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Medizinische Fakultät Mannheim
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Effects of photobiomodulation with blue light during and after adipocyte differentiation

Autor: Stefania Palumbo
Institut / Klinik: Zentrum für Medizinische Forschung
Doktorvater: Prof. Dr. N. Gretz

Photobiomodulation therapy is defined as a form of light therapy that utilizes non-ionizing light sources in the visible (400 – 700 nm) and near-infrared (700 – 1100 nm) electromagnetic spectrum. Despite the numerous studies reported, a high variability in irradiation settings and parameters has led to inconsistent outcomes. The greatest lack of knowledge is related to the effects of low wavelengths of blue/green light used for a limited range of medical applications because of its inhibitory and cytotoxic effects. However blue light effects have rarely been reported in adipogenesis or lipogenesis studies on adipose tissue. Hence, the biomodulatory potential of blue light at 453 nm wavelength was tested on 3T3-L1 cells during and after the differentiation process with respect to adipogenesis/lipogenesis, metabolic processes, cell proliferation and transcriptome changes.
PBM using blue light revealed dose dependent effects during preadipocytes 3T3-L1 differentiation. A single irradiation performed at the first day of induction (Day0) led to a slight effect with a reduced lipid accumulation and changes in the expression of adipogenic markers that appeared down-regulated already after one exposure. Also metabolism, reflecting mitochondria activity, was negatively affected by blue light since oxidative phosphorylation and ATP contents were decreased with effects that were long lasting until 24h. Tests with repeated irradiations for the differentiation period showed an enhanced inhibition in lipid accumulation and metabolism. This chronic exposure was supposed to rise the ROS amount leading to DNA damage that has had as consequence a cell cycle delay, reduced proliferation rate and activation of cell death processes. Gene expression analysis supported this hypothesis by an up-regulation of the p53 pathway and for all the other genes involved in repair systems such as ATM, Chk1 and Claspin. On the other hand mature adipocytes treated with 21.6 j/cm^2 or 43.2 j/cm^2 of blue light have proven to be less responsive. No significant differences were reported in metabolism, growth and lipid storage. Similarly apoptosis has not been deregulated and no changes in ROS levels or cellular damages have been observed.
In conclusion: adipocytes seem to be more sensitive to blue light exposure during early rather than late differentiation phases. Furthermore, the high doses of irradiation chosen led to inhibitory effects on metabolism and differentiation promoting cell death in preadipocytes subjected to chronic exposure while no effects were recorded in irradiated mature adipocytes. Though inhibitory effects in adipogenesis or proliferation are requested relating to the treatment of hyperplastic obesity or dysregulation of lipid accumulation during childhood, the formation of aberrant cells has to be avoided. Therefore additional studies are needed to promote or reject blue light application in these fields. However, there is currently no evidence of a possible application in obesity.