PERSONAL DOSIMETRY OF SOLAR UVB USING POLYSULPHONE FILM

HP Gies, CR Roy, E Herlihy* and J Rivers#

Australian Radiation Laboratory
Lower Plenty Road, Yallambie, Victoria, 3085

* Menzies Centre for Population Health Research
43 Collins St, Hobart, 7000

Sydney Melanoma Unit, Royal Prince Alfred Hospital
Camperdown, NSW, 2050

ABSTRACT

Polysulphone film badges have been used to quantify the solar UVR exposure received by different subjects and these measured results are compared to those calculated from personal diaries and measured ambient solar UVB. In general, when UVR exposure activities took place under close supervision, good correlations were obtained between the polysulphone badges and the ambient/diaries approach. UVR exposures for indoor workers and a number of outdoor activities are presented.

INTRODUCTION

Recent evidence confirming the presence of global ozone depletion and of Antarctic ozone 'holes' has increased the concern over possible adverse human health effects as a result of increased levels of solar UVR. The scarcity of accurate long-term ambient UVR measurements and the lack of knowledge of personal solar UVR exposure has also become apparent.

Previous measurements of the anatomical distribution of solar UVR using polysulphone (PS) film as a dosimeter have been made with both mannikins and headforms as well as volunteers in a variety of outdoor activities[1,2]. Personal histories of UVR exposures have been determined from retrospective questionaires and the results used in epidemiological studies into factors affecting skin cancer incidence. Careful design of the questionaire or diary of UVR exposure is crucial, as is the choice of sites at which the badges are worn.

EXPERIMENTAL MEASUREMENTS

The ARL radiometer/datalogger network[3], which collects data continuously during daylight hours, provided ambient UVB levels for both the Sydney and Hobart studies. The dose response of PS film to solar UVR, which relates the change of absorbance (dA) to the erythemally effective dose (EED) in $J.m^{-2}$, can be determined from simultaneous exposure of the PS film and measurement of the incident solar UVR spectral power distributions[4,5]. As the change in absorbance dA increases (ie for larger UVR exposures) the estimation of EED becomes less accurate. Any study to monitor UVR should try to limit the UVR dose to PS badges to the linear or near linear region of the dose response curve (dA less than 0.5).

Two studies using polysulphone dosimeters and volunteers were undertaken. The month-long Sydney study, in February and early March 1990 was undertaken in collaboration with the Sydney Melanoma Unit. The group of 40 indoor workers each wore a single PS badge attached at the shoulder. A new badge was used each day, some subjects recording the time periods spent outdoors on a time line in a diary at the end of each day, while others were asked to record the information only at the end of the study. In this way it was hoped to detect whether there was any variation in recall between the two groups of subjects. Following initial discussions at the beginning of the study, the subjects were given their PS badges and no further direct supervision took place.

The Hobart study, in collaboration with the Menzies Centre, took place primarily on two days in February 1991, with two small groups participating in a trial the previous day. Subjects each wore eight PS badges at different anatomical sites, while participating in one of the following activities, pool swimming (SM), sailing (SL), bushwalking (BW), gardening (GN), playing tennis (TN) or golf (GF). The subjects then filled in a comprehensive questionnaire covering the duration of solar UVR exposure, type of clothing or sunscreen worn, ground surface cover, and many other details. As well as determining the anatomical distributions of UVR, the calculated ambient/diary UVB exposure could be compared with the PS badge measurement to determine whether the subjects' diaries gave an accurate reflection of their UVR exposures.

RESULTS

As the Sydney study volunteers were indoor workers, the measured PS badge EEDs were generally low, the mean value for the group of subjects was 82 ± 51 $J.m^{-2}$. In most cases exposure to solar UVR was in the morning and evenings on the way to and from work, with some contribution to the UVB exposure during lunch hour.

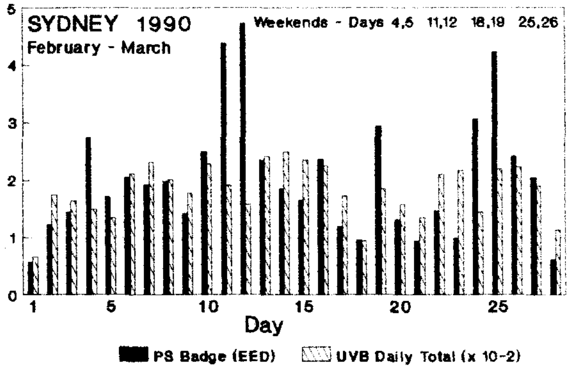

Figure 1. A comparison of the total measured PS badge exposures EED ($J.m^{-2}$) for the group of subjects for each day with the daily total UVB (radiometer counts).

Correlation between the EED from the PS badges and the calculated ambient/diary exposure for the Sydney study was poor. The variation between individuals was large. The diary provided no opportunity to indicate the quality of the UVR exposure, which is affected by shade and buildings in the immediate vicinity. If the subjects were analysed as a group, a pattern did emerge. Figure 1 shows the sum of the exposures in $J.m^{-2}$ for the entire group of subjects for each day, while also showing the daily total of ambient UVB (to a different scale). The weekend days stand out as days of high UVR exposures, the mean week day exposure being 65 ± 26 $J.m^{-2}$ while that for the weekend days was twice this at 123 ± 54 $J.m^{-2}$. The maximum measured daily total EED for any subject was 2060 $J.m^{-2}$, which occured on a weekend. Monthly UVR exposure totals for each subject ranged from 500 to 6865 $J.m^{-2}$ (mean of 2294 ± 1430 $J.m^{-2}$).

Supervision of subjects and PS badge placement was more tightly controlled in the Hobart study. Figure 2 shows a comparison of the PS badge exposures EED in $J.m^{-2}$ with the UVB/diary calculations. The activities in the Hobart study can be considered to fall into two broad categories, the first where the subjects would have spent a fair proportion of their time out of the direct sun (in amongst trees etc for the BW, GF and GN), the second where the activities took place predominately in the open. Comparison of the PS badge readings with the UVB/diary calculations for the TN, SL and SM subjects in Figure 2(A) shows a series of points scattered about the expected straight line (ie good correlation). However, the comparison for the BW, GF, and GN in Figure 2(B) shows considerable scatter, with the points all in the region of the graph where the PS badge readings are less than the corresponding UVB/diary entries. These lower measured EEDs and the scatter in the results (BW,GF,GN) are almost certainly due to subjects spending different amounts of time in the shade. The effective exposure rates I in $W.m^{-2}$ (Table 1) are generally less than for the other activities (TN, SL, SM).

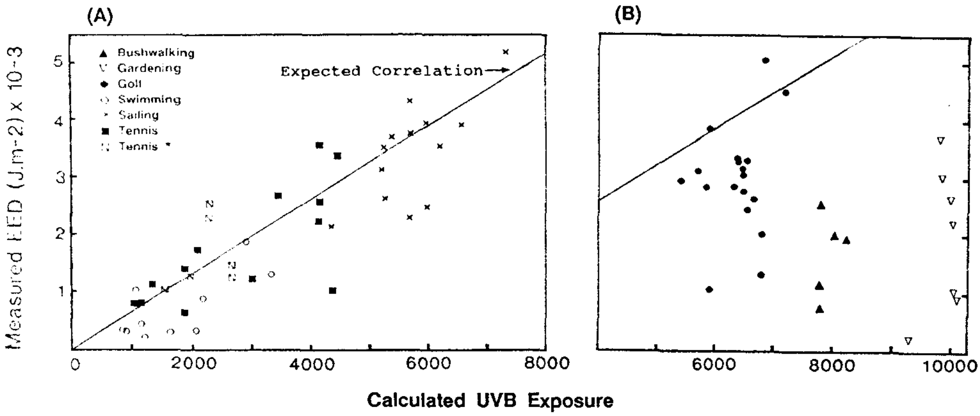

Figure 2. A comparison of the measured PS surface badge exposures EED ($J.m^{-2}$) for the different activities with the UVB exposures calculated from the diary entries and the measurement of ambient UVB (radiometer counts).

TABLE 1

The variation of UVR exposure with anatomical site as a fraction of ambient for different outdoor activities for the Hobart study (* denotes Day 1).

ACTIVITY	Tennis*	Tennis	Sailing	Swimming	Walking	Golf	Gardening*
SITE							
Cheek	0.20	0.36	0.25	0.43	0.08	0.21	0.24
Hand	0.43	0.54	0.54	0.94	0.30	0.51	0.19
Shoulder	0.52	0.79	0.70	1.39	0.22	0.76	0.30
Back	0.40	0.57	0.57	0.98	0.39	0.66	0.31
Chest	0.32	0.41	0.28	0.61	0.17	0.36	0.14
Thigh	0.26	0.47	0.44	0.72	0.20	0.42	0.14
Calf	0.40	0.51	0.25	0.62	0.19	0.41	0.16
Surface	1.00	1.00	1.00	1.00	0.39	0.74	0.30
EED($J.m^{-2}$)	814	928	1712	289	834	1355	766
I#($mW.m^{-2}$)	158	122	125	77	47	91	31

I is the effective irradiance calculated from the PS badges

The Hobart UVR exposures EEDs (Table 1) are higher than the average daily EED for the Sydney study, although they are comparable with many of the weekend exposures. Table 1 shows that the shoulder badges have the highest exposures, the reason this site was used for the Sydney study. The UVB exposure rates given by I in Table 1 show that activities (TN, SL, SM) which occur in the open have the highest UVB exposure, although (GF) can also have quite large UVB exposure rates.

CONCLUSIONS

Preliminary analysis of both studies indicate that good correlation between measured and calculated UVR exposures can be achieved if sufficient information is recorded in the diaries and if exposures occur under close supervision. In Australia the highest exposures to solar UVR (apart from outdoor workers) are due to outdoor recreational activities and any effort to reduce the general population's UVR exposures needs to concentrate on these.

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