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Effectiveness of Sun Protection in Outdoor Athletes in the Prevention of Skin Cancer – A Literature Review

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Abstract

Introduction and objective: Athletes practising outdoor sports are particularly exposed to prolonged and intense ultraviolet (UV) radiation, which significantly increases the risk of developing skin cancer, including melanoma and non-melanoma types. Despite growing awareness of these risks, the effectiveness of photoprotection in this population remains insufficient, mainly due to irregular sunscreen use, incorrect application habits, and numerous environmental and organisational barriers. The aim of this review is to present the current state of knowledge on the effectiveness of sun protection methods used by outdoor athletes and to assess their role in skin cancer prevention.

Review methods: All data were collected from publicly available sources. This article's databases were accessed via PubMed, Scopus and Web of Science.

A brief description of the state of knowledge: Research shows that athletes often use sun protection incorrectly - applying too little sunscreen, skipping reapplication and inconsistently using physical barriers like UPF clothing or headgear. Long-distance runners, cyclists, skiers and water sports enthusiasts are most exposed to UV radiation. Effective protection is further hampered by intense sweating, reflection of rays from water or snow, sporting pressure and concerns about comfort. Although awareness is growing, it rarely becomes routine. Educational programmes, coach support and technologies such as UV sensors or mobile apps show promising results.

Summary: Effective protection requires a multidimensional approach combining education, behavioural support and UV policies in sports settings. Best results come from using both chemical and physical methods, but only when applied regularly and correctly. Technology and stronger involvement of sports organisations can improve adherence. With rising skin cancer rates, sport-specific, practical UV-prevention guidelines are urgently needed.

Keywords: athletes, outdoor sports, sun protection, sunscreen, SPF, UV protective clothing, photoprotection, skin cancer, melanoma, non-melanoma skin cancer

1. Introduction

Skin cancer represents a growing public health problem worldwide and one of the most significant challenges in dermatology and oncology. Over the past decades, its incidence has been steadily increasing, both in highly developed countries and in regions with moderate sunlight exposure [1]. The most common types of skin cancer are melanoma and non-melanoma cancers, namely basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) [2]. The most significant factor in the development of melanoma and non-melanoma cancers is exposure to ultraviolet (UV) radiation [2,3]. UV induces DNA mutations, leads to oxidative stress, and

disrupts cellular repair mechanisms, thereby increasing the risk of malignant transformation [4].

Athletes who practise outdoor sports including running, cycling, sailing, windsurfing, tennis, and skiing are particularly exposed [2,5]. Their prolonged exposure to the sun, often during the hours of peak sunlight, can result in precancerous lesions and skin cancer [2,6]. Environmental factors such as the reflection of sunlight from water, snow or sand further increase the intensity of UV exposure [6]. High-intensity training which results in excessive sweating, combined with sun exposure, can exacerbate photodamage to the skin [2,5].

Photoprotection plays a key role in the prevention of skin cancer. Among the most commonly used methods are SPF sunscreen, UPF-rated protective clothing, headgear, sunglasses, and conscious planning of training during hours of lower sunlight exposure [5,6,7]. Important aspects include the proper application of sunscreen, the frequency of reapplication, the type of protective clothing material, and the specifics of the sport in question, all of which determine the effectiveness of sun protection [5,8].

Recent studies suggest that athletes' awareness of adequate sun protection remains insufficient, or even if sufficient, does not translate into active measures to prevent skin cancer [8,9,10]. Despite the availability of sun protection measures, outdoor athletes continue to be a high-risk group for UV exposure [8,10].

2. Objective

The aim of this review is to present the current state of knowledge on the effectiveness of sun protection in athletes practising outdoor sports and its importance in the prevention of skin cancer. The paper focuses on the analysis of photoprotection methods used, athletes' awareness and behaviour, and the identification of factors increasing the risk of skin cancer in this group.

3. Methodology

For this narrative review, all data were collected from publicly available sources. Three bibliographic databases: PubMed, Scopus, and Web of Science were searched in October 2025. The combination of terms for record extraction was ("sun protection" OR "sunscreen" OR "SPF" OR "UV protective clothing") AND ("athletes" OR "sports" OR "outdoor sports") AND ("skin cancer" OR "melanoma" OR "non-melanoma skin cancer"). Only studies in English were retrieved. No time restrictions were applied to the publication dates of the articles. Conference abstracts and book chapters were excluded. The reference lists of identified studies were also

reviewed to find additional articles. Duplicate studies were removed using Rayyan - a web and mobile app for systematic reviews. Studies were screened based on the title and abstract and then selected for full-text review by the first author.

4. The mechanisms of UV radiation and its effect on the skin

Ultraviolet radiation from sunlight is a recognised environmental carcinogen and plays a crucial role in the development of both melanoma and non-melanoma skin cancers. It is divided into three ranges: UVC (100-280 nm, mostly absorbed by the atmosphere), UVB (280-320 nm) and UVA (320-400 nm) [11]. UVB radiation has higher energy and is mainly responsible for direct DNA damage through the formation of pyrimidine dimers (CPDs) and 6-4 photoproducts, while UVA penetrates deeper into the dermis, causing the formation of reactive oxygen species (ROS), which indirectly damage DNA, proteins and lipids and lead to oxidative stress and immunosuppression [12,13].

Both mechanisms - direct DNA damage and oxidative stress – contribute to the development of skin carcinogenesis. UV radiation causes characteristic mutations in suppressor genes, such as TP53, and activates oncogenic pathways in keratinocytes and melanocytes [14]. Persistent, unrepaired DNA damage, combined with chronic inflammation and disturbances in the skin microenvironment, promote the malignant transformation of cells. For this reason, photoprotection, aimed at limiting exposure to UV radiation, is a key element of cancer prevention, especially among people with increased sun exposure, such as athletes practising outdoor sports.

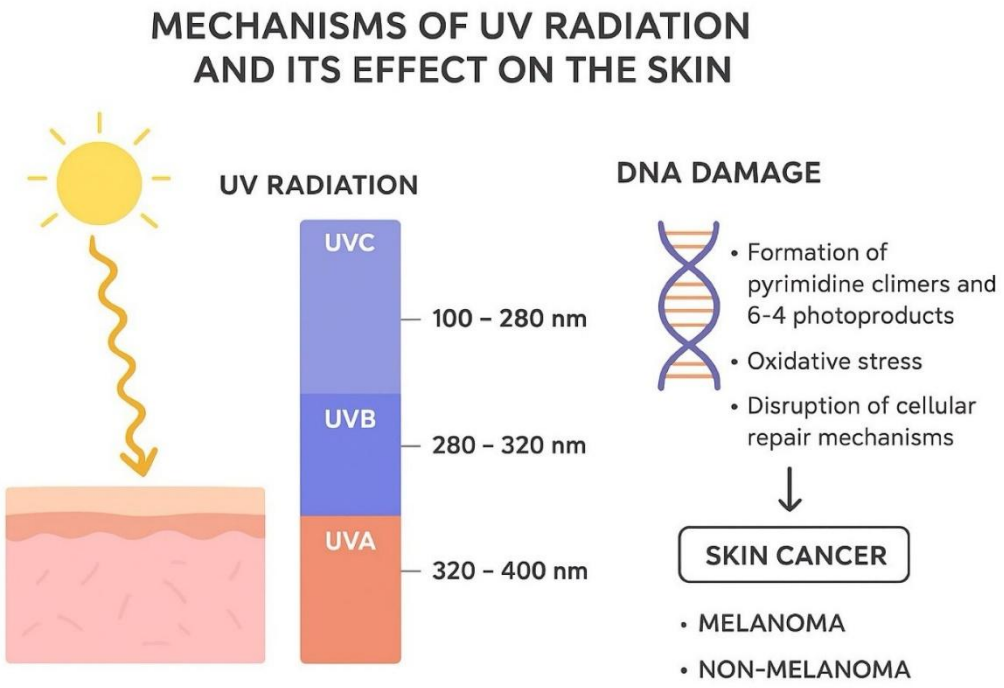

Figure 1. Mechanisms of ultraviolet (UV) radiation and its effects on the skin, including differences between UVA, UVB and UVC wavelengths and their role in DNA damage leading to skin carcinogenesis.

5. Types of sun protection methods used by athletes

Sun protection is a pivotal element in the prevention of skin cancer, particularly among individuals with increased exposure to ultraviolet radiation, such as athletes who train or compete outdoors. The most commonly employed photoprotection strategies include the use of sunscreen (SPF), protective clothing with an ultraviolet protection factor (UPF), headgear, sunglasses, and scheduling training sessions during periods of lower solar intensity [15,16].

According to Moehrle [16], effective sun protection requires a combination of physical and chemical measures, as athletes frequently train under conditions of intense sunlight and UV reflection from surfaces such as water, sand, or snow. In the case of sunscreen use, it is crucial to select an appropriate protection level (SPF 30 or higher), apply it evenly, and reapply every 2-3 hours, particularly after heavy sweating or water exposure [17].

Protective clothing, especially garments made from densely woven fabrics labelled with a UPF of 40–50+, serves as an effective complement to chemical protection. Gambichler et al. [18] emphasised that the photoprotective properties of textiles depend not only on fabric density, but also on colour, fibre composition, and the presence of mineral additives that reflect UV radiation. Headgear and sunglasses protect particularly sensitive areas of the face, ears, and

eyes, which is crucial in disciplines where complete avoidance of sun exposure is not feasible [18,19].

Innovative forms of photoprotection, such as cooling garments with UV filters, abrasion-resistant sports lotions, and aerosol-based protective agents adapted for physical exertion, are gaining increasing importance [17,20,21]. The development of these technologies is particularly relevant in the context of growing UV exposure among both amateur and professional athletes [5,22].

To maximise the effectiveness of photoprotection strategies, it is essential to educate athletes on proper application techniques, the importance of regular reapplication, and the risks associated with prolonged UV exposure [23,24]. Recent technological advances, including wearable UV sensors and mobile applications that monitor UV exposure, can further support athletes in tracking their risk and optimising the use of protective measures [24,25].

6. Effectiveness and awareness of sun protection among athletes

The effectiveness of photoprotection depends not only on the type of protective products used but also on their consistent and correct application. Research indicates that the overall efficacy of sun protection largely relies on awareness and adherence. Even the most advanced protective measures lose their effectiveness if applied irregularly or in insufficient amounts. Therefore, educating athletes on the correct use of sunscreen and protective clothing constitutes a key component of skin cancer prevention within this population [8,26,27].

Petersen et al. [28] demonstrated that athletes often apply inadequate amounts of sunscreen or neglect to reapply it, which significantly reduces its protective effect. Similar findings were reported by Moehrle et al. [29], who observed that intense sweating can further lower the minimal erythema dose and consequently decrease sunscreen efficacy.

At the same time, the effectiveness of photoprotection varies according to sport type, training intensity, and environmental conditions. Thieden et al. [19] found that water sports participants, skiers, and long-distance runners experience the highest daily exposure to UV radiation, necessitating comprehensive and consistent protection.

Although recent studies suggest that athletes generally demonstrate a relatively high awareness of UV-related risks, this knowledge does not always translate into consistent protective behaviour [8,30]. In practice, many athletes acknowledge the importance of sunscreen use but fail to apply it regularly or in sufficient quantities.

Awareness and attitudes towards sun protection also vary by gender, age, and sport discipline. Women tend to use sunscreen more frequently than men, whereas competitive athletes are more likely to neglect protection for fear of impairing training comfort [31]

Jinna et al. [32] and Peters et al. [33] highlighted that educational interventions in sun protection are limited in effectiveness if not accompanied by practical training and the involvement of coaches and sports federations. Therefore, education should focus not only on knowledge dissemination but also on developing lasting behavioural habits.

Consistent and correct use of sunscreen, protective clothing, and headgear is essential for effective UV protection. The highest level of photoprotection is achieved through a combination of chemical and physical methods - sunscreen should be complemented by UPF-rated clothing, headwear, and sunglasses. Modern technologies, such as wearable UV sensors and mobile applications that monitor exposure, support athletes in maintaining protective routines and enhance educational outcomes. Inconsistent protection increases the risk of sunburn, photoaging, and skin cancer, underscoring the critical importance of awareness, education, and adherence to proper photoprotection practices.

7. Barriers and challenges in implementing sun protection among athletes

Despite growing awareness of the risks associated with ultraviolet (UV) radiation, many athletes still fail to implement effective sun protection strategies in their daily routines. Numerous studies indicate that the discrepancy between knowledge and actual behaviour arises from both individual and environmental factors [17,26,34].

One of the main barriers is the perceived discomfort and inconvenience associated with protective measures. Athletes often report that sunscreen products are sticky, inhibit perspiration, or reduce skin breathability, thereby decreasing training comfort and potentially affecting physical performance [35]. Similarly, protective clothing and headgear are sometimes perceived as too warm or restrictive, particularly during intense exercise in hot conditions [36].

Another significant obstacle is the lack of time and the difficulty of incorporating sun protection into daily training routines. Many athletes do not view sunscreen application as an integral part of training preparation, often citing busy schedules or the belief that protection is unnecessary during short sessions or on cloudy days [34,37]. In addition, the need to reapply sunscreen every 2–3 hours is frequently overlooked due to the lack of training breaks or the perception that reapplication is impractical [38].

Social and behavioural factors are also relevant. Younger athletes and men are less likely to use regular sun protection, largely due to a lower perceived susceptibility to skin damage and cancer [8,39]. Within the sporting environment, aesthetic pressures may also play a role—the desire to maintain a "healthy tan" can discourage consistent sunscreen use [40].

Environmental conditions further influence the effectiveness and regularity of photoprotection. Training in water, snow, or at high altitudes increases UV reflection while making reapplication more difficult and accelerating the removal of sunscreen [17,41].

Organisational barriers, such as the absence of formal sun protection policies in sports clubs, limited access to appropriate photoprotective products, and insufficient engagement of coaches and sports associations in preventive activities, should also not be overlooked [17,33].

Overcoming these barriers requires a multifaceted approach combining education, behavioural interventions and institutional support. Facilitating application (e.g., through the use of sprays or protective wipes), developing sweat-resistant and lightweight formulas, and incorporating sun protection into daily training habits can increase adherence to photoprotection practices. Furthermore, the involvement of coaches, sports physicians and sports organisations is crucial to promoting pro-health behaviours as an integral part of professional training.

8. Strategies for improving photoprotection compliance among athletes

Effective sun protection among athletes requires not only adequate knowledge and access to protective measures, but also the implementation of sustainable behavioural, educational and organisational strategies. In recent years, there has been an increasing emphasis on integrated preventive measures that combine education, environmental interventions and the use of new technologies [8,42]. Research indicates that single educational campaigns usually have a short-term effect and do not lead to lasting behavioural change [32,33]. Therefore, effective improvement in compliance with photoprotection rules should include comprehensive measures at the individual, social and institutional levels.

8.1. Education and training in the sporting environment

As noted by Petersen et al. [28], awareness of the risks associated with ultraviolet radiation alone does not ensure effective protective behaviour, as the practical application of sunscreen often differs substantially from recommended guidelines. Effective educational programmes should focus not only on providing information, but also on building risk awareness, a sense of agency and a positive attitude towards the use of sun protection. As Jinna et al. [32], the

effectiveness of educational programmes increases when they are implemented with the active participation of coaches, physiotherapists and sports doctors, who are authority figures for athletes.

Programmes such as SunSmart Sport in Australia and Block the Sun, Not the Fun in the United States are examples of effective initiatives that have led to an increase in the use of sunscreen, protective clothing and headgear among young athletes [43,44]. Incorporating photoprotection principles into training programmes, club rules and daily training sessions promotes the normalisation of healthy behaviours and the perception of UV protection as an integral part of sports preparation.

8.2. Behavioural support and new technologies

In addition to education, behavioural and technological strategies play an important role. The use of reminders, progress monitoring and behaviour modelling by team leaders can increase the regularity of photoprotection use [8]. Modern technologies, such as UV sensors in smartwatches, mobile applications that monitor radiation intensity, and notifications reminding users to reapply sunscreen, support consistent protective behaviour [8,24,45,46].

Recent studies by Horsham et al. [45] demonstrate that the use of wearable UV sensors and mobile applications can significantly increase the regularity of sunscreen application, particularly among younger individuals. Similarly, Fernández-Ruiz et al. [8] emphasise that combining interactive digital tools with educational initiatives in sports clubs represents one of the most promising strategies for promoting photoprotective behaviour, especially in environments with high UV exposure.

8.3. The role of sports organisations and institutional policies

Sports institutions play a key role in improving compliance with photoprotection rules. The introduction of formal sun protection policies (UV policies) in sports clubs and federations is an important step in the systematic prevention of skin cancer. As highlighted by Gilaberte et al. [17] and Dobbinson et al. [47], the presence of clear guidelines regarding sunscreen use, availability of protective measures and the provision of shade during outdoor activities may support greater adherence to sun safety practices.

Sports organisations should ensure easy access to protective products, such as spray sunscreens or dispensers in training areas, and promote the use of UPF-rated clothing and sunglasses as standard elements of sportswear [17,48,49]. The integration of such measures into everyday training environments reinforces positive health behaviours and supports the normalisation of sun-safe practices among athletes [17,49].

9. Discussion

An analysis of the available literature indicates that athletes practising outdoor sports are particularly vulnerable to the negative effects of prolonged exposure to ultraviolet (UV) radiation. Although the mechanisms of skin damage and carcinogenesis are well understood, the practical application of photoprotection principles in the sporting environment remains insufficient. Many studies have shown that despite high awareness of the risk of skin cancer, this knowledge does not translate into actual protective behaviour. Athletes often do not use sunscreen in sufficient quantities, forget to reapply it after physical exertion, or forego protection on cloudy days, mistakenly assuming that cloud cover significantly reduces UV radiation levels.

Differences in the level of knowledge and use of photoprotection are also visible among groups of athletes. Women are more likely to declare using sunscreen than men, while endurance athletes, such as cyclists or long-distance runners, show a lower level of regularity in using sun protection. This is due to several factors – concerns about reduced training comfort, lack of breaks to reapply sunscreen, and the limited role of coaches and medical staff in promoting preventive behaviours.

From the point of view of sun protection effectiveness, it is crucial to combine physical and chemical methods. The most effective protection is achieved by using SPF sunscreen in combination with wearing clothing with a high UPF rating, headgear and sunglasses. However, even the best products lose their effectiveness when they are used incorrectly, as confirmed by studies showing that athletes apply on average only 25-50% of the recommended amount of cream.

Innovative technologies supporting UV protection - including radiation intensity sensors, mobile applications reminding users to reapply sunscreen, and smart fabrics with built-in protective filters - have been playing an increasingly important role in recent years. Research shows that the use of such solutions promotes more systematic application of photoprotection rules, especially among young athletes. Educational activities carried out in sports clubs are also very important, especially those involving coaches, physiotherapists and doctors. It turns out that preventive programmes implemented in this way are more effective than one-off information campaigns.

However, there is still a lack of consistent, standardised guidelines on sun protection that take into account the specific nature of different sports. Different environmental conditions – such

as contact with water, snow, wind or high exposure to radiation at high altitudes – require an individual approach to the selection of photoprotection methods. It is therefore necessary to develop practical recommendations and introduce formal UV policy rules in the sporting environment, modelled on solutions in place in countries with high levels of sunshine, such as Australia.

10. Conclusions

Athletes who practise outdoor sports are a group at particularly high risk of excessive exposure to UV radiation, which significantly increases the chance of developing skin cancer. Although knowledge about the harmful effects of solar radiation is constantly growing, numerous studies indicate a persistent gap between awareness and actual protective behaviour. To be effective, photoprotection must include both chemical and physical methods – regular use of SPF sunscreen, appropriate protective clothing with a high UPF, headgear and sunglasses. However, their effectiveness is significantly reduced if the products are not applied in sufficient quantities or are not reapplied at appropriate intervals.

Identified barriers, such as discomfort associated with the use of sunscreen, lack of time, low risk perception, and insufficient support from coaches and sports organisations, continue to limit the effectiveness of preventive measures. It is therefore crucial to develop comprehensive strategies that include education, behavioural support and the implementation of formal UV policies in sports clubs and associations. Training programmes involving coaches, sports doctors and physiotherapists have proven to be particularly effective as they help to reinforce good protective habits.

Advancing technological capabilities, such as portable UV sensors, mobile applications that monitor exposure, and modern textiles with protective filters, are promising tools for supporting consistent photoprotection practices. Integrating them into daily training routines can significantly improve adherence to sun protection guidelines, especially among young athletes.

In summary, effective skin cancer prevention in the sporting environment requires an integrated approach in which education, technology and institutional support complement each other. The development of detailed, varied recommendations that take into account the specific nature of individual sports and the implementation of formal UV policies are key elements of effective health protection for athletes exposed to chronic sun exposure.

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References

1. Apalla Z, Lallas A, Sotiriou E, Lazaridou E, Ioannides D. Epidemiological trends in skin cancer. Dermatol Pract Concept. 2017;7(2):1-6.

2. Harrison SC, Soyer HP. Ultraviolet light and skin cancer in athletes. Clinics in Dermatology. 2009;27(4):351-356.

3. Beissert S, Loser K. Molecular and cellular mechanisms of photocarcinogenesis. Photochem Photobiol. 2008;84(1):29-34.

4. Garcia-Mouronte E, Pérez-González LA, Naharro-Rodriguez J, Fernández Guarino M. Understanding Active Photoprotection: DNA-Repair Enzymes and Antioxidants. Life. 2024; 14(7):822.

5. Snyder A, Valdebran M, Terrero D, Amber KT, Kelly KM. Solar Ultraviolet Exposure in Individuals Who Perform Outdoor Sport Activities. Sports Med Open. 2020;6(1):42.

6. Kliniec K, Tota M, Zalesińska A, Łyko M, Jankowska-Konsur A. Skin Cancer Risk, Sun-Protection Knowledge and Behavior in Athletes-A Narrative Review. Cancers (Basel). 2023;15(13):328.

7. Sander M, Sander M, Burbidge T, Beecker J. The efficacy and safety of sunscreen use for the prevention of skin cancer. CMAJ. 2020;192(50):E1802-E1808.

8. Fernandez-Ruiz J, Montero-Vilchez T, Buendia-Eisman A, Arias-Santiago S. Knowledge, Behaviour and Attitudes Related to Sun Exposure in Sportspeople: A Systematic Review. International Journal of Environmental Research and Public Health. 2022; 19(16):10175.

9. Arslan E, Ayvaz Çelik HH, Cinkara O, Ercan E, Gonedi F, Cetin C . Skin Cancer and Sun Knowledge Level and Dermatoscopic Examination Results of Outdoor and Indoor Athletes: A Cross-sectional Research. J Turk Acad Dermatol. 2022;16(4):86-93.

10. De Castro-Maqueda G, Gutierrez-Manzanedo JV, Lagares-Franco C, de Troya-Martin M. Sun Exposure during Water Sports: Do Elite Athletes Adequately Protect Their Skin against Skin Cancer? International Journal of Environmental Research and Public Health. 2021; 18(2):800.

11. Pfeifer GP. Mechanisms of UV-induced mutations and skin cancer. Genome Instab Dis. 2020;1(3):99-113.

12. Hussein MR. Ultraviolet radiation and skin cancer: molecular mechanisms. J Cutan Pathol. 2005;32(3):191-205.

13. Garibyan L, Fisher DE. How sunlight causes melanoma. Curr Oncol Rep. 2010;12(5):319-326.

14. Fan W, Rokohl AC, Guo Y, Chen H, Gao T, Kakkassery V, Heindl LM. Mechanism of ultraviolet radiation-induced basal cell carcinoma. Front Oral Maxillofac Med. 2023;5:9.

15. Narayanan DL, Saladi RN, Fox JL. Ultraviolet radiation and skin cancer: Molecular mechanisms. Journal of Carcinogenesis. 2010;9:19.

16. Moehrle M. Outdoor sports and skin cancer. Clinics in Dermatology. 2008;26(1):12-15.

17. Gilaberte Y, Trullàs C, Granger C, de Troya-Martín M. Photoprotection in Outdoor Sports: A Review of the Literature and Recommendations to Reduce Risk Among Athletes. Dermatol Ther (Heidelb). 2022;12(2):329-343.

18. Gambichler T, Laperre J, Hoffmann K. The European standard for sun-protective clothing: EN 13758. J Eur Acad Dermatol Venereol. 2006;20(2):125-130.

19. Thieden E, Philipsen PA, Heydenreich J, Wulf HC. UV radiation exposure related to age, sex, occupation, and sun behavior based on time-stamped personal dosimeter readings. Arch Dermatol. 2004;140(2):197-203.

20. Keshavarzi F, Knudsen NØ, Komjani NM, Ebbesen MF, Brewer JR, Jafarzadeh S, et al. Enhancing the sweat resistance of sunscreens. Skin Res Technol. 2022;28(2):225-235.

21. Sieniawska D, Proszowska P, Madoń M, Kotowicz Z, Orzeł A, Pich-Czekierda A, et al. Ultraviolet-Protective Clothing and Sunscreen: Sun-Protection for Healthy Skin. J Educ Health Sport. 2024;71:51237.

22. Kohmura Y. Importance of vision and sun protection in outdoor sports: a narrative review. JPES. 2021;22(4):424-32.

23. Aguilera J, Navarrete-de Gálvez E, Sánchez-Roldán C, Herrera-Ceballos E, de Gálvez MV. Sun-protective Properties of Technical Sportswear Fabrics 100% Polyester: The Influence of Moisture and Sweat on Protection against Different Biological Effects of Ultraviolet (UV) Radiation. Photochem Photobiol. 2023;99(1):184-192.

24. Horsham C, Ford H, Hacker E. Promoting sunscreen use in adolescents playing outdoor sports using UV detection stickers. Prev Med Rep. 2020;19:101166.

25. García-Malinis AJ, Gracia-Cazaña T, Zazo M, Rivaz-Ruis F, de Troya Martín M, Gilaberte Y, et al. Sun Protection Behaviors and Knowledge in Mountain Marathon Runners and Risk Factors for Sunburn. Hábitos y conocimientos sobre fotoprotección

y factores de riesgo para quemadura solar en corredores de maratones de montaña. Actas Dermosifiliogr (Engl Ed). 2021;112(2):159-166.

26. Tenforde AS, Fredericson M, Toth KES, Sainani KL. Sun Protective Behaviors and Attitudes of Runners. Sports (Basel). 2021;10(1):1.

27. Tertipi N, Sfyri E, Kefala V, Rallis E. Prevalence of sunscreen use and sunburn in Greek athletes: a cross-sectional study. J Sports Med Phys Fitness. 2024;64(5):496-503.

28. Petersen B, Wulf HC. Application of sunscreen--theory and reality. Photodermatol Photoimmunol Photomed. 2014;30(2-3):96-101.

29. Moehrle M, Koehle W, Dietz K, Lischka G. Reduction of minimal erythema dose by sweating. Photodermatol Photoimmunol Photomed. 2000;16(6):260-262.

30. Buljan M, Kolić M, Šitum M, Šekerija M, Franceschi N. Do Athletes Practicing Outdoors Know and Care Enough About the Importance of Photoprotection?. Acta Dermatovenerol Croat. 2020;28(1):41-42.

31. Zaslow T, Patel AR, Coel R, Katzel M, Wren T. The effects of sport, setting, and demographics on sunscreen use and education in young athletes. Research in Sports Medicine: An International Journal. 2023;32(1):1-9.

32. Jinna S, Adams BB. Ultraviolet radiation and the athlete: risk, sun safety, and barriers to implementation of protective strategies. Sports Med. 2013;43(7):531-537.

33. Peters CE, Koehoorn MW, Demers PA, Nicol AM, Kalia S. Outdoor Workers' Use of Sun Protection at Work and Leisure. Saf Health Work. 2016;7(3):208-212.

34. Wysong A, Gladstone H, Kim D, Lingala B, Copeland J, Tang J Y. Sunscreen use in NCAA collegiate athletes: identifying targets for intervention and barriers to use. Prev Med. 2012;55(5):493-496.

35. Ellis RM, Mohr MR, Indika SH, Salkey KS. Sunscreen use in student athletes: a survey study. J Am Acad Dermatol. 2012;67(1):159-160.

36. Stölzel F, Wolff M, Fieber V, Glausch M, Wachs C, Breitbart E, et al. UV protection for young athletes: using participatory program planning to address barriers in training and competition. Environ Health Prev Med. 2020;25(1):39.

37. Andrews L, Shope C, Snyder A, Valdebran M. Commentary: Sport-specific Factors Impacting Solar Ultraviolet Exposure in Individuals Who Perform Outdoor Sport Activities. J Dermatol & Skin Sci. 2022;4(2):7-9.

38. Ruvolo E, Aeschliman L, Cole C. Evaluation of sunscreen efficacy over time and re-application using hybrid diffuse reflectance spectroscopy. Photodermatol Photoimmunol Photomed. 2020;36(3):192-199.

39. Adams GJ, Goldstein EK, Goldstein BG, Jarman KL, Goldstein AO. Attitudes and Behaviors That Impact Skin Cancer Risk among Men. *Int J Environ Res Public Health*. 2021;18(19):9989.

40. Cafri G, Thompson JK, Roehrig M, Rojas A, Sperry S, Jacobsen PB, et al. Appearance motives to tan and not tan: evidence for validity and reliability of a new scale. Ann Behav Med. 2008;35(2):209-220.

41. Diffey BL. Sources and measurement of ultraviolet radiation. Methods. 2002;28(1):4-13.

42. Ally MS, Swetter SM, Hirotsu KE, Gordon J, Kim D, Wysong A, et al. Promoting sunscreen use and sun-protective practices in NCAA athletes: Impact of SUNSPORT educational intervention for student-athletes, athletic trainers, and coaches. J Am Acad Dermatol. 2018;78(2):289-292.e2.

43. Tabbakh T, Volkov A, Wakefield M, Dobbinson S. Implementation of the SunSmart program and population sun protection behaviour in Melbourne, Australia: Results from cross-sectional summer surveys from 1987 to 2017. PLoS Med. 2019;16(10):e1002932.

44. Crane LA, Schneider LS, Yohn JJ, Morelli JG, Plomer KD. "Block the sun, not the fun": evaluation of a skin cancer prevention program for child care centers. Am J Prev Med. 1999;17(1):31-37.

45. Horsham C, Antrobus J, Olsen CM, Ford H, Abernethy D, Hacker E. Testing Wearable UV Sensors to Improve Sun Protection in Young Adults at an Outdoor Festival: Field Study. JMIR Mhealth Uhealth. 2020;8(9):e21243.

46. Hacker E, Horsham C, Vagenas D, Jones L, Lowe J, Janda M. A Mobile Technology Intervention With Ultraviolet Radiation Dosimeters and Smartphone Apps for Skin Cancer Prevention in Young Adults: Randomized Controlled Trial. JMIR Mhealth Uhealth. 2018;6(11):e199.

47. Dobbinson SJ, Hayman JA, Livingston PM. Prevalence of health promotion policies in sports clubs in Victoria, Australia. Health Promot Int. 2006;21(2):121-129.

48. Dobbinson SJ, Wakefield MA, Jamsen KM, et al. Weekend sun protection and sunburn in Australia trends (1987-2002) and association with SunSmart television advertising. Am J Prev Med. 2008;34(2):94-101.

49. Eason CD, Rundle CW, Dunnick CA, Hugh J, Dellavalle R. National trends in free public sunscreen dispensers. Journal of the American Academy of Dermatology. 2021;84(1):213–215.