Preventing Melanoma with the Help of Occupational Physicians

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Abstract: Melanoma incidence is increasing constantly worldwide in recent years: 132,000 melanoma skin cancers occur globally each year (WHO-INTERSUN). Despite this, no adequate evidence regarding the role of cumulative solar UV exposure in inducing the skin cancer has been provided. Recently, some studies appear to indicate that, also in patients with melanoma history, the habit of completely avoiding sun exposure is not a positive prognostic factor. According to IARC monograph published in 2012, evidences regarding UV risk factors for melanoma are the intermittent UV exposure with recurrent sunburns, especially in childhood and adolescence.

According to these findings, various studies on occupational exposure to solar radiation (SR) failed to find an association between the performance of an outdoor job and the risk of melanoma. Recently, in Italy melanoma due to SR exposure has been erased from the national list of occupational diseases (D.P.R. 1124/65, last modification in 2014). But, in Europe an occupational health surveillance is needed for workers exposed to Artificial UV radiation according to EU Directive 2006/25/CE, and a skin examination for these workers is suggested, but quite paradoxically there are not similar indications for workers exposed to natural UV radiation.

Considering the great number of outdoor workers employed in Europe, at least 14 million according to OSHA, and worldwide, the consideration of occupational solar radiation exposure as a specific professional risk requiring the health surveillance of exposed workers will be very helpful in order to prevent melanoma and other UV related diseases.

Keywords: Malignant melanoma, occupational cancer, solar radiation, outdoor work, UV exposure prevention.

SOLAR RADIATION EXPOSURE AS AN OCCUPATIONAL RISK

The Sun represents the main exposure source for all the frequency bands of optical radiation, that is the part of the electromagnetic spectrum ranging between 100 nm and 1 mm, including ultraviolet (UV) radiation. The UV radiation (UVR) is further divided into UV-A (wavelength 380-315 nm), UV-B (315-280 nm) and UV-C (280 - 100 nm) [1]. The atmospheric gaseous components, in particular the ozone, partially absorb UVR: all wavelengths of less than 290 nm, and so all the UV-C and a significant part of the UV- B are blocked. Due to the atmospheric filtering effect, the SR reaching the Earth surface is composed only for the 5% of UVR, but the health risk related to this optical radiation band is relevant, because UVR is able to induce severe adverse health effects, both acute and chronic, particularly to the skin and the eyes [2]. It has to be noted that both UV radiation and SR have been classified by IARC as human carcinogens, group I [3].

Various methods can be used to evaluate SR exposure in workers. In radiometry, among the physical quantities adopted to measure the SR exposure, there are the irradiance and the radiant energy. Irradiance is the radiant flux received by a surface per unit area, generally expressed in watt per square meter. Radiant energy is the energy of electromagnetic radiation emitted by a source into the surrounding environment, measured in Joules. However, the effectiveness of SR in inducing biological effects varies in function of the wavelength and of the spectral composition. Therefore, in order to compare exposures with different spectral compositions, and consequently to determine comparable risk levels, the effective quantities derived from the previous mentioned radiometric physical quantities are used, and they are respectively called effective irradiance (watts eff / m^2) and effective radiant exposure (joules eff / m^2) [4].

A simplified measure of solar UV irradiance is represented by the UV index (UVI), an estimation of the risk of sunburn for different geographic regions adopted by the World Health Organization (WHO) in 1994. UVI is a linear numeric scale, ranging from 1 to 11+: the higher the value, the greater the potential for skin and eye damage. Above a score of 3, the use of sunscreen protections is recommended. Considering the linearity of this scale, it can be said that, as in example, one hour of exposure at index 3 is approximately equivalent to a half-hour at index 6, but certainly individual factors have also to be considered in evaluating skin exposure. The calculation of the UVI is weighted for the UV wavelengths to which the skin is most sensitive, according to the CIE action spectrum, and so UVI represents a number linearly related to the intensity of sunburns produced by UVR at a specific place. It has also to be considered that the most dangerous UVR bands reaching the skin are that among 295 to 325 nanometers (nm) of wavelength, because the vast

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majority of UVR with a shorter wavelength, even if they have a higher skin penetration and damage power, are absorbed by the Earth atmosphere, in particular by the ozone layer [5].

Other quantities with a clinical significance used to evaluate UV exposure are the “Minimum Erythemal Dose" (MED) and the “Standard Erythemal Dose” (SED). The MED is defined as the erythemal radiant exposure that produces a just noticeable erythema on a single individual's previously unexposed skin [6]. It is a subjective measure, depending on many variables, including individual photo-type, as in example Fitzpatrick skin photo-type evaluating the sensitivity to solar skin damage, varying from type I, that identifies subjects with low levels of melanin pigments and a pale white skin, blue or green eyes and blond or red hair who always experience sunburns and never become tanned, to type VI, where the individuals with dark brown or black skin, never been sunburned and always tanned, are included [7]. The SED is equivalent to an erythemal radiant exposure of 100 J/m^2 and it is a standardized – taking into account also individual sensitivity to the damage - measure proposed by the International Standards Organization (ISO) and the Commission Internationale d'Eclairage (CIE) [8].

These physical quantities are generally applied to measure an acute exposure of few hours or few days. In particular, radiometric physical quantities are obtained with spectroradiometer and dosimeter, evaluating the exposure of an environment where a worker is performing is activity, often being worn by the subjects. Among the most used personal dosimeters there are the polysulphone dosimeters and the more recent electronic dosimeter [9, 10].

According to recent studies, outdoor workers have a relevant acute exposure to SR. The highest exposure to UVR have been registered among farmers, construction and maritime workers [11]. For example, regarding construction workers, recent studies have showed that they are exposed to SR with a SED of 9.9 in Australia [12]; they have a daily dose ranging from 11.9 to 28.6 SED depending on the altitude in Switzerland [13] and they are exposed to 6.11 SED in Spain [14, 15]. For farmers, high exposures to UVR have been reported in New Zeland, Australia, Austria, and in Italy, where it has been collected a measure of 1870 Joule / m^2 in April [16-18]. With regard to other outdoor workers, in a Spanish study a personal exposure dose of 413 and 1143 Joule / m^2 respectively in a group of gardeners and lifeguards have been measured [19]. Lifeguards have been investigated also in an Australian study and their exposure ranged from 6.9 to 1.7 SED [20].

The measures reported in these studies are useful to evaluate occupational risk due to SR exposure in different professional activities, but they are a measure of acute exposure. For research and preventing purposes, in order to associate cumulative occupational SR exposure with the possible occurrence of chronic adverse health effects, such as malignant melanoma, more detailed evaluations of the exposure are needed. Both semi-quantitative strategies using acute objective measurements and long term environmental exposure data available through specific databases and also subjective investigation systems, such as questionnaires, can be applied to reconstruct long term history of occupational solar radiation exposure [21]. Only few studies in scientific literature have applied these methods, because they required big samples of workers and very detailed questionnaires integrated with personal and environmental exposure measures [22]. This point may be a possible reason of the lack of knowledge on the possible associations between different UV exposure levels in various working activities, considering possibly also the particular characteristic of the activities (where and when the activities are performed, which are the postures adopted from the workers, the presence of reflective phenomena, etc) and the occurrence of different types of malignant melanoma, even early stage dysplastic nevus [23].

EPIDEMIOLOGY OF MALIGNANT MELANOMA IN OUTDOOR WORKERS

Malignant melanoma incidence has increased constantly worldwide in recent years, e.g. an average 4 per cent every year in the U.S. [24], and the incidence of this skin cancer in individuals with a fair skin photo-type increases dramatically with a decreasing in latitude: the highest recorded incidences occur in Australia, about 10-20 times higher than the incidences in Europe for people with the same photo-type. Currently, the melanoma incidence worldwide is approximately 132,000 cases per year (data from WHO – INTERSUN programme, http://www.who.int/uv/health/uv_health2) [25]. Considering also non-melanoma skin cancers, it is estimated that one in every three cancers diagnosed is a skin cancer and in U.S. one in every five Americans will develop skin cancer in their lifetime [24, 25].

As ozone levels are depleted, the atmosphere loses more and more of its protective filter function and more solar UVR reaches the Earth's surface. It is estimated that a 10 per cent decrease in ozone levels will result in an additional 4,500 melanoma skin cancer cases. Considering the mortality, according to recent studies the number of death per year for malignant melanoma are approximately 26,000 in males and 21,000 in females [25].

Considering as in example the European Union situation, the EUCAN network, founded in 2009 with the support of the Cancéropôle Lyon Auvergne-Rhône-Alpes (CLARA), the European Network of Cancer Registries (ENCR) and the WHO International Agency for Research on Cancer (IARC), esteemed in 2012 in the European Union (27 States) 82075 malignant melanoma per year, with an age-standardized incidence rate per year of 13 x 100,000 inhabitants, while the mortality is of 15724 per year and the five year prevalence of the disease is 323,467 [26].

It is estimated that about 14.5 million workers in Europe, the vast majority of which (90 %) are generally male, are exposed to SR for at least 75 % of their working time. Data from the European Agency for Safety and Health at Work show that UVR is a carcinogen in 36 employment sectors of the European Union and for 11 of these ranks first among the other carcinogens [11].

Considering these data and comparing them with the incidence and prevalence data, we can affirm that the 5-years prevalence of malignant melanoma in outdoor workers is approximately at least 7,000 in Europe (0.05 %), that means that 1 outdoor worker (OW) on 2,000 OW eventually medically examined by an occupational physician may be affected from a malignant melanoma.

Looking now at the evidence of association between malignant melanoma and long-term UV exposure, the kind of exposure that can be considered typical of OW, the results of one of the biggest meta-analyses published in 2005 show a strong association between the presence of malignant melanoma and of actinic tumors, sunburns and intermittent sun exposure. On the contrary, low association was found with regard to “total sun exposure” variable, and no association for “chronic sun exposure” variable. But it has to be noted than in many studies, like for example the studies reviewed from the IARC working group for the publication of the monograph “100-D” in 2012, actinic keratosis was considered as a measure of chronic SR exposure. Furthermore, in the IARC monograph it is reported that *“…the causal association of cutaneous melanoma and solar exposure is established, this link has become clearer in the last decade or so through the observation of the site-specific heterogeneity of melanoma, the lower-than average phenotypic risk for skin carcinogenesis among outdoor workers, and the recognition that the different associations of melanoma with sun exposure observed among Caucasian people at different latitudes around the world correlate with marked variations in sun exposure opportunity and behavior … ”.* IARC recognizes among the UV risk factors for melanoma the intermittent UV exposure with recurrent sunburns, especially in childhood and adolescence, but the Working Group noted that the omission from many studies reviewed in the monograph of the “lentigo maligna melanoma” (LMM) may potentially result in an underestimation of the association between SR exposure and MM of head and limbs. According to the CAREX (CARcinogen EXposure) database, which was established with support from the Europe Against Cancer Programme of the European Union, solar radiation is listed as a Group I carcinogen, being sufficient to cause NMSC and malignant melanoma in outdoor workers [3; 26-30].

Nevertheless, quite surprising, various studies on occupational exposure to solar radiation (SR) failed to find an association between the performance of an outdoor job and the diagnosis of malignant melanoma [23, 31]. As in example, a study performed in Germany in 2009 on 454 subjects affected by malignant melanoma and other 2 thousands of subjects affected by non-melanoma skin cancers, the Authors did not find any positive association between the presence of the disease and the occupation of the workers [32].

LEGISLATION AND REQUIREMENTS FOR THE HEALTH SURVEILLANCE OF UV EXPOSED WORKERS

On a general basis, usually the legislation on safety and health at work contemplates that all the occupational risks possibly determining an adverse health effect in exposed workers have to be adequately managed and prevented. This is a quite general affirmation, and usually the national legislators provide indications for the specific occupational risks considered (as in example indications to prevent occupational exposure to noise that may induce hearing loss in workers). Considering as in example the European Union situation, the current legislation on health and safety at work recognizes as an occupational risk, the risk related to artificial optical radiation exposure, including UV, according to the European Directive 2006/25/EC. This directive has also established a series of occupational limit values that have not to be exceeded for workers exposed to artificial UV. The lowest limit, considering the various frequency bands of incoherent artificial UVR, is of 30 Joule / m^2 of effective radiant exposure (H*eff*), considering a daily exposure of 8 hours. This limit set in the European Directive 2006/25/EC can prevent the non-cancer adverse effects of non-coherent artificial optical radiation with a wavelength of 180-400 nm (UVA, UVB and UVC), in particular to the lens and to the skin [33].

After the emanation of the directive, the European Commission published a "Non-binding guide to good practice for implementing Directive 2006/25/EC". In the introductive part of the guide it is clearly affirmed that *"…Sources such as volcanic eruptions, the sun and reflected solar radiation from, for example, the moon, are clearly excluded. … "*. So, the European Directive can't be applied for outdoor workers, even if we can theoretically compare the exposure limit of 30 Joule per square meter with the exposure levels measured in OW, and we can find out that OW SR exposures often largely exceeded these daily limit values. Considering the sources of occupational UV exposure, the non-binding guide identifies various sources, such as germicidal sterilization lamps, fluorescence lamps, arc welding, UVB sunbeds, phototherapy lamps and others. If we think to the number of workers exposed to these kind of sources, we can affirm that they represent a very small percentage compared to the number of OW exposed to solar UV. But considering the possible adverse effects to be prevented, the guide contemplates skin cancers, including malignant melanoma, and it gives also indications for the medical examination of exposed workers: "…*A medical examination should be made available to a worker if it is suspected or known that they have been exposed to artificial optical radiation in excess of the exposure limit value. A medical examination should be carried out if a worker is found to have an identifiable disease or adverse health effects, which is considered to be a result of exposure to artificial optical radiation. A challenge for implementing this requirement is that many adverse health effects may be due to exposure to natural optical radiation…*." [33]. Health surveillance of exposed workers should be carried by a doctor, or a specifically trained occupational health professional, or a medical authority responsible for health surveillance in accordance with national law and practice. In many Nations, such as Italy and various other European countries, there are trained doctors called Occupational Physicians (OPs), who are in charge of periodically examine the workers of a company exposed to specific occupational risks. In order to prevent work-related health effects, the OPs may require specific examinations, including dermatologic visits, in particular cases. Considering occupational UV exposure, the OP may indicate a specific health surveillance protocol that include a dermatologic examination of the exposed workers, with a periodicity based on the presence of skin alterations and/or a particular skin sensitivity (e.g. workers with fair photo-types, Fitzpatrick I or II). OPs have also relevant preventive roles in informing and training the workers on the health consequences of occupational risks, and the can indicate specific preventive measures, such as, for example, the use of adequate protective clothes and hats.

Quite paradoxically, even if the "natural optical radiation" occupational risk is currently not specifically recognized in Europe, many European countries include UV induced skin cancers in the official lists of "occupational diseases", defined as diseases that may be certified as "professionally induced" for insurance or legal purposes. Reporting as in example the Italian situation, the Italian Workers´ Compensation Authority (INAIL) registers all the cases of occupational skin diseases notified by physicians, based on occupational diseases lists (D.P.R. 1124/65, last modification in 2014), and publishes national and regional statistics on an annual basis. Despite the fact that occupational skin cancers should be notified, the numbers reported are still very low: one of the possible reason is that the health surveillance for UV exposure in outdoor workers is not mandatory. Nevertheless, recently in 2014 in Italy malignant melanoma due to SR exposure was erased from the national list of occupational diseases [34-38].

CONCLUSIONS

There is still some lack of knowledge on the association between malignant melanoma and cumulative occupational SR exposure. Maybe only some groups of outdoor workers (OW) have an increased risk, for example those with intermittent high exposures and those with particular sensitivity for skin damage (e.g. Fitzpatrick photo-type I or II). But for sure the performance of outdoor jobs represents one of the major factors influencing individual UV exposure and so it increases the likely of a chronic UV skin damage in these workers. According to these considerations, OW are certainly a work category with relevant occupational risks and they have to be periodically examined by an occupational physician (OP), in order to prevent work-related adverse health effects. The OPs usually establish a health surveillance protocol in order to monitor the health status of workers, considering specific medical examinations according to the specific occupational risks. In case of occupational UV exposure, the OPs may require a specific dermatologic examination, that, considering the high number of OW worldwide, could be highly effective in reducing the incidence of malignant melanomas, possibly determining a reduction in mortality rates and of the costs for the national health-care systems, because of the early stage of the skin cancers diagnosed by dermatologists with the help of occupational physicians. For these reasons the recognition of solar UV exposure as a specific occupational risk is fundamental for the prevention of malignant melanoma.

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