Original Article

Seasonal Variation in Exposure Level of Types A and B Ultraviolet Radiation: An Environmental Skin Carcinogen

Rafieepour A, Ghamari F[1], Mohammadbeigi A[2], Asghari M[3]

Department of Occupational Health, Arak University of Medical Sciences,Arak, [1]Department of Occupational Health, Hamadan University of Medical Sciences, Hamadan, [2]Department of Epidemiology and Biostatistics, Faculty of Health, Research Center for Environmental Air Pollutants, Qom University of Medical Sciences, Qom, [3]Department of Occupational Health Tehran University of Medical Science, University of Tehran, Tehran, Iran

Address for correspondence:
Dr. Abolfazl Mohammadbeigi,
Department of Epidemiology and Biostatistics, Faculty of Health, Qom University of Medical Sciences, Qom, Iran.
E-mail: beigi6o@gmail.com.

Abstract

Background: The main source of ultraviolet radiation (UVR) is the sun, affecting organs such as the skin, eyes, and immune system. According to American Conference of Governmental Industrial Hygienist (ACGIH) reports, the amount of UVR reaching the Earth's surface is increasing yearly and is responsible for an increase in solar radiation-related diseases. **Aims:** To investigate the amount of UVR reaching the Earth's surface and understand the risk of UVR on disease among outdoor laborers in one of the central provinces of Iran. **Materials and Methods:** Arak city was divided into two geographic areas, and the weekly measurement of UVR was done in three locations) asphalt, grass and rooftop). To measure UVR, Hanger UV spectrometer, standard deviation (SD8-A), and SD8-B detectors were used. Amounts of UVR for a consecutive year and varying weather conditions were measured. Finally, values obtained were compared to ACGIH standards. **Results:** The minimum and maximum levels of UV type A radiation occurred in April 1.27 (0.724) W/m^2 and September 7.147 (4.128) W/m^2, these figures for UV type B were in March–April 0.005 (0.003) and September 0.083 (0.077). The maximum UVR is received between 11 and 15 o'clock. **Conclusions:** In the central cities of Iran, the minimum and maximum UV type A and B is received in March–April and in September, respectively. Based on the results, the angular position of the sun in the sky, cloud cover, and height from ground level affected the amount of UVR received, but the geographic locations studied did not.

Keywords: Outdoor Job, Skin Cancer, Carcinogen, Ultraviolet radiation, Ultraviolet A, Ultraviolet B, Iran

Introduction

Ultraviolet radiation (UVR) is composed of electromagnetic waves at a wavelength range of 100–400 nm. Ultraviolet radiation can be further divided into three types: UVA (320–400 nm), UV type B (290–320 nm), and UV type C (200–290 nm). Ultraviolet radiation and its effects on the skin is an important matter because it causes aging of the skin and sunburn development, produces precancerous and cancerous lesions, and is an immunosuppressant.[1] The estimated occurrence rate of skin cancers in different studies displayed 10–15 new cases/100,000 population because of the bright sunlight during most seasons and the direct exposure to the sunlight in most Iranian cities.[2,3]

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Among the natural factors, the sun is one of the main sources of UVR on Earth. Intensity of such radiation is of such an extent that life would perish without a protective shield.[4] Ultraviolet radiation is the most important factors of skin cancer and increases the global burden of cancer.[5] Fortunately, lethal radiation is absorbed by the different layers of the atmosphere and the ozone layer, in particular.[1] Approximately 100% of UV type C and 90% of UV type B radiation is absorbed by the ozone layer, moisture, oxygen, and carbon dioxide in the atmosphere.[1,6] Therefore, approximately 99% of UVR reaching the Earth's surface is A type. The reason for the lack of attention to UV type C is because of its trivial dosage of radiation to the Earth's surface.[7] In addition, there are other factors such as varying atmospheric conditions, height, sea level, angle of radiation, latitude, and season of the year that the influence dosage of UVR.[5-8] Taking into account daily exposure to sunlight and UVR as well as the increase of a number of open-air occupations, an increasing number of studies are conducted in the field each year.[8-11] According to the World Health Organization (WHO), there is an increase in dosage of UVR reaching the Earth's surface every year and this is the main cause of the increase of diseases caused by solar radiation.[1] It is estimated that more than 90% of malignant melanomas and other types of skin cancer all around the world are caused by over-exposure to solar UVR.[12,13] Although additional repugnance were expressed about positive and negative effects of sunlight,[14] Incidences of skin cancer occurred primarily in male populations due to work-related exposure.[12,13] Some employees such as outdoor labors and taxi drivers are exposed to UV continuously. In addition, increased air pollution due to polluting industries and an increasing amount of cars on streets has accelerated the growth of the hole in the ozone layer. This process may eventuate in an increase of rate of UVR reaching the Earth's surface[15] and a consequent surge in rate of diseases such as cataract and cornea cancer,[16,17] sunburns and skin cancer.[18] Ultraviolet waves, though they are helpful in the production of vitamin D in the human body, water disinfection, and some methods of treatment are outweighed by their negative effects. These negative effects underline the necessity of controlling exposure to the radiation.[19,20]

Considering the negative effects of solar UVR and the industrial development of Arak city, the specific climate of the region, and given the rarity of similar studies on the relation between level of UVR and the population of workers in open-air condition in the city, the current study was conducted to measure the level and change of the level of radiation at different times and locations.

Materials and Methods

The study was ethically approved by Arak university of medical university, the ethical committee number is 89-79_6. This study was conducted as a cross section-analytical survey and the level of solar UVR in Arak city was measured over one year. To this end, one calibrated UV-meter (Hanger S4; made in Sweden) was used. The mobile device was connectable to detectors (standard deviation [SD8-A] and SD8-B) using a connector switch to measure A and B type of UVR. The whole set of UV-meter and the detectors weighed about 1.2 kg and the detectors were equipped with a silicon photodiodes display measuring 10 mm in diameter. Solar UV exposure dosage was examined in this study in an effort to determined exposure to radiation among outdoor laborers engaged in open-air jobs. The standard levels of exposure recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) (1.04 W/m^2 type A and 3×10^{-6} type B for 8 h exposure) were used as the criterion. To carry out the study, the city was divided into two geographical districts of Sardasht, Arak (west) and the industrial zone (north east). The reason for dividing the city was because of a concentration of industrial facilities in the two districts. Radiation levels were measured in both districts on a weekly basis over one year beginning in July 2011 and ending in May 2012. Radiation types A and B were measured by connecting special detectors to the UV-meter at three locations: An asphalt surface, a grass-covered area and at a 15 m rooftop height. The measurements were taken five times over the course of a 24 hour period, (7–9 o'clock, 9–11, 11–13, 13–15, and 15–17). To avoid an interruption of reflected UVR, the detectors were positioned in a horizontal position at one meter above the ground and ten meters away from walls of adjacent buildings, trees, and other reflective surfaces. Each measurement took about 30 seconds (the time required to have a figure fixed on the display). The measurements were carried out continuously and in varying weather conditions (cloudy, partly cloudy, and clear). This enabled the researcher to determine the effect of clouds on the radiation. The average level of radiation obtained from all measurements was calculated. The results were compared with standard levels determined by the ACGIH for occupation exposure. Moreover, minimum/maximum levels of UVR were obtained on seasonal, day and night, and location bases. All analyses were conducted with Statistical Package for the Social Sciences software, Version 16.0 (Chicago Il, USA).

Results

Our results showed that the level of A and B UVR is maximized between August and November [Table 1]. As represented in Table 1, the minimum and maximum levels of UV type A radiation occurred in April 1.27 (0.724) W/m^2 and September 7.147 (4.128) W/m^2 respectively, these figures for UV type B

Table 1: The results of UV radiation types A and B measurements basis on mean of monthly

Month	Mean (SD)	
	UV-B (W/m^2)	UV-A (W/m^2)
July	0.015 (0.013)	3.36 (2.99)
August	0.033 (0.034)	5.43 (3.79)
September	0.077 (0.083)	7.15 (4.13)
October	0.046 (0.054)	3.91 (3.24)
November	0.045 (0.047)	5.04 (3.18)
December	0.017 (0.015)	3.76 (2.69)
January	0.011 (0.006)	2.97 (1.68)
February	0.007 (0.004)	1.62 (0.97)
March	0.005 (0.003)	1.39 (0.77)
April	0.005 (0.003)	1.27 (0.72)
May	0.006 (0.003)	1.66 (0.93)
June	0.010 (0.004)	2.89 (1.73)

SD: Standard deviation, UV: Ultraviolet

were in March–April 0.005 (0.003) W/m^2 and September 0.083 (0.077) W/m^2. The dosage of UV type A in September was approximately 5.62 times of that of April and for type B the dosage in September was approximately 15.4 times more than that of March and April. Furthermore, the highest amount of A and B UVR reach the Earth between 11 and 15 o'clock of each day [Table 2]. However, our results in Table 3 show that the amount of UVR did not differ between rooftop, asphalt, and grassy locations.

Figures 1 and 2 depict the results of the comparison of UVR types A and B at the two geographical districts based on the month that the measurements were taken.

Discussion

The minimum and maximum levels of UV type A radiations occurred in April. These considerable variations might be a due to the Earth's rotation around the sun and the differing positions of the Earth relative to the sun. In addition, results of previous studies showed that the rate of UV absorber molecules in the troposphere (the lowest layer of the atmosphere) is at the minimum level during the summer when the sun radiates vertically.[21] On the other hand, spring is characterized with an increase in thickness of the ozone layer and consequently, a decrease in level of UVR crossing the atmosphere.[18] In the same way, Xia *et al*.[22] and Trabea and Salem[23] argued that the level or absorption of radiation is much lower in cold seasons compared to hot seasons. Behrooz *et al*. concluded that level of UVR in May and December is at maximum and minimum levels respectively.[24] In another study, Rostampour *et al*. maintained that the maximum level of UV type A radiation happens in September, while the minimum level occurs in December,[25] which is consistent with our results to some extent. Moreover, in Yazd study, maximum and minimum levels of UV were assigned to July and December, respectively.[26]

Table 2: The results of UV radiation types A and B measurements on the bases of hour in day

Hour	Mean (SD)	
	UV-B (W/m^2)	UV-A (W/m^2)
7-9	0.026 (0.002)	083 (1.1)
9-11	0.010 (0.004)	2.44 (1.1)
11-13	0.035 (0.04)	5.46 (3.1)
13-15	0.052 (0.07)	5.02 (3.7)
15-17	0.017 (0.02)	3.25 (2.7)

SD: Standard deviation, UV: Ultraviolet

Table 3: The results of UV radiation types A and B measurements on the bases of location

Location	Mean (SD)	
	UV-B (W/m^2)	UV-A (W/m^2)
Roof	0.024 (0.04)	3.49 (3.05)
Asphalt	0.022 (0.04)	3.33 (3.08)
Grass	0.023 (0.04)	3.40 (3.08)

SD: Standard deviation, UV: Ultraviolet

In addition, the results showed that the peak of UVR was between 11 and 15 o'clock, which is because radiation is directed to the Earth closest to a vertical angle around noon. In their studies, Rostampour *et al*.,[25] Tavakoli and Shahi,[21] and Behrooz *et al*.[24] concluded that noon is the time of the maximum level of UVR.

Taking into account that a great portion of UVR type B is absorbed by clouds, dust, and moisture in the air, the dosage of this type of radiation is at a minimum level on cloudy days. In one occasion, the detector of UV type B on a cloudy day (dark clouds) read 12–16, while a considerable reduction in the radiation type A was observed on cloudy days. This is consistent with our results and results of the Grant study.[22]

Our results also revealed that the difference between the dosage of radiation on the 15 m high roof of a building and an asphalt surface on the ground did not show a significant statistical difference. The surveys showed only few studies regarding the effect of different land coverage and height on the level of UVR. However, among them Weaver[27] showed that a considerable increase in the level of UVR occurred by changing the point of measurement from ground to the height

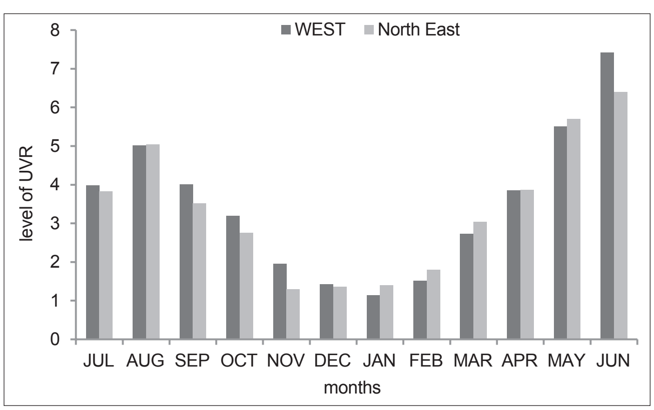

Figure 1: The results of ultraviolet type A radiation at the two geographical districts based in Arak city

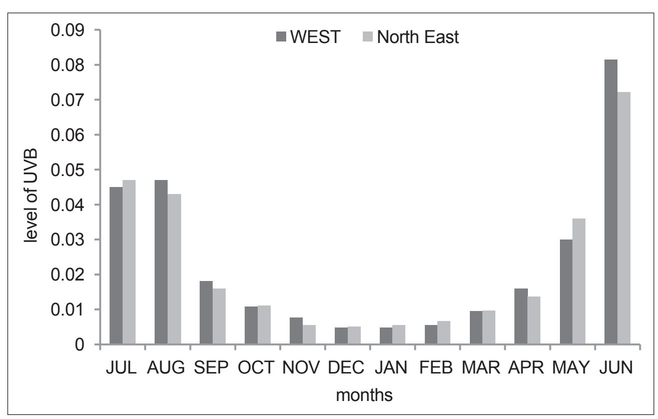

Figure 2: The results of ultraviolet type B radiation at the two geographical districts based in Arak city

of 1.5 m, whereas our study showed inconsiderable changes between ground measurements and measurements at 15 m high. Comparison between the results of measurement of UVR at Lhasa, Tibet (2007)[28] and the measurements made in the cities of Hamadan and Ahvaz confirmed considerable differences up to 96%. A probable explanation is the different heights of the points of measurement.

In addition, no statistically significant difference was observed regarding level of UVR in the two districts under study. No similar study regarding the effect of geographical positions on the level of exposure to radiation was found. However, some studies have pointed out that latitude may have an effect on the dose of exposure to UVR.

It is also noticeable that only 24.2% of UV type A and 0.2% of UV type B radiations were at the standard level recommended by ACGIH for 8 hours of work. Similar results obtained in the studies of Rostampour *et al*.[25] and Trabea and Salem[23] reported that the levels of exposures were above WHO standards. Probably, one of the main reasons for the ascending trend of skin cancer in Iran and Arak city in particular is over-exposure to UVR. Skin cancer is the most prevalent type of cancer in Iran. According to report of Iranian cancer research center Arak, with 16.5% of all cancers among men and 11.5% among women, is at the top of the list of Iranian cities.[4] Furthermore, the results showed that, in spite of the fact that lower level UV type B reaches the Earth's surface, it is up to 1000 times more destructive to skin than UV type A. In other words, this type of radiation is the leading cause of skin cancer and negative biological consequences.[29]

Conclusion

Considering the results, the level of exposure to radiation among individuals working in open-air conditions was much higher than permitted levels. Because of this exposure, this group of workers suffers a higher level of risk to skin and cataract cancer. Therefore, comprehensive studies on the effects of different levels of coverage and effects of working at different heights on levels of exposure to radiation and studies on rates of different types of disease among individuals working in open-air conditions and others studies may help improve the results of disease controlling programs and attenuation of the diseases caused by exposure to radiation. Moreover, conducting similar measurements for other cities may help the development of a neural network to estimate the level of exposure throughout the year and to base health control measures on the results.

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References

1. Rai R, Shanmuga SC, Srinivas C. Update on photoprotection. Indian J Dermatol. 2012;57:335-42.
2. Noorbala MT, Kafaie P. Analysis of 15 years of skin cancer in central Iran (Yazd). Dermatol Online J. 2007;13:1.
3. Iraji F, Arbabi N, Asilian A, Siadat A, Keshavarz J. Incidence of non-melanoma skin cancers in Isfahan. Iran J Dermatol. 2007;38:330-4.
4. Daryasari RR. Center for Disease Control and Prevention f3D communicable Islamic Diseases Unit Cancer Office. Islamic Republic Iran Ministry of Health and Medical Education Health and Treatment. Iranian Annual of National Cancer Registration Report 2009-2010. Gavan Publication; 2012.
5. Trakatelli M, Ulrich C, del Marmol V, Euvrard S, Stockfleth E, Abeni D. Epidemiology of nonmelanoma skin cancer (NMSC) in Europe: Accurate and comparable data are needed for effective public health monitoring and interventions. Br J Dermatol. 2007;156 Suppl 3:1-7.
6. World Health Organization, Protection ICoN-IR. Global solar UV index: A practical guide. 2002.
7. Leyden J. What is photoaged skin? Eur J Dermatol. 2001;11:165-7.
8. Herlihy E, Gies PH, Roy CR, Jones M. Personal dosimetry of solar UV radiation for different outdoor activities. Photochem Photobiol. 1994;60:288-94.
9. Gies HP, Roy CR, Elliott G, Zongli W. Ultraviolet radiation protection factors for clothing. Health Phys. 1994;67:131-9.
10. Gies P, Wright J. Measured solar ultraviolet radiation exposures of outdoor workers in Queensland in the building and construction industry. Photochem Photobiol. 2003;78:342-8.
11. Kimlin MG, Martinez N, Green AC, Whiteman DC. Anatomical distribution of solar ultraviolet exposures among cyclists. J Photochem Photobiol B. 2006;85:23-7.
12. Guénel P, Laforest L, Cyr D, Févotte J, Sabroe S, Dufour C, *et al*. Occupational risk factors, ultraviolet radiation, and ocular melanoma: A case-control study in France. Cancer Causes Control. 2001;12:451-9.
13. Leun J.C, Tang X, Tevini M. Environmental Effects of Ozone Depletion. United Nations Environmental Programme (UNEP); 1998. p. 1-205.
14. Reichrath J. The challenge resulting from positive and negative effects of sunlight: How much solar UV exposure is appropriate to balance between risks of vitamin D deficiency and skin cancer? Prog Biophys Mol Biol. 2006;92:9-16.
15. Bernhard GR, Booth CH, Ehramjian JC. Ultraviolet Radiation and its Influencing Factors at Barrow, Alaska, and Summit, Greenland. San Diego, USA: Biospherical Instruments Inc.; 2010.
16. Dolin PJ. Ultraviolet radiation and cataract: A review of the epidemiological evidence. Br J Ophthalmol. 1994;78:478-82.
17. Ayala MN, Michael R, Söderberg PG. Influence of exposure

time for UV radiation-induced cataract. Invest Ophthalmol Vis Sci. 2000;41:3539-43.

18. Australian Institute of Health and Welfare. Health system expenditures on cancer and other neoplasms in Australia, 2001. In Health and Welfare Expenditure Series. Canberra: Australian Institute of Health and Welfare; 2005.
19. World Health Organization. Estimating the global disease burden due to ultraviolet radiation exposure. Int J Epidemiol. 2008;37:654-67.
20. UNEP. Production and Consumption of Ozone-Depleting Substances 1986-1996. United Nations Environment Programme, Nairobi; 1998.
21. Tavakoli MB, Shahi Z. Solar ultraviolet radiation on the ground level of Isfahan. Iran J Radiat Res. 2007;5:101-4.
22. Grant, R.H. and W. Gao, Diffuse fraction of UV radiation under partly cloudy skies as defined by the Automated Surface Observation System (ASOS). Journal of Geophysical Research: Atmospheres (1984–2012), 2003. 108(D2).
23. Trabea AA, Salem I. Empirical relationship for ultraviolet solar radiation over Egypt. Egypt J Solids. 2001;24:123-31.
24. Behrooz MA, Seif F, Fattahi-Asl J, Behrooz L. Variation of cosmic ultraviolet radiation measurements in Ahvaz at different months of year. Sci Med J. 2010;9:45-51.
25. Rostampour N, Almasi T, Rostampour M, Bayat H, Karimi S. Assessment of solar ultraviolet a radiation in Hamadan City. Sci J Hamadan Univ Med Sci. 2013;19:69-74.
26. Bouzarjomehri, F. and V. Tsapaki, Measurement of solar ultraviolet radiation in Yazd, Iran. International Journal of Radiation Research, 2012. 10 (3):187-191.
27. Weaver BA. Solar Ultraviolet Radiation Exposure in Outdoor Work Environment at Bowling Green, Ohio. In Partial Fulfillment of the Requirements for the Degree of Master of Science in Occupational Health. University of Toledo Health Science Campus College of Medicine; 2008.
28. Dahlback A, Gelsor N, Stamnes JJ, Gjessing Y. UV Measurements in the 3000-5000 m altitude region in Tibet. J Geophys Res. 2007;112:1029-34.
29. Australian Government, Australian Guide for UV Protective Products; 2003. p. 1-16. Available from: http://www.arpansa.gov.au/uvrg/index.cfm. Last access date: 11.29.2014

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