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The Role of Outdoor Activities in The Development of Malignant Melanoma: A Literature Review

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ABSTRACT

Malignant melanoma (MM) is a highly aggressive skin malignancy primarily linked to ultraviolet radiation (UVR) exposure. Outdoor activities increase the risk of MM due to prolonged UVR exposure, which can suppress the immune system and promote cancer development. This literature review evaluates the correlation between outdoor activities and the development of MM, emphasizing the role of UVR in inducing DNA damage, immunosuppression, and genetic mutations. Factors such as genetic predisposition, skin phenotype, and occupational exposure further amplify susceptibility to MM. Acute and chronic UVR exposures influence melanoma development differently, with intermittent intense exposure posing the greatest risk. Preventive strategies, including the use of broad-spectrum sunscreens with a minimum SPF of 30, protective clothing, and sun-safe practices, are highlighted as essential measures to mitigate MM risk. Early detection methods, such as self-administered questionnaires and routine skin examinations, are discussed to improve diagnostic accuracy and treatment outcomes. This review underscores the necessity of public health awareness and targeted interventions to address the rising incidence of malignant melanoma globally.

Keywords: malignant melanoma; ultraviolet radiation; outdoor activities.

INTRODUCTION

Outdoor activities refer to actions or events conducted in outdoor settings [1], [2]. Individuals who frequently engage in outdoor activities have a high risk of malignant melanoma due to increased Ultraviolet Radiation (UVR) exposure from sunlight, which significantly contributes to skin carcinogenesis [3].

Prolonged exposure can lead to radiation effects on the body, primarily targeting the skin as the first point of contact with environmental exogenous factors. Studies have confirmed that sunlight exposure is a significant contributor to various skin disorders, including cancer [4].

Malignant melanoma (MM) has a relatively low incidence compared to other skin cancers but accounts for 75% of skin cancer-related deaths, making it the deadliest form [5]. MM commonly affects the extremities and facial regions. In light-skinned populations, ultraviolet (UV) exposure is the most significant environmental factor alongside genetic predisposition. Conversely, in darker-skinned populations, MM often occurs in sun-protected areas with reduced pigmentation [6].

UVR is a major risk factor for MM development. Its effects depend on the dose, duration, and wavelength of exposure. High doses or prolonged exposure can result in immunosuppression, creating an environment conducive to cancer progression [7]. Approximately 65% of melanoma cases are linked to UVR, which stimulates mediators that suppress systemic immunity, thereby facilitating cancer development [8].

RESULTS AND DISCUSSION

1. Outdoor Activities

1. 1 *Definition*

Outdoor activities refer to actions or events conducted in outdoor environments [1]. These activities are categorized into two types: resource-based, which relies on specific natural or physical resources, and user-oriented, which can be performed anywhere without reliance on external resources [2]. Additionally, common outdoor occupations such as farming, construction work, fishing, and law enforcement also fall under the category of outdoor activities. Older study proves the correlation between prolonged outdoor work and an increased risk of developing skin cancer. The study demonstrates that individuals exposed to sunlight for five or more years in outdoor occupations experience a significantly higher risk of various skin cancer types [3].

1. 2 *Ultraviolet Rays*

Ultraviolet radiation (UVR) is an electromagnetic wave emitted by the sun or artificial sources with wavelengths between 100–400 nm. UVR is classified into three types based on wavelength: UV-C (100–280 nm), UV-B (280–315 nm), and UV-A (315–400 nm).

Of the UV radiation reaching the earth's surface, 95% is UV-A, while the remaining 5% is UV-B [9]. The intensity of UV-A and UV-B gradually increases from 8:00 AM to midday, peaking between 11:30 AM and 1:30 PM, and subsequently declines. At midday, the sun is directly overhead, reducing the atmospheric path of sunlight by half compared to morning and evening, resulting in more intense UVR penetration [10].

• UV-A Radiation

UV-A radiation has the longest wavelength in the UV spectrum. It is present throughout the day, from morning to late afternoon. UV-A is sufficiently potent to penetrate glass and can reach the dermal layer of the skin, impacting melanocytes located in the basal layer of the epidermis [11].

• UV-B Radiation

UV-B radiation is primarily responsible for causing sunburn, with its intensity peaking at midday, unlike UV-A, which remains relatively constant throughout the day [12]. Various artificial light sources also emit UVR, contributing to an increased risk of melanoma [13].

2. Malignant Melanoma

2. 1 *Definition and Clinical Presentation*

Malignant melanoma (MM) is an aggressive tumor that originates from melanocytes with the depiction of blackish lesions on the skin [5]. Approximately 80% of MM begin with a superficial and radial growth phase. This phase is characterized by the expansion of pigmented macules or plaques displaying a heterogeneous coloration, including shades of black, brown, blue, tan, and pink. The lesions typically exhibit irregular margins with notched or renal-like contours. Initially, MM proliferates within the epidermis and subsequently invades the dermis, with the potential to metastasize to deeper tissues[14].

Malignant melanoma can develop on all parts of the body where melanocytes are present. The most commonly encountered type of melanoma is cutaneous melanoma; however, melanoma can also develop in the mucosal lining, uveal tract, and meningeal membranes [15].

2. 2 *Epidemiology*

Malignant melanoma's incident rate continues to rise annually. According to 2020 statistics by GLOBOCAN (Global Cancer Observatory), there were 325,000 new cases and 57,000 mortality worldwide [16]. MM predominantly affects middle-aged individuals, contrasting with most solid tumors. The average diagnosis occurs at 57 years, while mortality occurs at 67 years. However, the rate increases linearly between 15 and 50 years, followed by deceleration, particularly among females. This shift suggests an increasing rise in MM incidence among children and adolescents [17].

In populations with fair skin, exposure to ultraviolet (UV) radiation is the most significant environmental factor, along with genetic predisposition, contributing to the development of MM. However, in populations with darker skin, MM tends to arise in areas of skin that are not exposed to sunlight, specifically in regions with less pigmentation [6].

2. 3 *Etiology*

There are many factors that contribute to the development of malignant melanoma, with two key factors being genetic predisposition and sunlight exposure [15].

• Sunlight Exposure

Sunlight exposure, containing ultraviolet rays (UVR), is the primary environmental factor contributing to melanoma development. Intensive and intermittent exposure poses the highest risk for melanoma compared to prolonged and continuous exposure [15]. This is due to the effect of UVR that stimulates keratinocytes and will then release interleukin-10 (IL-10) into the circulation, an immunosuppressive cytokine, leading to immunosuppression and increased tumor risk [7]. Individual measurements of sun exposure vary between studies but are generally classified as "intermittent" (short, intense exposure through activities like sunbathing, outdoor recreation, and vacations in regions with strong sunlight), "chronic" (sustained exposure due to occupational settings), and "total" (a combination of intermittent and chronic exposure) [18]. Intermittent, intense sun exposure presents a greater risk factor for the development of MM than chronic exposure [19].

• Skin Phenotype

Skin phenotypes are a key determinant of skin sensitivity to UVR. The minimal erythematous dose (MED) is defined as the amount of UVR that induces visible erythema within 24–48 hours after exposure. MED is assessed based on the appearance of erythema and edema on the skin. In individuals with low pigmentation or skin phenotype I-II, the MED value is significantly lower, indicating greater sensitivity to sunlight [20]. Individuals with skin phenotypes I-II have a two- to threefold higher risk of developing melanoma compared to those with phenotypes V-VI. This highlights the critical role of skin pigmentation in protecting against melanoma [15].

2. 4 *Pathogenesis*

Ten to fifteen percent of melanomas are familial or genetic, with individuals having fair skin, blonde or red hair, and difficulty tanning being at higher risk due to molecular defects in tumor suppressor genes and oncogenes [14]. MM has one of the highest mutation rates among cancers, with UVR causing oxidative damage by stimulating melanin production [21]. UVR is DNA-damaging, carcinogenic, inflammatory, and immunosuppressive, thus contributing significantly to MM development [15]. Particularly, UV-A can cause malignant transformation of melanocytes, either through direct mutations in proto-oncogenes and tumor suppressor genes (e.g., TP53, NF1, PTEN) or by converting nevi with BRAFV600E mutations into malignant cancer due to additional genetic changes like TERT and CDKN2A mutations [22].

3. The Role of Outdoor Activities in The Development of Malignant Melanoma

Acute UVR exposure can increase T-cell proliferation, whereas chronic exposure can lead to changes in cytokine production. This highlights the connection between UVR exposure, outdoor activities, and the development of malignant melanoma. UVR exposure can cause immune suppression, which is influenced by factors such as dose, duration, and wavelength. High doses and prolonged exposure can lead to immunosuppressive conditions [7].

In a previous study, cumulative sun exposure in individuals engaged in outdoor activities increases apoptosis (Bax/Bcl-2 ratio) in CLA+ T-lymphocytes in peripheral blood, leading to immunosuppressive effects [8]. This condition elevates the risk of developing malignant melanoma. Consequently, outdoor workers are at a higher risk compared to indoor workers who spend less time being exposed to UVR [13].

However, in other studies, intermittent intense sun exposure is a more significant risk factor for melanoma compared to chronic exposure [19]. Intermittent intense exposure carries a higher risk than low-level chronic exposure, even when the total UV dose is equivalent [13]. This concept is further supported by studies on high-intensity occupational sun exposure, which often show a reduced melanoma risk in individuals less sensitive to sunlight, such as those with darker skin tones [23].

4. Prevention and Management

Primary prevention for malignant melanoma focuses on minimizing excessive exposure to UV radiation. Encouraging sun-safe practices plays a crucial role in preventing the harmful effects of UV radiation, such as wearing protective clothing and using broad-spectrum sunscreens with a minimum SPF of 30. Studies have shown that regular sunscreen application provides long-term benefits, significantly reducing the incidence of primary melanoma for up to 10 years [24].

Early screening is the best approach for the early detection of malignant melanoma, especially for individuals with risk factors for MM. A self-administered, unsupervised questionnaire utilized in a dermatology setting demonstrated moderate effectiveness in identifying individuals at high risk for melanoma, along with regular skin self-examination for everyone [25].

A complete tumor excision is the management for patients with MM. Surgical resection is proven to be curative for local disease [26].

CONCLUSION

Prolonged exposure to ultraviolet radiation during outdoor activities is a significant risk factor in the development of malignant melanoma. Both chronic and intermittent exposure patterns contribute to malignant melanoma risk.

However, intermittent and intense exposure poses a higher threat to the development of malignant melanoma. Genetic predisposition, skin phenotype, and occupational exposure further amplify susceptibility. Preventive strategies, including sunscreen use, protective clothing, and education about sun safety, are essential in reducing MM incidence. Early detection through skin self-assessment questionnaires and regular dermatological examinations can improve prognosis by enabling timely interventions. Future research should focus on preventive interventions, enhancing screening protocols, and targeted therapies to address this growing public health concern.

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