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Red, near-infrared, and blue light do not induce DNA damage in human dermal fibroblasts

Abstract: Photobiomodulation (PBM), the use of non-ionizing light to modulate biological activity, is increasingly utilized in dermatology for wound healing, skin rejuvenation, and anti-inflammatory effects. Despite its widespread clinical and consumer use, concerns remain regarding the potential of visible and near-infrared light to induce DNA damage. In this series of in vitro studies, we systematically investigated the genotoxic potential of red (633 ± 6 nm), near-infrared (830 ± 5 nm), and fluorescent blue (417 ± 5 nm) light across a range of clinically relevant and supratherapeutic fluences.

Using well-established enzyme-linked immunosorbent assay (ELISA) and DNA immunoblotting, we quantified the formation of cyclobutane pyrimidine dimers (CPDs) and (6-4)- photoproducts (6-4PPs)—two hallmark markers of ultraviolet-induced DNA damage—in human dermal fibroblasts (HDFs) immediately, 3 hours, and 24 hours post-irradiation. Across all wavelengths and fluences tested, no significant induction of CPDs or 6-4PPs was observed relative to matched controls. Ultraviolet-B (UVB) exposure was included as a positive control and consistently induced robust DNA damage.

These findings collectively demonstrate that red, near-infrared, and blue light do not induce measurable DNA damage in HDFs at fluences used in dermatologic practice and home devices. This work provides important preclinical safety data and supports the continued investigation and responsible use of PBM technologies in clinical dermatology. Future studies will be necessary to assess the impact of these wavelengths on other cell types, particularly pigmented or keratinized cells, and to evaluate additional biomarkers of phototoxicity and long-term genomic stability.

Keywords: photobiomodulation, cyclobutane pyrimidine dimers, 6-4 photoproducts, DNA damage, human dermal fibroblasts

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