Clinics in Dermatology (2008) **26**, 12–15

ELSEVIER

Clinics in Dermatology

Outdoor sports and skin cancer

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Abstract Ultraviolet radiation is estimated to be one of the most important risk factors for nonmelanoma and melanoma skin cancers. Athletes practicing outdoor sports receive considerable UV doses because of training and competition schedules with high sun exposure, and in alpine sports, by altitude-related increase of UV radiation and reflection from snow- and ice-covered surfaces. Extreme UV exposure in outdoor sports such as skiing, mountaineering, cycling, or triathlon has been documented in a series of dosimetric studies. Sweating because of physical exercise may contribute to UV-related skin damage as it increases the individual photosensitivity of the skin, facilitating the risk of sunburns. Large epidemiological studies showed that recreational activities such as sun exposure on the beach or during water sports were associated with an increased risk of basal cell carcinoma, whereas skiing has been shown to be at increased risk for squamous cell carcinoma. Risk factors of cutaneous melanoma such as the number of melanocytic nevi and solar lentigines have been found to be more frequent in subjects practicing endurance outdoor sports. An increased risk for cutaneous melanoma may be assumed for these athletes. In addition to the important sun exposure, exercise-induced immunosuppression may increase the risk for nonmelanoma skin cancer and cutaneous melanoma in athletes. Frequently, athletes seem to know little about the risk of sun exposure. Protective means such as avoiding training and competition with considerable sun exposure, choosing adequate clothing, and applying water-resistant sunscreen still need to be propagated in the community of outdoor sportsmen.
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Ultraviolet exposure and skin cancer

Besides other risk factors, including genetics and immunity, UV radiation (UVR) has been established as the most important risk factor for both melanoma and nonmelanoma skin cancer.[1,2] Long-term suberythemal UV doses can mutate the DNA of an individual and lead to pyrimidine dimer formation in dermal and epidermal tissue.[3] Long-term repeated UV-A exposure has been shown to lead to photodamage and to potentiate the effects of UV-B on skin cancer formation.

Outdoor athletes are exposed to solar UVR and probably are at higher risk for developing skin cancer. The aim of this article is to review on UV exposure, sun protection, and skin cancer risk in outdoor sports.

Ultraviolet exposure in outdoor sports

Sensitivity of the human skin to UVR is dependent on the wavelength of UVR from 250 to 400 nm.[4,5] Biologically weighted dosimeters integrate the UVR effect

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0738-081X/$ – see front matter © 2008 Published by Elsevier Inc.
doi:10.1016/j.clindermatol.2007.10.001

over the whole spectrum and simulate the relative sensitivity curve critical for human skin for each individual wavelength within this range.

In cutaneous photobiology, radiant exposure is frequently expressed as "exposure dose" in units of joules per square meter. "Biologically effective dose," derived from radiant exposure weighted by such an action spectrum, is expressed in units of joules per square meter (effective) or as multiples of "standard erythema dose" (SED) or "minimal erythema dose" (MED). One MED has been defined as the lowest radiant exposure to UVR that is sufficient to produce erythema with sharp margins 24 hours after exposure. When the term *MED* is used as a unit of exposure dose, a representative value is chosen for sun-sensitive individuals.[6] For radiation protection purposes, one MED is generally taken in the range of 200 to 300 J/m^2 as effective[7]; one SED corresponds to 100 J/m^2.

In various studies, polysulfone dosimeters as small portable badges have been used to determine the anatomical distribution of sunlight on dummies and living subjects during various occupational and recreational activities.[8-11] The optical absorbency of the film material increases in a dose-dependent manner upon exposure to UVR especially in the UV-B range (280-315 m).[10,12] For example, the practice of tennis, sailing, and golf was associated with relatively high-UV exposure ranging from 3.5 to 5.4 SED per hour. In these sports, the highest relative exposure was measured on the shoulders, which was about 60% of ambient radiation.[10] During activities at a girl scout camp, baseball camp, and community baseball field, solar UV exposure was measured on the arms, cheek, and forehead.[11] Median arm exposure to children playing baseball at a camp ranged from 27.6% to 33.2% of the possible ambient exposure. Median exposure to the arm at the girl scout camp during mixed activities ranged from 9.0% to 26.5% of possible ambient exposure. At the girl scout camp, exposure both within and between activity groups varied substantially and were more variable than the baseball players' exposure. Arm exposure was about 2-fold greater than cheek and forehead exposure for all groups. For organized sports such as baseball, it may be possible to assign a single-exposure estimate for use in epidemiological studies or risk estimates. For less uniform outdoor activities, however, wide variability in exposure makes it more difficult to predict an individual's exposure.[11]

Some years ago, a new approach to UV dosimetry has been developed. The biologic effects of UV light are measured by determination of the harmful effects on spores of *Bacillus subtilis*. After UV irradiation, the spore film is allowed to germinate in culture. The proteins synthesized by the bacteria exposed to UVR are photometrically quantified and compared with controls with defined radiation exposures. Applying this new method, standardized personal dosimeters have already been produced and tested under different stationary conditions[13-15] and in personal dosimetry: professional cyclists in the Tour de Suisse cycling race have been shown to have an average daily personal UV exposure of 20.3 SED.[16] During the Ironman Triathlon World Championships 1999 in Hawaii (3.9-km swim, 180.2-km bike, 42.4-km run), the mean personal UV exposure of 3 triathletes was 20.8 SED.[17] The highest UV exposures have been measured in mountain guides. On 23 different occasions of mountaineering activity in the Swiss Alps, Alaska, Bolivia, and Tibet, a mean personal daily exposure of 29.8 SED was found. Personal UV doses ranged from about 11 to more than 42.5 SED per day.[18] In another study, 9 mountain guide instructors carried dosimeters on the sides of their heads during 1 year. The mean individual monthly UV exposure was 107 SED (median, 71 SED; range, 10-505 SED). The mean annual cumulative UV exposure was 1097 SED (median, 1273 SED; range, 312-1770 SED) per mountain guide. The mean UV dose per day (4-10 hours) was 6.6 SED (median, 5.7 SED; range, 0.6-24.2 SED). In mountain guides, median daily UV exposure exceeded limits for UVR 6-fold (eg, American Conference of Industrial Hygienists (ACGIH) effective dose 30 J/m^2 per 8-hour period corresponding to 1.08 SED per day); maximal exposure exceeded these limits 23-fold.[19]

Recently, UV-A– and UV-B–integrating digital dosimeters have been developed: 10 ski instructors in Vail, CO, carrying such digital dosimeters on the arm during about 1 month in November/December 2000 had a mean daily UV exposure of 0.5 to 7.6 MED (1.3-19.0 SED per day).[20]

From the dosimetric studies, it can be concluded that there is extreme sun exposure in outdoor sports. It is not sufficient to interpolate annual UV exposure from a few days' measurements.

Only long-term dosimetry can give reliable yearly information of UVR load.

Sweating induced by heat or physical exercise may significantly contribute to UV-related skin damage as it increases the photosensitivity of the skin, facilitating the risk of sunburns.[21] This effect is probably because of the hydration of the horny layer to a shift in the stratum corneum UV absorption spectrum to shorter wave lengths and to a decrease in reflection and dispersion.[22]

Sun protection

Sun protection is based on 3 principles:

- Avoidance and shade;
- textiles and hats;
- use of sunscreen preparations.

Education programs aim to reduce sun exposure while swimming, sunbathing, playing soccer, or walking during the summer season, but winter sports have been mostly ignored.[23-25] Recently, a study from New Zealand revealed

that 48% of skiers interviewed recalled being sunburned while skiing or snowboarding in the past. Reported awareness of educational messages specific to sun protection while skiing or snowboarding was poor. Sixty-eight percent were unaware of any educational messages.[26] Similarly, a study from the western United States showed that skiers knew little about the risk of sun exposure and often took no precautions at all, especially in cold and cloudy weather.[27]

Outdoor sports rarely can be practiced in shade. Training and competition schedules should be chosen in periods with lower sun exposure. In summer, sports activities should not be practiced from 11:00 AM to 3:00 PM.

Sports apparels such as cycling jerseys rarely do fulfil the requirements of solar protective textiles (eg, as required by the European Committee of Standardization, EN 13758-1 Textiles—Solar UV protective properties) for body surface to be covered by the textile and absorption of UVR by the fabric.[28]

Runners participating in the Graz Marathon (Austria) were reported to wear in training and competition shorts (97%) and short-sleeved (88%) or sleeveless (11%) shirts, which would not or only partially cover the shoulders and upper arms.[29]

Sunscreen preparations might be less efficient because of water exposure, sweating, and friction: for instance, athletes participating in the Ironman Triathlon World Championships had sunburn despite the use of water-resistant sunscreen (SPF 25+) on sun-exposed skin.[17]

In some sports with an intense UV exposure, competition rules hinder athletes from sun-protective behavior.

For instance, in beach volleyball, the medical health certificate has to state that an athlete is able to play in beach volleyball competitions, which can last up to 3 hours of exposure to intense sunlight. Under such sun intensive conditions, however, the official rules of the International Volleyball Federation do prescribe tiny sexy shirts and shorts that barely cover any skin.

In the Hawaii Ironman Triathlon, sunscreen application on the upper arms was not allowed to mark competition numbers onto the skin.[17]

Nonmelanoma skin cancer and melanoma in outdoor sports

Regular, low-impact exercise is well established to improve one's health. In contrast, overtraining, high-intensity training, and excessive exercise may lead to suppressed immune function. This is because of repetitive tissue trauma sustained during intense exercise, inducing cytokines toward a T helper 2 lymphocytic profile resulting in simultaneous suppression of cell-mediated immunity.[30] In outdoor sports, UV-induced immunosuppression may facilitate tumor initiation and tumor promotion.

Participating in outdoor sports increases the risk of developing basal cell carcinoma (BCC): beach holidays and water sports emerged as independent risk factors for BCC.[31]

Skiers have been shown in epidemiological studies to be at an increased risk for the development of squamous cell carcinoma[32] and suggested to indirectly be at increased risk for melanoma.

In a recent case-control study, sun exposure during leisure time activities such as sports at the beach and outdoor sports in general showed only slightly above-unit but not significant odds ratio for cutaneous melanoma (CM). Sun exposure during childhood outdoor activities was associated with a significant risk increase for CM (odds $\text{ratio}_{\text{adjusted}}$, 2.7; 95% confidence interval, 1.04-6.80) and BCC (odds $\text{ratio}_{\text{adjusted}}$, 2.8; 95% confidence interval, 1.18-3.49).[33]

Dermatologists from Graz University compared 210 marathon runners with an age- and sex-matched control group. Despite controls had a higher sun sensitivity and a higher number of melanocytic nevi, marathon runners exhibited more atypical melanocytic nevi, solar lentigines, and lesions suggestive of nonmelanoma skin cancer.[29] Taking into account that the number of common melanocytic nevi, the number of atypical melanocytic nevi, and solar lentigines have been shown to be the strongest independent risk factor for CM, marathon runners seem to be at increased risk for developing CM.[34]

Professional mountaineering was associated with an increased prevalence of precancerous skin lesions and skin cancer. Two hundred eighty-three men who are mountain guides from Austria, Switzerland, and Germany had a standardized interview and were examined on professionally sun-exposed skin areas (head, neck, arms). As controls, traumatology patients and healthy men were evaluated. Precancerous lesions such as solar keratosis (25% vs 7%) and solar cheilitis (53% vs 12%) were significantly more frequent in mountain guides. Basal cell carcinoma was diagnosed in 19 mountain guides (7%) and squamous cell carcinoma in 3 mountain guides (1%). In the mountain guide group, one melanoma was confirmed histologically. Risks factors for solar keratoses were profession (mountain guide vs control), age, severe sunburns, and skin pigmentation. Within the mountain guide group, age, lifetime working days as a guide, severe sunburns during lifetime, sunburns during the last year, and the skin type were independent risk factors for solar keratosis. Severe lifetime sunburn was the only significant risk factor for BCC. In the mountain guide group, lifetime working days as a guide was a significant risk factor for BCC (M Moehrle, unpublished results).

The incidence of BCC was significantly greater in Texas Gulf Coast surfers than in a self-selected population of similar age participating in a skin cancer screening program. Therefore, the authors concluded that skin cancer screening programs should focus on at-risk populations such as outdoor athletes even more than screening self-selected populations.[35]

Conclusions

Athletes practicing outdoor sports are at increased risk for melanoma and nonmelanoma skin cancer.

In addition to the important sun exposure, exercise-induced immunosuppression may increase the risk for nonmelanoma skin cancer and CM in athletes.

Frequently, athletes seem to know little about the risk of sun exposure. Protective means such as avoiding training and competition with considerable sun exposure, choosing adequate clothing, and applying water-resistant sunscreen still need to be propagated in the community of outdoor sportsmen.

Further efforts to identify individuals with skin cancer should be focused on including especially high-risk populations such as outdoor sportsmen.

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