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Defining minimal sunburn thresholds in different skin types using near-infrared (785 nm) laser speckle contrast imaging of blood flux

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Accurate assessment of individual sensitivity to ultraviolet radiation (UVR) is important for understanding the risks and benefits of sun exposure, but the standard way of determining this, i.e. visual assessment of the minimum UVR dose inducing erythema (MED), may be impeded by skin colour. Established objective detection methods are also hampered by absorption and scattering of UVR and visible light by melanin. Our aim was to explore the use of infrared (785 nm) laser speckle imaging of perfusion to determine a threshold sunburn response in people of skin types I to VI.
31 healthy volunteers (skin type I: n=2, II: n=5, III: n=4, IV: n=2, V: n=8, VI: n=10; mean age 33 years, range 19-58; 13 males) were recruited. Phototesting was performed by applying geometric series of 10 erythemally-weighted UVR doses (7-80 to 53-600 mJ/cm^2 dependent on skin type) to photoprotected skin using a broadband UVB lamp (Philips TL12/Waldman UV6). Phototested and control skin sites were assessed after 24h, visually, with a handheld spectrophotometer (CM-600D; Konica Minolta) and with the 785 nm laser speckle contrast imager (FLPI-2, Moor Instruments). Videos of red cell flux over 20-60 seconds were stacked into a single image, from which the average flux for Phototested and adjacent control sites was determined. Using flux data in light skin (skin type I-III), the minimum flux dose (MFD) for a threshold sunburn was determined to correspond to a 30% (2SD) increase over mean flux in adjacent control skin. The determined MFD were within 1 UVR dose step of the visual MED for 91% of skin type I-III but only 56% of skin type V and VI individuals (always MED>MFD), indicating the superior sensitivity of the imager versus visual assessment in pigmented skin. This sensitivity was also demonstrated by the observation that while the participant with the darkest skin in our study (L*=31.8) showed no detectable erythema, positive responses in 5 of 10 phototested sites were visualised with the imager. We additionally found the imaging method to be more consistent across all skin types when compared to the a*, haemoglobin index, oxyhaemoglobin values, and reflectance spectra using the handheld spectrophotometer.
In conclusion, we have defined a method for the determination of minimal sunburn responses across all skin types. This is envisaged to be of considerable value in future research in people with a range of skin types.