The use of real-time ultraviolet radiation data to modify the UV exposure of primary schoolchildren

Kimlin, M.G.*+ and Parisi, A.V*

*Centre for Astronomy and Atmospheric Research, University of Southern Queensland, Toowoomba, Australia.

+National Ultraviolet Monitoring Centre (NUVMC), Department of Physics and Astronomy, University of Georgia. Athens, GA. USA. 30606

Abstract. Schoolchildren in their everyday school life are exposed to solar ultraviolet (UV) radiation. This may be through time spent outdoors whilst having meal breaks, physical education classes or other outdoor class orientated activities. This research, conducted at the University of Southern Queensland, investigates the UV exposure of schoolchildren and the effect real-time UV irradiances data and an associated software package, *UVGUIDE*, have on their personal UV exposure. The software utilises scientifically collected data, such as facial distribution of UV, as well as accessing real-time on-line UV irradiances data to estimate the UV distribution to the head region. The students can also enter other parameters such as hat usage and hat type to show the effect on their facial UV distribution of using such a UV protective device.

Introduction

Research indicates that human activity directly influences the level of human UV exposure (Diffey, 1992). Therefore, programs that are aimed at modifying human behaviour whilst outdoors, exposed to solar UV, should have maximum impact on reducing the subsequent exposure of humans. Although intervention programs (for example, Sunsmart or Slip, Slop, Slap) have been employed for the reduction of personal UV exposure for schoolchildren, no package based on the use of real-time solar UV radiation data is available to the authors' knowledge to predict the personal UV exposure and provide the result of a protective strategy such as hats. The use of protective methods for reducing harmful solar radiation must be carefully planned (Wong *et al.* 1997). These findings point to the need for a new technique to be employed in the form of an information package providing personalised advice on reduction of solar UV exposure.

Methods

Ambient UV Irradiances

The ambient erythemal UV irradiances in Toowoomba (27.5°S, 151.9°E, altitude 693m), Queensland, Australia were monitored during this project using a permanently mounted outdoor erythemal UV meter (model 501, Solar Light Co., Philadelphia, PA). The meter is located at the campus of the University of Southern Queensland (USQ) on the roof of a 4-storey building with an unobstructed field of view. The meter continually records the average erythemal exposure over each 15-minute interval. The calibrated output of the ambient UV detector was interfaced to the World Wide Web (WWW) to allow the interrogation of the erythemal UV data from any remote site with access to the WWW. This provides the real-time UV data that is updated every 15 minutes. The data is plotted as a function of time, with the current and maximum UV index displayed on the screen. A sample screen of the UV data is shown in Figure 1.

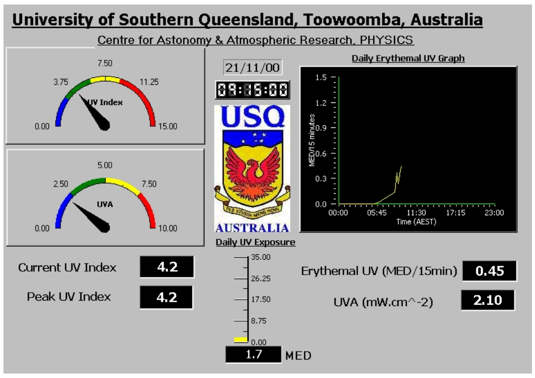

Figure 1. Sample Screen shot of the USQ "live" UV web page.

Personal UV Exposure Measurements

Polysulphone film has been used by previous investigators to measure personal ultraviolet radiation exposure (Kimlin *et al.* 1998a, Gies *et al.* 1998). The film for the present project was cast using equipment at the USQ where strict quality control (QC) procedures could be implemented. The polysulphone sheet was cut and then mounted into a 25 mm x 25 mm rigid plastic holder with a 1 cm^2 central aperture. The pre and post optical absorbency of the polysulphone dosimeters at 330 nm was measured in a spectrophotometer (Shimadzu Co., Kyoto, Japan). The polysulphone film was calibrated against the calibrated outdoor erythemal UV meter in full sun conditions at a similar date to the experiments conducted in this research.

Exposure Ratios

The UV exposure over a human face is a difficult task to evaluate due to the human face being a complex shape and subtle changes in facial dimensions can occur between individuals. Therefore a simplified model of the face, as employed in previous research (Kimlin *et al.* 1998b) has been used. In order to measure the exposure ratio, ER, (defined as the ratio of the UV exposure to the anatomical site to the ambient UV exposure on a horizontal plane), polysulphone dosimeters were placed at 15 selected anatomical locations over a manikin headform (vertex of head, nose, left and right cheek, chin, left and right ear, upper and lower front neck, left and right neck, left and right shoulder, rear upper and lower neck). The upright manikin headforms were placed on a rotating platform in an open unshaded field to model the random movements of a human head and shoulder region in an upright position using an established technique employed by other researchers (for example, Airey *et al*. 1997).

Software Development

The software developed for this study, UVGUIDE, uses the following equation as the basis of the calculations:

$$UV(S) = \left(\frac{AE \times ER(S)}{PF(S)} \right) \qquad (1)$$

where UV(S) is the UV exposure to a particular anatomical site, ER(S) is the exposure ratio for the same anatomical site, AE is the current ambient UV, and PF(S) is the protection factor provided by protective devices (such as hats) to the anatomical site. The PF(S) for three different types of hats employed in Toowoomba schools was measured for each of the 15 facial sites using polysulphone dosimeters. The facial region was divided into 4 zones, namely front, rear, left and right and these zones were broken up into a 1 cm^2 grid as described elsewhere (Kimlin *et al*. 1998b). Following this, the UV exposures calculated for each of the 15 facial sites were interpolated between sites to provide the facial UV distribution.

Field Experiment Design

The research consisted of 2 groups, firstly, a class of 25 students, who were given an education program consisting of the computer software, *UVGUIDE*. From this point on in this paper, this group will be referred to as the experimental group. The second group of 23 students, did not receive any extra UV information, from this point on in this paper, this group will be referred to as the control group. Both classes selected in this study were randomly chosen from 5 classes in the year level by the principal of the school. To assure that the polysulphone dosimeters were worn by the students they were attached on the day of the study by the students' teachers before the school day began. This was to measure the UV exposure during school hours only. The dosimeters were placed on the left shoulder via a small clip at 09:00 EST and removed at 15:00 EST. These times were selected as they represent the start and finish times of the school day at this school. Through visual observation by the author and the classroom teacher, all of the badges were worn at all times whilst the children were outdoors in the playground. Prior and post exposure, the polysulphone dosimeters were stored in a lightproof envelope to stop unwanted UV exposure of the dosimeters. Both groups (experimental and control), undertook meal breaks and sporting activities at the same time, however the experimental group was given extra UV information through access to the UV software, *UVGUIDE*. The statistical software SPSS version 6 was used for the analysis of the measured UV exposures. The experimental group was given the opportunity to access the on-line UV data for Toowoomba before their meal breaks and outdoor activities in order to obtain the current UV index. The accessing of the on-line UV data was undertaken under the direct supervision of the students' teacher by using the classroom networked computer in groups of 5 students. When the students had obtained the current UV index, they input the value into the computer software, and the software accessed the database of ER(S) and PF(S) values and employed equation (1) to evaluate the UV exposure distribution to the face, and displayed graphically the UV "hot spots" on the face. The students then had the option of inputting the type of hat they were wearing as follows: 1) no hat; 2) broad brimmed hat; or 3) cap. The software provided them with a graphical view of the changes in UV exposure distribution to the face if a particular type of hat was worn. This procedure took, on average, 15 minutes for the whole class to complete prior to each meal break time. However, the time taken using the software and internet did not cross over into any meal break times. Additionally, the classroom teacher was strictly instructed not to interpret any of the information the software produced for the students.

Results

The figure presented (Figure 2) shows a simplistic diagram of the human face, along with shaded areas indicating where the UV is highest over the face. An output screen also occurs for the rear and side views of the head. An example of the effect of a broad brimmed hat on the UV exposure distribution over the human face is shown in the figure. The output of the computer software is shown in an arbitrary scale of sunburn units. The higher the sunburn units, the greater the UV exposure to that site.

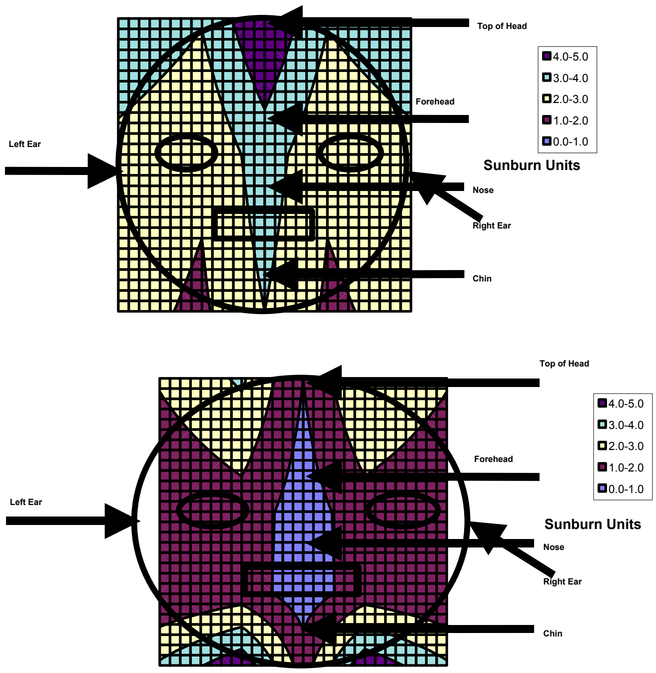

Figure 2. *UVGUIDE* software facial prediction output (a) no hat (top), (b) broad brimmed hat (bottom).

Statistically significant differences occurred between the UV exposures to the control and experimental groups on each measurement day (as shown in Figure 3) using a Student's t-test ($p<0.05$) in summer (21, 28 February, 1 March), autumn (10–12 May) and spring (4-6 September). No statistical differences were found in the winter (2-4 August). Differences were noted in the UV exposures to boys and girls in both the experimental and control groups, with the boys having the higher UV exposure, in the range of 2-5% in all seasons, however no significant statistical associations were found. Although the summer, autumn and spring UV exposures of the experimental group were lower than the UV exposures of the control group, both groups had a high level of UV exposure on a daily basis. For example, in summer, both groups recorded a mean value of over an MED (minimum erythemal dose) per school day to the left shoulder. This exposure relates to the exposure to sites not covered by clothing, for example, the face. This is comparable to that found by other studies of UV exposure of schoolchildren in this region (Kimlin *et al.* 1998a).

Conclusion

The daily erythemal exposure to primary schoolchildren at a location in south east Queensland was measured over a three day period in summer, autumn, winter and spring. It was found that students exposed to extra information in the form of computer software incorporating, real-time UV levels and the effect UV protection devices had, when averaged over all seasons, the UV exposure to the left shoulder reduced by 35% when compared to the exposure to the left shoulder of students without any of this extra educational UV information. There was still variability of the UV exposure within each of the groups; however, statistical associations were still found for the two groups. The 35% reduction in exposure is important for skin cancer prevention as the Australian National Health and Medical Research Council (NHMRC, 1989) recommended that the reduction of UV exposure during childhood is an important factor for reducing the risk of developing skin cancer later in life. The plausible reason for the lower UV exposures of the experimental group is that, the education program may have altered the students' behaviour whilst outdoors. Additionally, the teacher may have stressed the importance of solar UV minimisation strategies. They may have sought more shade, spent time indoors during meal break times or altered their playing habits. In summer, on average, both groups received an exposure of over an MED to the left shoulder in one day. This exceeds the occupational UV exposure limit set by the National Medical Health Research Council of Australia (NHMRC, 1989). Schools should be aware that their students are potentially being exposed to high levels of solar UV radiation, and more effort may need to be placed into enhancing primary cancer prevention programs in schools. This highlights the necessity of an educational program of the type described in this research that incorporates collected scientific data to produce a change in the UV exposure of schoolchildren. The method proposed (using live UV data) has been shown in this research to reduce the UV exposure of this particular group of schoolchildren.

References

Airey, D.K., Wong, J.C.F., Fleming, R.A., Meldrum, L.R. 1997. An estimate of the total UV-B exposure for outdoor workers during a south-east Queensland summer. *Health Phys.* 72, 544-549.

Diffey, B.L. 1992. Stratospheric ozone depletion and the risk of non-melanoma skin cancer in a British population. *Phys. Med. Biol.* 37, 2267-2279.

Gies, P., Roy, C., Toomey, S., MacLennan, R., Watson, M. 1998. Solar UVR exposures of primary school children at three locations in Queensland. *Photochem. Photobiol.* 68, 78-83.

Kimlin, M.G., Parisi, A.V., Wong, J.C.F. 1998a. Quantification of the personal solar UV exposure of outdoor workers, indoor workers and adolescents at two locations in southeast Queensland. *Photodermatol. Photoimmunol. Photomed.* 14(1), 7-11.

Kimlin, M.G., Parisi, A.V., Wong, J.C.F. 1998b. The facial distribution of erythemal ultraviolet exposure in south east Queensland. *Phys. Med. Biol.* 43, 231-240.

NHMRC (National Health and Medical Research Council). 1989. Occupational standard for exposure to ultraviolet radiation. Radiation Health Series No.29. NHMRC, Canberra

.Wong, J. C., Cowling, I., Parisi, A. V. 1997. Reducing human exposure to solar ultraviolet radiation. *Proc. First Internet Conf. Photochem. Photobiol. Nov 17 -Dec 19 1997*, Internet Photochemistry and Photobiology.

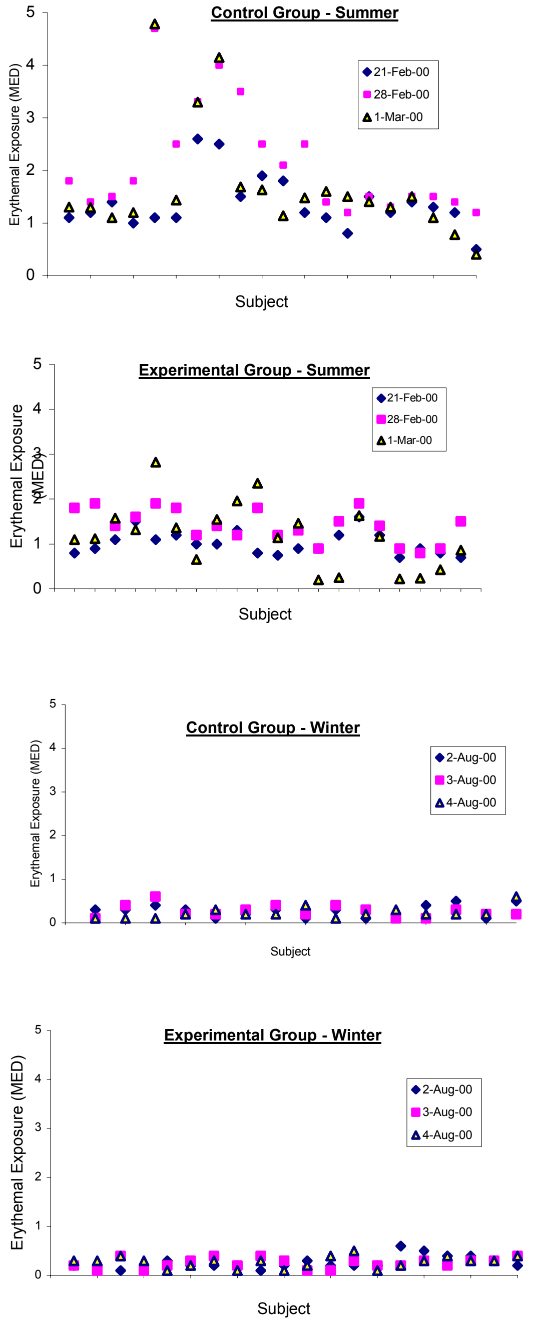

Figure 3. Personal UV Exposure of the schoolchildren during the winter and summer experimental time periods.