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Anatomical distribution of solar ultraviolet exposures among cyclists

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Abstract

Exposure to solar ultraviolet (UV) radiation is the major environmental factor implicated in the development of melanoma and other skin cancers, as well as eye damage and skin photoaging. Outdoor recreational activities such as cycling are increasingly pursued for health benefits, however little information is available regarding potential adverse effects of excessive sun exposure in this setting, nor about the anatomical distribution of solar dose. Polysulphone badges (UV dosimeters) were attached to the head, backs of hands and ankles of 22 cyclists during a seven-day charity bicycle ride in Queensland, Australia. Average daily exposures exceeded one minimal erythemal dose (MED) at all body sites except the ankle. Significant differences in UV dose among the various body sites were noted, with highest exposures recorded on the top of the head. Mean doses received at the ankle (0.94 MED), back of the hand (1.28 MED) and side of the head (1.14 MED) were 51%, 71% and 63% of those received at the top of the head (1.80 MED), respectively. These data indicate that cycling exposes adherents to substantial doses of UV radiation. Moreover, our observations suggest that even vertically-oriented, potentially shaded sites such as the lower leg typically receive doses of solar radiation no less than half of maximally exposed sites.

Keywords: Ultraviolet; Human; Anotomical distribution; Cyclists

1. Introduction

Cancers of the skin are the most commonly occurring malignancies in fair-skinned populations around the world, associated with substantial costs for their diagnosis and treatment [1]. Recent estimates indicate that more than 800,000 new cases of squamous cell carcinoma (SCC) and basal cell carcinoma (BCC) and more than 45,000 new cases of melanoma are diagnosed in the US population each year [2]. Some of the highest rates for cancers of the skin are observed among the Australian population, where more than 420,000 histologically-confirmed skin cancers are excised each year from within a population of 20 million, with cumulative risk to age 70 years of having at least NMSC were 70% for men and 58% for women [3]. In Australia, the costs of diagnosing and treating skin cancer are higher than for any other cancer [4].

There is general agreement from epidemiological and molecular studies that exposure to ultraviolet (UV) radiation is the principal environmental cause of each of the common types of skin cancer (BCC, SCC, melanoma). Skin cancers tend to develop more frequently in fair skinned people with lightly pigmented eye and hair colour, tend to occur on parts of the body that are more often exposed to solar UV, are more likely to occur in sunny climates at low latitudes [5], and can be related to past personal histories of exposure to terrestrial UV [6].

Cycling is a popular outdoor activity undertaken for recreational, transportation and competitive purposes. While cardiovascular and other health benefits of cycling are well documented [7], it is likely that cyclists are potentially exposed to harmful doses of UV radiation while pursuing their activity. Case reports of melanoma among cyclists [8] lend support to the contention that this activity may place adherents at an increased risk of skin cancer. Yet

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despite the popularity of cycling, there are relatively few published data describing the magnitude of UV exposures received by cyclists, nor about exposures received at specific body sites. Indeed, one of the few papers written on UV exposures whilst cycling does not deal with cycling exposures per se, rather it deals with exposures during "Ironman Triathlons" [8]. In this research [8], the author found that the mean personal UV exposures to the back (between the shoulders) during a triathlon were 8.3 MED after around 9 h of competition. No data were collected specifically on the exposures during the cycling leg of this competition and no data were available to describe the anatomical distribution of UV exposures.

Here, we report the findings of a study designed to quantify the dose of erythemal ultraviolet radiation received by cyclists, focusing specifically on the anatomical distribution of exposure.

2. Materials and methods

2.1. Subjects – ride for research (RFR)

We measured UV exposures among 22 cyclists participating in a charity ride ("Ride for Research") in southern Queensland, Australia. Over 7 days in June, 2005 (southern hemisphere winter) participants cycled from the tropical city of Rockhampton (23.22°S, 150.32°E) to the state capital Brisbane (27.25°S, 153.02°E), a total travel distance of 875 km. The ride was divided into daily stages averaging approximately 125 km beginning on the 11th of June 2005 and finishing on the 17th of June 2005. Approval to conduct the study was obtained from the human research ethics committee of the Queensland Institute of Medical Research.

2.2. Dosimeter

We used polysulphone dosimeters to measure the personal UV exposure of the cyclists. The spectral response of polysulphone is similar to the erythemal action spectrum, making it a suitable detector for the assessment of exposures. The polysulphone film was made at the Queensland University of Technology's (QUT) Sun and Health Research Laboratory located in the Institute of Health and Biomedical Innovation (IHBI). Thin film casting of polysulphone was conducted under carefully controlled conditions to ensure uniform thickness of the film (40 μm) and consistent physical attributes. The film was cut and mounted into rigid plastic holders and the pre-UV exposure absorbancy at 330 nm was measured using a UV/Visible spectrophotometer (Shimadzu UV1700) [6].

The badges were packaged in sealed, light protected envelopes and labelled for identification purposes. Each morning of the ride, the badges were distributed by one of the authors participating in the ride (NM). Table 1 documents the times at which badges were administered and removed on each day of the RFR, as well as the prevailing weather conditions as recorded by the Commonwealth Bureau of Meteorology.

Table 1
Dosimeter exposure times and weather conditions

Date	Time on	Time off	Total time (h:min)	Weather conditions[a]
11 June, 05	8.50 a.m.	3.20 p.m.	6:30	Mostly sunny
12 June, 05	10.10 a.m.	5.30 p.m.	7:20	Mostly sunny
13 June, 05	9.40 a.m.	1.40 p.m.	4:00	Sunny
14 June, 05	8.40 a.m.	5.30 p.m.	8:50	Mostly sunny
15 June, 05	8.20 a.m.	5.30 p.m.	9:10	Isolated showers
16 June, 05	8.20 a.m.	3.30 p.m.	9:10	Isolated showers
17 June, 05	7.30 a.m.	2.30 p.m.	7:00	Sunny

[a] Weather conditions from the Commonwealth Bureau of Meteorology website www.bom.gov.au.

Badges were attached using adhesive medical tape. The sites selected were the posterior surface of the ankle (a vertically-oriented, potentially shaded body site), handlebar of bicycle (to approximate solar exposure received on the dorsal surface of the hands), lateral aspect of the helmet (to approximate solar exposure received on the face) and vertex of helmet (to record the maximum available solar dose for each cyclist).The face and dorsum of hands were chosen because of the predilection for actinic skin damage and skin cancers at these sites in the general population. The ankle was chosen as a site that a priori was considered to receive lower exposures, but for which there are case reports of melanoma among cyclists [8]. At the end of each day, the exposed dosimeters were collected, sealed in envelopes and stored in a light proof location.

One week after the conclusion of the ride, the change in optical absorbancy at 330 nm was measured for each polysulphone badge at the QUT UV laboratory. Briefly, a series of polysulphone dosimeters from the same batch as those used in the ride were exposed to sunlight from early morning to late afternoon and removed at time intervals of 30 min. At the same time, the ambient erythemal UV irradiances were measured using a broadband solar UV detector (Solar Light Co., USA). The change in optical absorbancy at 330 nm (Post–Pre UV Exposure values) was compared with the UV dose received (as measured with the broad-band UV detector) and a calibration curve was determined. We have presented the exposure data in units of minimal erythemal dose (MED), defined as the lowest dose at which erythema is just perceptible in previously unexposed human skin. For this series of exposures, 1 MED is equivalent to 20 mJ cm^{-2} [9].

2.3. Statistical analysis

We calculated the dose of UV radiation absorbed by each polysulphone badge using the calibration curve described above, and excluded the small number of outlying readings ($MED > 4.0$, $n = 3$). For each anatomical site, we estimated the mean dose and 95% confidence interval on each separate day of the RFR. We then calculated an overall adjusted mean dose for each anatomical site by