COMPARING VARIATIONS IN THE UV FACIAL EXPOSURE RECEIVED BY SCHOOL CHILDREN IN SOUTH-EAST QUEENSLAND

N.J.Downs[A] *and A.V. Parisi*[A]
[A] Centre for Rural and Remote Area Health, University of Southern Queensland, Toowoomba, Australia.

Abstract
The study examines and compares the protective effectiveness of broad-brimmed hats at reducing the received solar ultraviolet facial exposure when worn by students while playing outdoor sport within a school environment. The preliminary results of a 12 month study program to investigate variation in facial exposure when playing basketball and soccer at a coastal location in South-East Queensland are presented. Facial cheek exposures were shown to be reduced significantly when broad-brimmed hats were used while playing soccer during both clear sky and overcast conditions. Maximum exposure levels received by school children were also shown to be less than those recorded by a rotating manikin headform when playing both basketball and soccer.

Additional Keywords
Albedo, Erythema, Skin Cancer, UV

Introduction
The incidence rates of the diagnosis and treatment of skin cancers in Queensland are higher than those reported for other regions in Australia. High solar altitudes, particularly in summer, and low ozone and aerosol concentrations contribute to the causative effect on the development of skin cancers due to the ultraviolet levels experienced in the region . Other risk factors relevant to the development of skin cancers in South-East Queensland include: high number of sunshine days, a proportionately high fair skinned population and an outdoor lifestyle. Exposure to ultraviolet radiation (UVR) during the early stages of life increases the risk of the development of melanoma and non melanoma skin cancers (Diffey 1991). School children can potentially receive high cumulative and acute exposures to solar UVR between 9:00am and 3:00pm during periods of high solar elevation and are therefore placed at significant risk of developing melanoma and non melanoma skin cancers later in life.

Protective strategies aimed at reducing exposure to solar UVR in schools include the active use of suitable clothing, hat and eyewear, the application of sunscreens and the use of physical shade structures designed to minimise direct exposure to the sun in a variety of playground environments. Within any given school environment however, there exist a number of locations which can increase the ambient levels of UV. These may include highly reflective surfaces such as glass windows, galvanised roofing or concrete surfaces. Proximity to certain locations within a school environment including swimming pools, reflective buildings, sporting surfaces or regions which offer little shade therefore determine the overall risk associated with the level of UVR received by children when at school. Minimising the risk associated with solar UVR exposure within a school environment is dependent on the time of the outdoors activity and therefore the resulting variation in UV levels due to solar elevation, their proximity or position within the localised ambient UV environment and the level of personal protection used. This study examines variations in exposure received by school children at Hervey Bay State High School (20 ^{o}S, 153 ^{o}E) when involved in two different sporting activities, during different UV conditions while using and not using hat protection.

Materials and Methods
Both male and female student volunteers taking part in the study were asked to play mixed games of five on five basketball or soccer for 60 minute intervals over a four month period within the Hervey Bay State High School grounds. The preliminary results recorded over the four month period and presented here form part of a full year trial conducted at the school.

Trial Location
Student volunteers were required to remain in the designated trial areas for the duration of each 60 minute game. The soccer field trial area was orientated with goals north and south and was located at least 100 meters away from the nearest buildings. Trees were located along the soccer field's western and eastern boundaries though no shade was cast on the field during the trials (Figure 1a). The outdoor basketball court was oriented with goals at the western and eastern ends.

The court was located 30 meters away from the nearest buildings and no shade was cast on the court during trials. Each of the games (both basketball and soccer) were divided into two 25 minute halves including a 10 minute break. Students were not allowed to leave the trial area nor remove hats during the break period.

Measuring Facial Exposures

During the sporting trials, one team of five students wore broad-brimmed hats and the other had no hat protection. Levels of localised solar UV exposure were recorded at different facial locations using small polysulphone dosimeters. Each rectangular dosimeter was cut from flexible cardboard measuring 1 cm by 1.5 cm having a clear circular aperture of 6 mm over which polysulphone film was attached. Two dosimeters were given to each student and adhered using bandaids. The change in absorbency of each polysulphone dosimeter between pre and post exposure was recorded at 330 nm using a UV spectrophotometer (model UV1601, Shimadzu Co. Kyoto). Measured changes in polysulphone absorbency were used to approximate the erythemal response of human skin (CIE 1987) expressed relative to a dosimeter exposed on a horizontal plane for the duration of each 60 minute trial. The exposure recorded by each facial dosimeter was expressed as a percentage relative to the horizontal plane exposure.

$$E = \frac{K(9\Delta A^3 + \Delta A^2 + \Delta A)}{K(9\Delta A_{Hor}^3 + \Delta A_{Hor}^2 + \Delta A_{Hor})} \times 100$$

From the equation, E represents the relative exposure level, ΔA is the recorded change in polysulphone absorbency measured at 330 nm, ΔA_{hor} is the recorded change in polysulphone absorbency of the horizontal plane dosimeter, and K is a constant needed to accurately represent a time-exposure curve for a given batch of polysulphone. Note that exposure levels are expressed as a fraction of two polynomials due to the non-linear response with increasing exposure of polysulphone film measured at 330 nm. Note also that the constant, K cancels in this expression provided the horizontal plane polysulphone dosimeter was fabricated from the same batch used to create each of the facial dosimeters. This expression, has been used previously to approximate the relative exposure of polysulphone film (Airey et al. 1995).

Exposures were recorded on a manikin headform for the duration of each sporting trial at each of the viable facial locations. The manikin base rotated twice every minute at a height of 30 cm above the ground and was placed alongside the student's sporting field (Figure 1b). The same rotating base has been used previously to approximate the random movement of human subjects and can accommodate variations in head tilt. For this research however, manikin headforms were placed in an upright vertical position. These formed the control to allow comparison of the exposures to the students. The albedo of each sporting area was recorded with a hand held Robertson-Berger meter (Solar Light Co. USA) by determining the percentage of upward UVR compared to the downward UVR measured at a height of 30 cm.

Figure 1a: Students using the soccer trial area

Figure 1b: Location of manikin headform during a soccer trial

Results and Discussion

The recorded exposure levels for facial sites expressed as a percentage of the maximum horizontal plane exposure for both soccer and basketball trials are listed in Table 1 and Table 2. Exposure levels listed in Table 1 represent the average facial exposure levels recorded by students across two field experiments. The data represents a general variation in facial exposure for solar elevation angles of 40^o to 50^o. Atmospheric conditions during both trials varied from clear sky to total cloud cover. A number of dosimeters were damaged due to the perspiration of students and could not be included in this comparison. Furthermore, as students chose their own facial locations, not all facial sites have been included. Manikin exposure levels recorded during one of the outdoor trials are included here for comparison. Manikin exposure data has not been averaged.

The manikin exposure levels presented in Table 1 clearly indicate the benefit of broad-brimmed hats when compared to the unprotected manikin headform. In a similar study conducted by Gies et al. (2006), the protective effectiveness of various hat types used by school children was studied. Gies et al. (2006) showed that broad-brimmed hats were effective at protecting wider regions of the face when compared with caps due to the hat being able to provide more facial shading. The results presented here indicate the expected protective benefit of broad-brimmed hats at reducing facial exposures to a variety of locations. Also noticeable in the results presented in Table 1 are the higher exposure levels recorded by both the protected and unprotected manikin compared to student exposures. This is particularly noticeable for the higher exposure level recorded at the manikin headform vertex when compared to the average exposure level recorded for student vertices, highlighting the influence of head tilt on the maximum recorded exposure. Further work comparing manikin head tilt angles and student exposures could be completed using the method presented here to determine optimal manikin head tilt angles required to simulate the actual position human head angles take during sporting activities.

Of particular note however, from the results presented below, is the comparison made between protected and unprotected cheek exposures recorded for student subjects playing soccer. Variation in recorded cheek exposure data used to produce the averages listed in Table 1 is also presented in Figure 2. The results indicate a wider range in exposures recorded for unprotected students. This may be due to variation in student hair styles whereby longer hair may shade the cheek region during a trial.

Table 1. Soccer Trial Exposure levels (surface albedo 5%)

Facial Location	**Average Student Exposure (%)**		**Average Manikin Exposure (%)**	
	Hat	**No Hat**	**Hat**	**No Hat**
Vertex	92			100
upper forehead		34	47	64
forehead (between eyes)	33		29	51
Cheek	21	27		43
ear top			10	50
ear lobe				
upper lip			35	54
lower lip			15	44
Chin				
nose bridge			27	51
nose end	35		43	60
Temple		24		
Jaw		15		29

Table 2. Basketball Trial Exposure levels (surface albedo 7%)

Facial Location	**Average Student Exposure (%)**		**Average Manikin Exposure (%)**	
	Hat	**No Hat**	**Hat**	**No Hat**
Vertex	85			100
upper forehead		51		47
forehead (between eyes)	30			49
Cheek				
ear top				
ear lobe				
upper lip				
lower lip				
Chin	54	32		54
nose bridge	44			61
nose end		51		60
Temple				
Jaw				

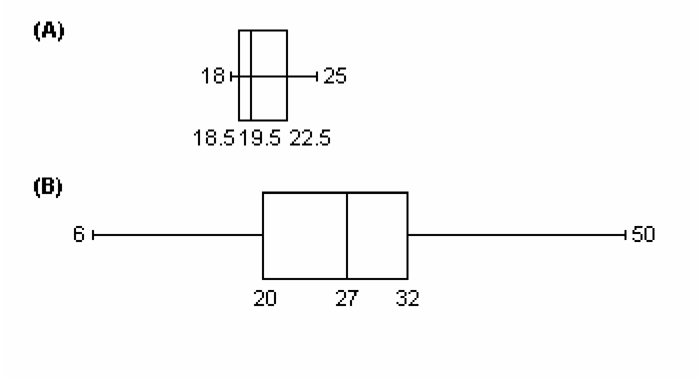

Figure 2: Variation in recorded cheek exposure percentage levels for students wearing broad-brimmed hats (A) and not wearing hats (B) while playing soccer

Conclusions

- Comparisons between manikin headforms and UVR exposures received by school children while playing sport are consistently higher on manikins.
- Broad-brimmed hats reduce exposure to a variety of facial regions on both high and low albedo surfaces.
- The use of broad-brimmed hats for school children engaged in sport on open surfaces reduces the variation in received facial exposure to the cheek region.

Acknowledgements

- The authors would like to thank the principal of Hervey Bay State High School, Mr Glenn Vaughan, for permission to conduct this research at the school.
- The authors would also like to acknowledge the technical staff at USQ for their involvement with the manufacture and maintenance of the necessary equipment.
- Thanks also to the following students and teachers at Hervey Bay State High School for their involvement in dosimeter manufacture and willingness to learn about UVR experimental techniques associated with this research: Marika Addison; Heather Bunting; Jacinta Baulch; Shannon Coad; Ally Coates; Steven Dean; Jonathan Digby; Kiara Hartley; Melissa Honey; Julian Hunter; Joel Huth; Stacey Josh; Mitchell Kennedy; Larissa Kimber; Danielle Mares; Suzanne Martin; Matt Napier; Tracey Oliphant; Lynton Paputsakis; Trent Passfield; Warren Power; Sam Ray; Hayley Reynolds; Isaac Sheehy; Riannon Saunders, Sarah Saunders; Maxine Vallance; Jarred Ware; Paul Woodland; Kiara Wright; and Xiao Xue.

References

Airey, D.K., Wong, J.C.F. and Fleming, A. (1995). A comparison of the human and headform based measurements of solar ultraviolet B dose. *Photoderrmatoloogy, Photoimmunology and Photomedicine* **11**(4), 155-158.

CIE (International Commission on Illumination). (1987). A reference action spectrum for ultraviolet induced erythema in human skin. *CIE-Journal* **6**(1), 17-22.

Diffey, B.L. (1991). Solar ultraviolet radiation effects on biological systems. *Physics in Medicine and Biology* **36**(3), 299-328.

Gies, P., Javorniczky, J., Roy, C. and Henderson, S. (2006). Measurements of the UVR Protection Provided by Hats Used at School. *Photochemistry and Photobiology* **82**, 750-754.

Parisi, A.V., Meldrum, L.R., Wong, J.C.F., Aitkin, J. and Fleming, R.A. (1999). Lifetime erythemal ultraviolet exposure estimates for selected population groups in south east Queensland, *Physics in Medicine and Biology* **44**(12), 2947-2953.