Ultraviolet Radiation in Alpine Skiing

Magnitude of Exposure and Importance of Regular Protection

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Background: Participation in outdoor alpine sports has been increasing over the last decade. Ultraviolet exposure levels for these activities can be extreme owing to the venue altitudes. The purpose of this study was to measure the levels of UV-A and UV-B radiation exposure incurred by performance skiers in a typical alpine venue and to determine the need for protection in that environment.

Observations: Total UV-B exposure ranged from 12 to 185 mJ/cm² (0.5-7.6 times the minimum erythemal dose [MED] for individuals with type II skin). Ten percent of subjects received more than 1 MED/h at peak exposure times. Daily UV-A exposure ranged from 10.6 to 28 J/cm² (daily average, 0.55 minimum melanogenic dose).

Conclusions: Alpine skiers with skin types I and II are exposed to measurable erythemal and suberythemal levels of UV radiation repeatedly over the long term at levels that can cause photodamage to their skin and potentially increase their later risk for skin cancer. Programs should be developed to educate skiers regarding the need for UV protection. Given the high levels of exposure noted, skiers should use UV protective measures, including sun-protection factor 30 broad-spectrum sunscreen.

Arch Dermatol. 2003;139:60-62

A TOTAL of 87,900 Americans developed melanoma in 2002. Melanoma risk strongly correlates with UV exposure and sunburn—especially when the exposure or sunburn occurs prior to age 18 years—and the face and neck can be common anatomic sites. At typical alpine skiing elevations, ambient UV irradiance increases approximately 2% to 3% for each 100 m of altitude, and irradiance may be further increased by up to 40% due to the albedo of snow. There have been no quantitative studies to date measuring UV radiation exposure in performance alpine skiers. The purpose of this study was to measure the levels of UV-B (290-320 nm) and UV-A (320-400 nm) radiation exposure incurred by performance skiers in a typical alpine venue and to determine the need for protection in that environment.

METHODS

Digital dosimeters were used to measure UV exposure levels of professional ski instructors under differing conditions at Vail, Colo (latitude, 39°N; elevation, 2500-3500 m above sea level). Individual digital UV-B and UV-A integrating sensors (Advanced Medical Electronics Corp, Fridley, Minn) were worn by 10 professional ski instructors on their distal arms, anterolateral forearms, or wrists outside their parkas from November 27 through December 22, 2000 (Figure 1). The wrist and forearm positions have been demonstrated to be a practical body site for personal UV dosimetry.

The dosimeters measured UV irradiance (watts per square centimeters) 3 times in each 5-minute interval during the study period and recorded the highest of the 3 values. The data were then downloaded from the dosimeter chips, integrated over each study day, and converted to UV radiation exposure units (irradiance \times time [millijoules per square centimeter]) to obtain mean hourly average exposure values.

RESULTS

The subjects received a mean daily UV-B exposure of 62.08 mJ/cm², with a range of 12 to 185 mJ/cm², which is equal to 0.5

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to 7.6 minimum erythemal doses (MEDs; 1 MED for a person with type II skin is 25-40 mJ/cm²). Ten percent of subjects received more than 1 MED/h at peak exposure times for their individual skin types, with some hourly exposures at midday approaching 2.5 MEDs for fairer-skinned individuals. More than two thirds of the skiers were exposed to more than 2 MEDs of UV-B radiation per day while skiing during the study period.

Average daily UV-A exposure was 10.6 J/cm² (range, 0.5-28 J/cm²), or an average daily exposure of 0.55 minimum melanogenic dose (MMD) (range, 0.05-1.4 MMD). These MMD calculations are based on the assumption that a person with type II skin reaches 1 MMD at 15 to 20 J/cm². Average hourly exposure patterns (Figure 2) were consistent with diurnal UV level changes, with the exception of a small midday decrease noted due to indoor lunch activities.

**COMMENT**

High levels of UV exposure have been suggested to occur in many outdoor sporting activities, but few studies have attempted to quantify the magnitude of the exposure. Moehrle et al4 successfully measured UV exposure using biologic and chemically based dosimeters in several outdoor sports environments. The present study demonstrates that average daily UV radiation exposure levels in athletes in an outdoor venue could also be measured using personal digital dosimeters.

Participation in outdoor sports increases the risk of developing basal cell carcinoma.® Skiers have been shown in epidemiologic studies to be at increased risk for the development for squamous cell carcinoma,® and suggested to indirectly be at increased risk for melanoma.® Despite this fact, a recent study showed that skiers knew little about the risk of sun exposure and often took no precautions at all, especially in cold or cloudy weather.® Given the UV exposure levels noted in the present study, there is a need for a public education program to change skier UV protection behaviors.

Professional cyclists in the Tour de Suisse cycling race have been shown to have an average daily personal UV-B exposure of 8.1 MEDs® and were found to exceed international UV exposure limits by more than 30-fold. Ultraviolet B exposure levels for the ski instructor subjects in the present study would be at least 10 times greater than those same limits, even given the study period occurring at seasonal minimum UV levels. Since in many cases it would be impractical for skiers to avoid exposure during midday periods or to wear protective clothing on the exposed areas of the face, their use of sunscreen is particularly important. Given the UV exposure levels noted in the present study, even skiers with aver-
Long-term repeated UV-A exposure has been shown to cause damage to the skin. Ultraviolet radiation–induced photodamage has been shown to be increased on the unprotected skin of golfers. Long-term suberythemal doses of UV can mutate the DNA of an individual and lead to epidermal and dermal tissue. Although the mean daily exposure was less than 1 MED and 1 MMD for some of the subjects with darker skin types, other studies have demonstrated that long-term exposures to lesser amounts of UV can also cause damage to the skin. Therefore, even at the UV exposures found in the present study, all alpine skiers need to protect their exposed skin.

Our study has demonstrated that alpine skiers are exposed to measurable chronic erythema and suberythemal levels of UV radiation at levels that can cause photodamage to their skin over time and potentially increase their later risk for skin cancer. Programs must be developed to educate skiers about the need for protection. Given the daily levels of UV exposure noted, alpine skiers should consider the use of regular UV protection, including sunscreen of at least sun protection factor 30 with broad-spectrum coverage to minimize subsequent UV-related sequelae.

Accepted for publication May 16, 2002.

The personal digital dosimeters were developed by Advanced Medical Electronics, Fridley, Minn, through a Small Business Innovation Research grant from the National Cancer Institute, Bethesda, Md, and they were provided at no cost. This study was supported in part through this same grant.

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