LIGHT FLUENCE RATE ABSORBED BY SKIN TISSUE AND BLOOD AS APPLIED TO LOW-LEVEL PHOTOTHERAPEUTIC TECHNOLOGIES

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Light absorption is known to be one of possible mechanisms of light action on biological tissues. In any case, it always accompanies phototherapeutic irradiation of a living organism in practice. The objective of this paper is to quantitatively study the depth distributions of fluence rate absorbed by biotissue at several wavelengths of the visible to near-IR range, which can be used for phototherapeutic purposes. The investigations are made by the optical simulation method. The bases of them are the optical biotissue model [1] and the analytical procedures [2] for computing light transfer through biotissue. The model gives all optical (absorption and scattering coefficients and phase function) and geometrical (epidermis and dermis-layers thicknesses) parameters needed to solve the radiative transfer equation at various irradiation wavelengths. The model directly relates the optical parameters with tissue biophysical characteristics, such as melanin and blood volume fractions, f_m and f_b, and blood oxygen saturation S.

Figure 1 shows absorbed fluence rate P as a function of depth z beneath the skin surface. One can see that at λ = 575 nm, where blood absorbs light strongly, P values are mainly determined by blood only. At λ = 630 and 800 nm, P values are due to the combined absorption by blood and tissue collagen fibers. One can isolate three regions in the shown dependences. The first and third ones are at, respectively, small and large depths, where absorbed power P slowly or rapidly decreases with z to be approximately described by an exponential function with low and big exponents, correspondingly. The second region is intermediate. Here the $P(z)$ dependence cannot be represented by an exponential function.

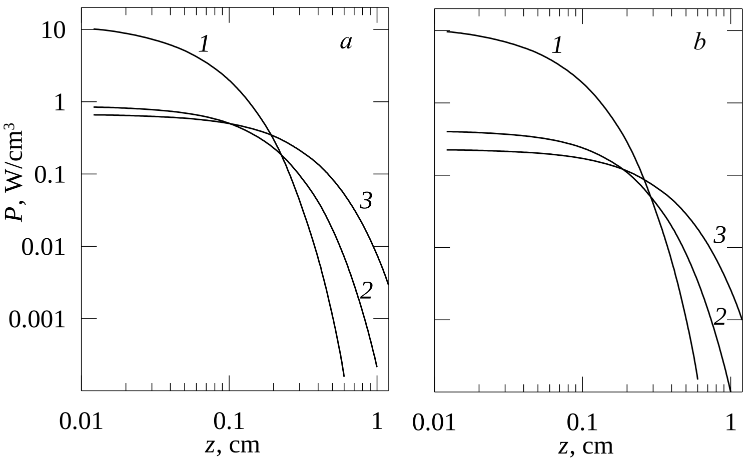

Fig. 1. Depth dependence of fluence rate (W/cm^3) absorbed by unit volume of skin tissue (a) and blood (b) under irradiation of skin surface with 1 W/cm^2 at wavelength λ = 575 (curves 1), 630 (2) or 800 nm (3), f_b = 0.04, f_m = 0.08, S = 0.75, epidermis thickness 100 μm

The data similar to those illustrated in Fig. 1 were obtained for wide variations of the structural and biophysical tissue parameters. They enable one to make useful quantitative evaluations as to the efficiencies of the irradiation at specific wavelengths for various phototherapeutic procedures.

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