Innovative digital solution supporting sun protection and vitamin D synthesis by using satellite-based monitoring of solar radiation

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Introduction & Objectives

Public health campaigns to prevent skin cancer advise minimizing sunburn and applying sunscreens when in the sun. At the same time solar UV radiation (UVR) is also the main source of vitamin D[(1)]. There is increasing evidence that there are benefits from solar UVR that are independent of vitamin D[(2)]. It is therefore important to balance solar UVR exposure based on risks and benefits. The Sun4Health app provides real-time UV Index (UVI) as well as accumulated erythema and vitamin D effective doses.

Thus, the app provides personalised recommendations on sunscreen application and time in the sun to optimise the risk/benefit balance. Such advice is based on the user's estimated minimal erythema dose (MED) and the spectral transmission of given sunscreens. HappySun satellite technology enables the app to monitor solar radiation in real-time[(3)] and, when coupled to a wearable device, it can also provide recommendations for avoiding sunburn in each body part by monitoring sun exposure in 3D (international patent WO2017153832A1).

A clinical field study was performed to evaluate the effects of using this digital app on sun exposure behaviour and skin health in real-life conditions under intense insolation. This was done with or without an integrated wearable device. The study received ethical approval and was done in the context of a project co-funded by the European Space Agency. The Sun4Health apps are commercialised as "Sun3P" in the personal care market.

Materials & Methods

The study took place over 3 days on a Brazilian beach (24º S) in December. The weather was sunny or partly cloudy with a day-time temperature of 25-30 °C and peak UVI of 12.1 (classed as extreme) and an average noon UVI of 8 (classified as very high) as shown in figure 1. 59 healthy volunteers (37F, 22M, 18-50 years, Fitzpatrick skin types I-III) were divided into 3 groups, each given a different app. All the volunteers were provided with sunscreens (SPF 30 & 50) to use at their discretion, according to their app recommendations. The app groups were (1) Basic (control app)- that provided UVI only; (2) Intermediate (Sun4Health app) - that gave personalised recommendations to avoid sunburn without compromising vitamin D synthesis, by warning alerts based on personal data and (3) Complete (Sun4Health-3D app) - same as (2) but blue-toothed to a wearable device for sun exposure body monitoring in 3D. Illustrations of the app are shown in figure 2.

Erythema (redness) was measured on the mornings and late afternoons of each study day by reflectance spectroscopy (Mexameter MX18WL) on six body sites: underarm right (control), right and left shoulders (on top), back (in the middle, 20 cm below the neck), right and left abdomen (13 cm from navel towards hips). Vitamin D serum level ($25(OH)D_3$) was measured 1 day before the study and 3 days afterwards.

Results

The change (Δ) in cumulative erythema scores between the first and the last measurements for each body site was compared in each app group. There were no substantial changes in the control site (underarm). In all cases, the erythema scores were higher in group 1 (control) than groups 2 and 3. The cumulative body site results are shown in figure 3. A group comparison of mean (± SE) Δerythema (Mexameter Units) of all exposed body sites resulted in: 51.31 ± 2.49 for control group 1, 40.27 ± 1.9 for group 2, 37.12 ± 1.53 for group 3 (ANOVA $p < 0.05$ with *post hoc* comparisons showing group 1>2&3 $p < 0.05$ and group 2=3 $p > 0.05$). Thus, the mean Δ erythema in group 3 increased 28% less than the control group. Moreover, a group comparison on the average Δ vitamin D serum level showed the following results (nmol/L): 1.32 ± 4.19 for control group (1), 6.38 ± 2.37 for group 2, 18.68 ± 4.07 for group 3 (ANOVA $p > 0.05$) as shown in figure 4.

Discussion and Conclusions

The World Health Organization (WHO) recommends protection when the UVI reaches 3 but some researchers have suggested a lower threshold[(4,5)]. This study shows that the Sun4Health apps are safe to use and can reduce sunburn from outdoor activities at any time of day under very high UVI, while allowing vitamin D synthesis. Indeed, the evidence shows a healthier skin in terms of less erythema for the volunteers using the Sun4Health apps and an improvement of their vitamin D status, obtaining the best results with the 3D version. This prevention of erythemal sun exposure dose could help to limit skin photoageing because the action spectrum for erythema predicts the induction of mRNA for matrix metalloproteinase-1 (MMP-1) in human skin *in vivo*.[(6)]

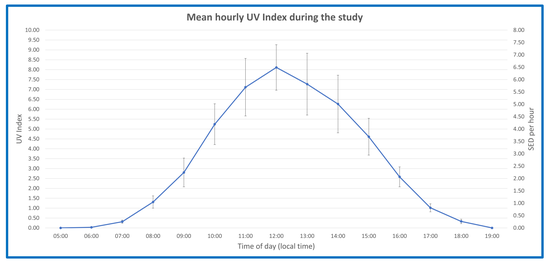

Figure 1: UV index on left and standard erythema dose (SED) per hour on right

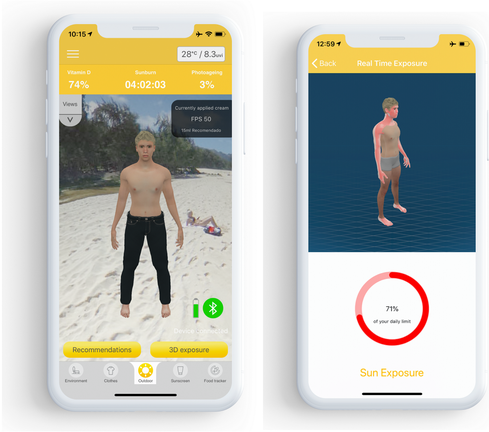

Figure 2: Examples of app with the wearable 3D device of the right

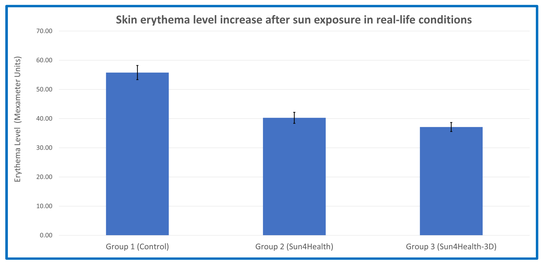

Figure 3: Significantly more erythema is seen in control group

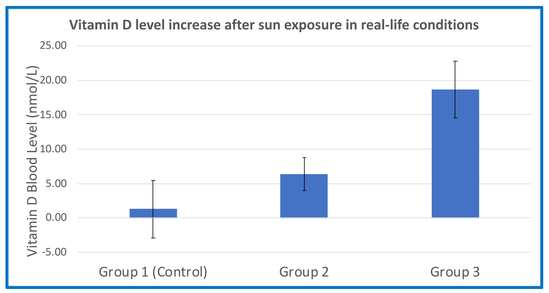

Figure 4: Increase in serum $25(OH)D_3$ in the different groups

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