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Comparing Measurements of UV Radiation in Winter and Summer in Finland

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***Abstract*—**The objective of our study is to investigate UV exposure in Finland through sample measurements as a typical case study in summer and winter. We measured UV-BC weighted radiation and calculated a daily dose, which is about 100–150 times the Finnish exposure limit value in summer and 1–6 times in winter. The measured ultraviolet indices varied from 0 to 7 (scale 0–18), which is less than the values obtained in countries that are located farther south from Tampere latitude of 61 degrees. In wintertime, the UV exposure was modest compared to summertime, 50–150 mW/m^2 and about 1–5 mW/m^2 in summer and winter, respectively. However, technical means to manage UV exposure in Scandinavia are also needed in summer- and springtime.

***Keywords*—**Ultraviolet radiation, measurement, winter, summer.

I. Introduction

ULTRAVIOLET (UV) radiation is part of the electromagnetic spectrum emitted by the sun, whereas UVC rays (wavelengths of 100–280 nm) are absorbed by the atmospheric ozone, most radiation in the UVA range (315–400 nm) and about 10 % of the UVB rays (280–315 nm) reach the Earth’s surface. Both UVA and UVB are of major importance to human health. Small amounts of UV are essential for the production of vitamin D in people, yet overexposure may result in acute and chronic health effects on the skin, eyes, and immune system.

UV radiation exposure in Finland is relatively low compared to that found in many other European countries, such as Italy or Spain. However, Nordic individuals’ skin tone is often lighter than that found in other parts of Europe; thus, the risk of adverse effects from UV radiation exposure can also exist in Finland. Approximately, 30 percent of Finnish persons have skin type I-II, and most Finns have skin type III. Therefore, at least 30 percent of Finns have a relatively high risk of sunburn if they are exposed to solar radiation in summer in Finland [1]. More than 1200 persons in Finland receive a melanoma every year, which indicates a prevalence of 8–9/100,000 person [4]. The prevalence of melanomas is also increasing across the entire Western world due to many reasons; therefore, also the sunburns should be avoided. The riskiest occupations for solar radiation exposure are farming, construction, service and maintenance activities, and also many other outdoor jobs especially in summertime [5]–[7].

It is a popular misconception that only light-skinned people need to be concerned about overexposure to the sun. Darker skin has more protective melanin pigment, and the incidence of skin cancer is lower in dark-skinned people. Nevertheless, skin cancers do occur within this group, and unfortunately, they are often detected at a later, more dangerous stage. The risk of UV radiation-related health effects on the eye, and immune system is independent of skin type [8], [9]

The Finnish exposure limit value at work for weighted ultraviolet radiation (UV-BC) is 30 J/m^2 for eight hours of exposure (based on European directive (2006/25/EU)) [2], which, however, is not applicable to solar radiation. The American Conference of Industrial Hygienists (ACGIH) has recommended an instantaneous value of 1 mW/m^2 over eight hours that equals to dose of 30 J/m^2 over eight hours [3]. In Finland, it is a typical to measure ultraviolet radiation, so there is a need to develop both measurement facilities and disseminate information via social media. Nowadays, there are simple UV index meters available, but the user must know what the indices mean, what the skin types are, what the sun protection factor means, and how clothing and sunglasses diminish exposure to solar radiation. The UV index is a global index that in Finland is at a maximum of about 5–7, whereas globally, the index varies 0–18 [10].

The aim of our study was to investigate UV exposure in Finland through sample measurements in winter and summer. Our aim was to get basic data for exposure evaluation. There are many science areas to evaluate UV exposure. This study focuses only to human health and safety.

II. Methods

A. Meters

We measured UV-BC weighted radiation with a Solar PMA2100 meter equipped with a safety probe PMA2120 (factory-calibrated in 2016). We also measured UV index by using a new Oregon Scientific EB612 meter.

B. Measurement Sites

Fig. 1 shows an example of our measurement site on a summer day, and Fig. 2 shows the measurement site on a winter day. Fig. 3 shows measurements on a summer day, and Figs. 4 and 5 show measurements on a winter day.

The measurements were carried out in July and November. In the Tampere region (latitude 61.5 degrees), the sun rises in July at 04:25 and sets at 22:36, and in November rises at 08:36 and sets at 15:43.

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Fig. 1 Measurement site on a summer day

Fig. 2 Measurement site on a winter day

Fig. 3 Measurements of UV in summer

Fig. 4 Measurements of UV in winter

III. Results

A. Measurements in Summertime

Table I shows the measurement situation in each case. We measured instantaneous values of irradiance to be 2–150 mW/m^2 (Table II). The measurements were taken in the middle of the day (11:00 – 15:00) on July 20 in Tampere Region, and these values represent the Finnish maximum values.

Fig. 5 Measurements of UV-index in winter

TABLE I
MEASUREMENT SITUATION IN SUMMER

Case	Measurement Situation
1	cloudy
2	sunny
3	sunny
4	towards the sun
5	away from the sun
6	towards the ground
7	reflection from aluminum paper on ground
8	in shadow, the sun behind clouds

TABLE II
MEASUREMENT SITUATION IN SUMMER

Case	UV measurements mW/m^2
1	55
2	112
3	127
4	148
5	5.0
6	2.0
7	3.0
8	55…65

Fig. 6 shows UV index measurement results over a July day. Maximum value for the index was 7, and the value was more than 6 over 4.5 hours.

B. Measurements in Wintertime

We measured instantaneous values of irradiance to be 3–6.5 mW/m^2 (Table III). The measurements were taken in the middle of the day (10:00 – 15:00) on November 15-16 in the Tampere region, and these values represent Finnish minimum values (cloudy skies, short days). Value for the UV index was 0.

Table IV shows illumination, ranging 1600–3200 lx, which shows how dark the winter days can be. No direct sunlight, partly cloudy weather existed.

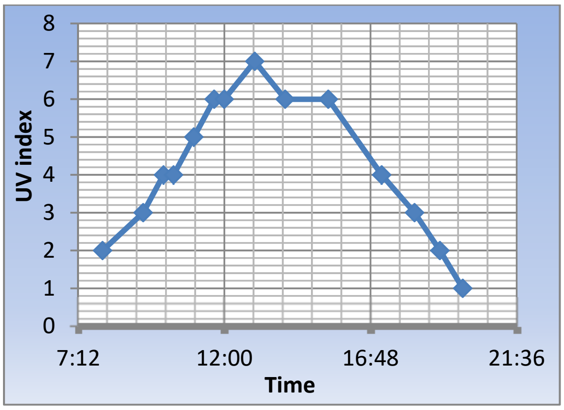

Fig. 6 UV index measurement results over a summer day

TABLE III
INSTANTANEOUS UV MEASUREMENTS IN WINTER

Time (at 15 November 2017)	UV, mW/m^2	UV index
time 14:10	5.1–6.0	0
time 14:25	3.9–4.4	0
time 14:40	4.4–4.7	0
Time (at 16 November 2017)		
time 10:10	3.0–3.5	0
time 10:20	3.6–4.0	0
time 10:30	6.0–6.5	0
time 10:40	5,5	0

TABLE IV
INSTANTANEOUS ILLUMINATION IN WINTER

Time (at 15 November 2017)	Illumination, Lx
time 14:25	2000
time 14:40	1600–1800
Time (at 16 November 2017)	
time 10:10	1800
time 10:20	2300
time 10:30	3600
time 10:40	2500

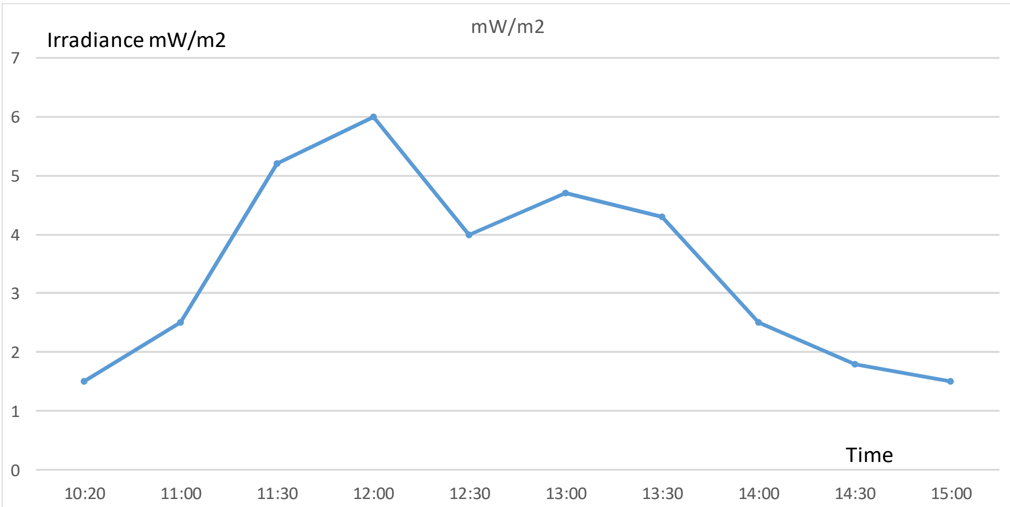

Fig. 7 Measured UV irradiance in Tampere region on November 17th

IV. DISCUSSION

If we calculate the daily dose from our measurements, we receive an exposure of around 30 J/m^2, depending on exposure duration, which is about the same as the Finnish exposure limit value at work for weighted ultraviolet radiation (UV-BC) (based on European directive (2006/25/EU) [2]. Hence, it is probable that these values are not exceeded at other times of the day or during the year. In any case, it means that limit values are not generally exceeded in Finland, and when they are, they are only exceeded for short periods of time.

The instantaneous values of irradiance were between 2–150 mW/m^2 in summer and 3–7 mW/m^2 in winter. This exceeds, for example, the maximum value recommended by the ACGIH [3], which is 1 mW/m^2. This also means that in Finland, the dose at which a light-skinned person is at risk of erythema can be reached and exceeded if protective measures, such as entering a shaded area or applying sunscreen, are not employed. In Finland, the recommended midsummer exposure is less than one hour for type II skin. Similar evaluation can be reached using the UV index [11], [12], and if the index exceeds a value of 3, then actions must be taken. Therefore, technical means are needed in Scandinavia against UV sun exposure during spring and summer. These means are the use of sun protective lotions, reasonable clothing, sunglasses, avoiding direct sunshine in the midday, using shadow, etc. Clouds and shade reduced the intensity of UV radiation to half, which means that the exposure time can be doubled, or the risk can be reduced to half. [9]. WHO lists following personal actions [9]:

- **Limit time in the midday sun:** To the extent possible, limit exposure to the sun during 10 a.m. and 4 p.m.
- **Watch for the UV index:** This helps you plan your

outdoor activities in ways that prevent overexposure to the sun's rays (Fig. 3). Take special care to adopt sun safety practices when the UV Index predicts exposure levels of moderate (index 3–5) or above.

- **Use shade wisely:** Seek shade when UV rays are the most intense.
- **Wear protective clothing:** A hat with a wide brim offers good sun protection for your eyes, ears, face, and the back or your neck. Sunglasses that provide 99 to 100 percent UV-A and UV-B protection will greatly reduce eye damage from sun exposure. Tightly woven, loose fitting clothes will provide additional protection from the sun.
- **Use sunscreen:** Apply a broad-spectrum sunscreen of SPF 15+ liberally and re-apply every two hours, or after working, swimming, playing, or exercising outdoors.

V. Conclusion

To conclude, we made a small case analysis on UV exposure dose, irradiance, and UV-index, and we noticed that they work in harmony when evaluating the practical exposure limitations against solar radiation in Finland. The UV dose in the middle of Finland is less than 30 J/m^2 (over a day), irradiance less than 200 mW/m^2, and UV index less than 7.

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