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Rationale of Eye Pupillary Diameter for the UV Protection for Sunglasses

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Abstract : Ultraviolet (UV) protection is critical for sunglasses, and mydriasis, as well as miosis, are relevant parameters to consider. The literature reports that for sunglasses, ultraviolet protection is critical because sunglasses can cause the opposite effect if the lenses do not provide adequate UV protection due to the greater dilation of the pupil when wearing sunglasses. However, the scientific literature does not properly quantify to support this rationale. The reasoning may be misleading by ignoring not only the inherent absorption of UV by the sunglass lens materials but also by ignoring the absorption of the anterior structures of the eye, i.e., the cornea and aqueous humor. Therefore, we estimate the pupil diameter and calculate the solar ultraviolet influx through the pupil of the human eye for two situations of an individual wearing and not wearing sunglasses. We quantify the dilation of the pupil as a function of the luminance of the surrounding. Therefore, we calculate the influx of solar UV through the pupil of the eye for two situations for an individual wearing sunglass and for the eyes free of shade. A typical boundary condition for the calculation is an individual in an upright position wearing sunglasses, staring at the horizon as if the sun is in the zenith. The calculation was done for the latitude of the geographic center of the state of São Paulo (-22º04'11.8'' S) from sunrise to sunset. A model from the literature is used for determining the sky luminance. The initial approach is to obtain pupil diameter as a function of luminance. Therefore, as a preliminary result, we calculate the pupil diameter as a function of the time of day, as the sun moves, for a particular day of the year. The working range for luminance is daylight (10^{-4} – 10^{5} cd/m^2). We are able to show how the pupil adjusts to brightness change (~2 - ~7.8 mm). At noon, with the sun higher, the direct incidence of light on the pupil is lower if compared to mid-morning or mid-afternoon, when the sun strikes more directly into the eye. Thus, the pupil is larger at midday. As expected, the two situations have opposite behaviors since higher luminance implies a smaller pupil. With these results, we can progress in the short term to obtain the transmittance spectra of sunglasses samples and quantify how light attenuation provided by the spectacles affects pupil diameter.

Keywords : sunglasses, UV protection, pupil diameter, solar irradiance, luminance
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