Ultraviolet Radiation and Health: from Hazard Identification to Effective Prevention

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The increased exposure to ultraviolet (UV) radiation due to ozone depletion is one of the most serious global health problems. The UV exposure is known to cause skin carcinoma, cataract and deteriorated immune function, but for countries like Japan, the magnitude of health effects of UV radiation is yet to be elucidated. The International Workshop on the Health Effects of Ultraviolet Radiation was held in Tokyo, Japan, on February 17-19, 1999, in attempts to visualize the size of this problem and to identify better solutions. Through this workshop, several lines of scientific evidence were provided, which clearly show that the risk of cataract and skin cancer among people living in Japan increases with the increasing level of sun exposure. We must seek, therefore, the extent to which the UV exposure of given intensity causes adverse health effects in Japanese population. Through the workshop, the importance of preventive measure was confirmed. The scientific basis of prevention is, of course, the knowledge of dose-response relationship and the current exposure status in Japanese population. It is hoped that the communications between researchers in Japan and other countries are strengthened through this workshop. J Epidemiol, 1999; 9 : S1-S4.

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The increased exposure to ultraviolet (UV) radiation due to ozone depletion is one of the most serious global health problems. As a result of international collaborative efforts, the health effects of increased UV exposure have been studied extensively. The UV exposure is known to cause skin carcinoma. Recent studies also suggest that UV exposure is related to cataract and deteriorated immune function. The health effects of UV exposure have long been thought of as a problem of countries with high sunlight exposure. However, the public concerns are raised in other countries like Japan, since very few studies have been conducted to evaluate how the ozone depletion will affect the public health in the future. Even if the health effects are expected to be less severe on the average in countries like Japan with lower sun exposures, there might be sub-populations, who have a higher risk of UV-induced health problems due to higher genetic susceptibility or concurrent exposures to other hazards such as chemical pollutants.

In light of the needs of extensive studies on the health effects of UV exposure in Japan, the Environmental Agency of Japan decided to sponsor an international workshop. This idea was realized as "the International Workshop on the Health Effects of Ultraviolet Radiation", which was held in the National Cancer Center in Tokyo, Japan, on February 17-19, 1999. Ten speakers were invited from abroad, five speakers from Europe, three speakers from the United States, and two speakers from Australia. Fifteen Japanese speakers also presented papers on the current research topics in Japan. The topics covered by the workshop include the current evidence on the health outcomes of UV exposure forecasting the future increase in skin cancer, cataract and other diseases due to increased UV exposure, and prevention of UV-induced health problems.

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UV DAMAGES OF EYE LENS

Among the health effects of UV radiation, the studies on cataract and other disorders of the eyes have the longest history. West, after reviewing a number of epidemiological studies and UV exposure assessment surveys, concluded that ultraviolet B (UVB) exposure from sunlight is a risk factor for cortical cataract. No age group, gender or racial group appears to be immune from the lens damage associated with ocular UVB exposure. According to Hockwin et al, the UV radiation has cataract-promoting effects even if the dosage is not high enough to directly cause opacity in the lens. Sasaki et al have reported the results of an international study, which confirmed a strong correlation between cortical opacification and the level of UV exposure. Sliney conducted the geometrical assessment of ocular exposure to environmental UV radiation and suggested that geometrical factors dominate the determination of UV exposure of the eye. As pointed by West, there are simple, inexpensive steps that can be taken to reduce ocular exposure to UVB in sunlight, including wearing a hat with a brim and wearing glasses made of plastic.

SKIN CANCER AND OTHER SKIN CONDITIONS

Green et al extensively reviewed epidemiological studies on UV-related skin disorders. Descriptive as well as analytic epidemiological studies have indicated that exposure to the UV component of sunlight is the major environmental determinant of squamous cell carcinoma and solar keratoses. On the other hand, results for basal cell carcinoma and melanoma appear to be more complicated partly due to the existence of subgroups of these diseases, which do not appear to be caused by sun exposure. There might be other factors, which are yet to be included in most etiological studies to date. Woodhead et al presented the role of sunlight, mostly UV, in the induction of non-melanoma and melanoma skin cancer. While the former seems to be correlated with accumulated exposure, the causation of melanoma is more complex, and may also involve the pattern of, and age at, exposure. Both epidemiological surveys and experiments with animal models suggest that ultraviolet A (UVA), and perhaps the visible solar radiation, may induce melanomas.

Araki et al reported the results obtained from a series of dermatological surveys of skin cancers and related skin lesions, including actinic keratosis, among residents of Kasai City (34.56 degrees N) and Ie-island (25.10 degrees N) of Japan. Takahashi et al conducted geographical correlation analyses of mortality from malignant melanoma and non-melanoma skin cancer in Japan, and found no significant correlation for malignant melanoma or non-melanoma skin cancer. This indicates that the geographical correlation analysis of skin cancer mortality is not appropriate for examining UV-related health effects, partly due to the contribution of etiological factors other than sun exposure. Tanaka et al, using data from the Osaka Cancer Registry (Japan) during the period between 1964-95, analyzed the time trend of incidence of invasive cutaneous malignant melanoma.

Rettberg et al pointed out that intrinsic biomarkers were useful to estimate quantitatively the individual susceptibility to UV radiation and the accumulated individual UV burden. For the risk assessment of potentially deleterious UV effects, extrinsic biomarkers have to be developed and tested as personal biological UV dosimeters. One example for such a well-characterized biological UV dosimeter is the DLR-biofilm, which consists of spores of the bacterium Bacillus subtilis as UV sensitive target. Akiba et al confirmed that chronic sun exposure, age and male sex were strong risk factors of the wrinkle number, using a digital imaging system. By this study, the wrinkle number was shown to be a good indicator for chronic sun exposure.

IMMUNE RESPONSE

Exposure to UV also induces immunosuppression to a variety of antigens encountered following the irradiation. According to Yamamoto et al, one of such examples is the increased susceptibility of mice to malaria infection following UVB radiation. Norval et al pointed out that sufficient data were generated from animal models to construct a risk assessment model for suppression of microbial immune responses of humans induced by sunlight exposure. Irradiation of human epidermal keratinocytes induces cytokine release, with cyclobutane pyrimidine dimers playing a significant role in the process. Green et al reported that the frequencies of mutations at the hprt locus in human T-lymphocytes and translocations involving the bcl2 locus in B-lymphocytes appeared to be associated with sunlight levels over the period before the blood sample was taken. He suggested that it might be an indirect cytokine-mediated effect, and might be relevant to the possible link between non-Hodgkin's lymphoma and sunlight exposure.

MUTATION AND OTHER BIOLOGICAL RESPONSES

Van Kranen et al reported the results of their experiments using hairless mice, which provided the opportunity to study the process of UV carcinogenesis in more detail. Their experiments have yielded quantitative data on how tumor development depends on dose, time and wavelength of UV radiation. In addition, at the molecular level, the interactions between UV, specific cancer genes, and the p53 tumor suppressor gene, together with the role of DNA repair in this process, have been elucidated recently. Negishi et al reported the usefulness of Drosophila test as a model for the effects of UV radiation on higher organisms. Noda et al made a struc-
Monitoring and assessment of UV exposure, together with disease monitoring, are important activities for the prevention of UV-related health problems. Gies et al reported the activities in Australia. Ambient solar ultraviolet radiation (UVR) has been monitored around Australia by the Australian Radiation Laboratory (ARL) and its successor ARPANSA since the mid 1980's using a network of radiometric detectors and a spectroradiometer for spectral measurements, based in Melbourne. In a continent with the size of Australia, the levels vary markedly, basically following a latitude gradient increasing towards the equator but with local geographical and weather effects also evident. ARL has also conducted personal exposure studies of various population groups in collaboration with other research centers to gather information on what fraction of the ambient UVR people receive. ARL also undertakes studies on the UVR protection provided by sunscreens, clothing, hats, sunglasses and other materials in an attempt to improve UVR protection used by the public.

CONCLUSION

Japanese people have long adopted the so-called sun-seeking behavior, believing that the sun exposure is essential to maintain our health. Some people even thought, without clear scientific evidence, that Asians were immune to sun exposure. Through this workshop, however, several line of scientific evidence were provided, which clearly showed that the risk of cataract and skin cancer among people living in Japan increased with the increasing level of sun exposure. In particular, the dramatic rise in skin cancer among Japanese-Americans in Hawaii exposed to high-intensity irradiation raises big concerns. The hazard of UV exposure has been successfully identified by this workshop. We should also realize, on the other hand, the fact that we cannot live our daily life without being exposed to the solar radiation. We must seek, therefore, the extent to which the UV exposure of given intensity causes adverse health effects in Japanese population. Thus, the next step we should proceed is the quantitative dose-response analysis of UV-related health effects in Japanese population. It was clearly shown by the participants from abroad that a precise exposure dosimetry is essential for dose-response assessment. The interaction of UV exposure with other environmental and host factors should also be taken into account, since a low UV exposure could exert visible health effects when other agents coexist.

Through the workshop, the importance of preventive measures was confirmed. We could learn from other countries on Authors fault preventive measures which are currently underway. The scientific basis of prevention is, of course, the knowledge of dose-response relationship and the current exposure status in Japanese population. In this regard, we could also learn from other countries how they are utilizing the knowledge on hand to implement effective and feasible preventive measures against UV exposure.

Finally, it should be noted that the ozone depletion has continued to be the first and largest global health problem, which researchers of various disciplines in the world should collaborate to fight against. Through the stimulating discussions during the workshop, the participants reached a conclusion that the current level of understanding on the health problems caused by ozone depletion and increased UV exposure is far from satisfactory. It is also hoped that the communications between researchers in Japan and other countries was strengthened through this workshop.

REFERENCES

8. Takahashi, K, Pan, G, Feng, Y, Ohtaki, M, Watanabe, S, Yamaguchi, N, Regional correlation between estimated UVB levels and skin cancer mortality in Japan. J...


