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Suitability of sunscreen for the prevention of skin cancer



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Abstract

Exposure to strong solar radiation may cause sunburn and skin cancer. Sunscreen products applied to the skin are therefore frequently used. Their main function is to protect against sunburn; their effectiveness in protecting against skin cancer is, however, also of interest. Articles published in the recent past have cast doubt upon the suitability of sunscreen products for protection against skin cancer. In order to clarify this issue, the BG Institute for Occupational Safety and Health (BGIA) therefore conducted an Internet and literature survey. In the scientific literature, the protective effect of sunscreen is the subject of controversy. Accordingly, a certain efficacy in the prevention of skin cancer cannot be excluded; however, the products do not generally appear suitable for this purpose, particularly in the absence of any other protective measure. It is therefore recommended that a combination of measures be taken to protect the skin against the hazards caused by solar radiation. Besides general avoidance of exposure to strong solar radiation, these measures include wearing of suitable clothing, use of sunscreen, consideration of the individual skin sensitivity, and wearing of sunglasses.

Eignung von Sonnenschutzmittel zur Hautkrebsprävention

Kurzfassung

Eine übermäßige Einwirkung von Sonnenstrahlung kann bei Menschen zu Sonnenbränden und zu Hautkrebs führen. Häufig werden Sonnenschutzmittel verwendet, die zum Schutz auf die Haut aufgetragen werden. Sie sollen primär vor Sonnenbrand schützen. Es stellte sich jedoch die Frage, ob sie auch zum Schutz vor Hautkrebs wirksam sind. In Veröffentlichungen der letzten Zeit wurden Zweifel an der Eignung von Sonnenschutzmitteln zur Prävention von Hautkrebs geäußert. Zur Klärung dieser Frage führte das Berufsgenossenschaftliche Institut für Arbeitsschutz – BGIA eine Internet- und Literaturrecherche durch. In der wissenschaftlichen Literatur wird die Schutzwirkung von Sonnenschutzmitteln kontrovers diskutiert. Danach ist eine gewisse Wirksamkeit zur Hautkrebsprävention nicht auszuschließen, eine generelle Eignung, insbesondere als alleinige Schutzmaßnahme, scheint jedoch nicht gegeben zu sein. Es ist daher empfehlenswert, zum Schutz der Haut vor den Gefahren der Sonnenstrahlung ein Bündel von Maßnahmen zu ergreifen. Dies schließt neben der grundsätzlichen Vermeidung starker Sonnenstrahlungsexpositionen das Tragen geeigneter Kleidung, die Verwendung von Sonnenschutzmitteln, die Berücksichtigung der individuellen Hautempfindlichkeit und das Tragen von Sonnenbrillen ein.

Utilisation de crèmes solaires pour la prévention des cancers de la peau

Résumé

Une exposition prolongée au rayonnement solaire peut provoquer, chez les êtres humains, des coups de soleil et des cancers de la peau. C'est pourquoi on applique souvent des crèmes solaires sur la peau, qui doivent, en premier lieu, protéger la peau contre les coups de soleil. On se demandait cependant si les crèmes solaires assurent également une protection contre les cancers de la peau. Dans des publications récentes, le fait que les crèmes solaires sont appropriées à la prévention des cancers de la peau était mis en doute. Pour éclaircir cette question, le Berufsgenossenschaftliches Institut für Arbeitsschutz – BGIA (Institut pour la Sécurité du Travail des organismes d'assurance et de prévention des risques professionnels) a effectué des recherches dans l'Internet et la littérature. Dans la littérature scientifique, la protection assurée par les crèmes solaires est controversée. D'après celle-ci, bien qu'une certaine efficacité ne soit pas à exclure, les crèmes solaires ne semblent cependant pas appropriées de façon générale, en particulier en tant que mesure de protection unique, à la prévention des cancers de la peau. C'est pourquoi il est recommandé de prendre tout une série de mesures pour protéger la peau contre les dangers du rayonnement solaire, dont voici quelques exemples : éviter, de façon générale, les expositions prolongées au rayonnement solaire, porter des vêtements appropriés, utiliser des crèmes solaires, tenir compte de la sensibilité individuelle de la peau et porter des lunettes de soleil.

Aptitud de protectores solares para proteger la piel contra el cáncer cutáneo

Resumen

Una exposición excesiva a radiación solar puede causar quemaduras y cáncer de piel. Debido a ello, a menudo, se aplican protectores solares para prevenir quemaduras de sol. Pero, se plantea la pregunta si también protegen contra cáncer cutáneo. En publicaciones recientes se levantaron dudas con relación a la aptitud de protectores solares para la prevención de cánceres de la piel. El BG-Instituto de Seguridad y Salud Laboral (BGIA por sus siglas en alemán) llevó a cabo una pesquisa bibliográfica, incluyendo fuentes disponibles vía Internet, para esclarecer esta interrogante. El debate sobre la eficacia de protectores solares en la literatura científica está marcado por una controversia. Por tanto, no se descarta una cierta eficacia relativa a la prevención de cáncer de piel, pero una aptitud generalizada, especialmente como medida exclusiva de protección, no se puede dar por hecha. Debido a ello, se recomienda adoptar un conjunto de medidas para proteger la piel contra los riesgos que derivan de la exposición a radiación solar. Además de evitar niveles excesivos de exposición solar, se recomienda vestir prendas adecuadas, utilizar protectores solares, considerar las condiciones cutáneas individuales y llevar gafas de sol.

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1 Preliminary remarks

Skin cancer is one of the most frequently occurring forms of cancer. The most important cause of skin cancer is exposure to ultraviolet (UV) radiation. This occurs particularly outdoors through exposure to solar radiation. Along with other measures, the application of sunscreen to the skin is recommended for protection from solar radiation.

Sunscreen is primarily intended as a means of protecting the skin from sunburn (skin erythema). Since people who spend time in the sun also have to be protected from long-term harm, e.g. skin cancer, the question arises whether sunscreen also provides protection from skin cancer. In recent scientific publications, doubts have been expressed about the suitability of sunscreen to prevent skin cancer. Acting on its own initiative, the German Federation of Institutions for Statutory Accident Insurance and Prevention (Hauptverband der gewerblichen Berufsgenossenschaften, HVBG) therefore posed the question whether sunscreen is suitable at all of preventing skin cancer among persons working outdoors. The BG Institute for Occupational Safety and Health (Berufsgenossenschaftliches Institut für Arbeitsschutz – BGIA) took this as its cue to carry out an Internet and literature survey in its project entitled “Suitability of sunscreen for the prevention of skin cancer”. This report contains the results of the survey. The literature was selected in consultation with medical experts and evaluated by the BGIA. An epidemiological and statistical analysis to ensure the soundness of the methods and an investigation of dermatological mechanisms can be subsequently performed if required.



2 Problem and objective

The incidence of skin cancer and skin cancer mortality have been increasing worldwide for decades and have now reached a high level [1]. One of the main causes of this is the exposure of persons outdoors to UV radiation from the sun. For protection from acute and long-term harm caused by exposure to the sun, a number of protective measures can be taken. These include applying sunscreen to the skin. Recently, however, scientific investigations have been published which cast doubt on the suitability of sunscreen to prevent skin cancer.

The goal of this project was to conduct an Internet and literature survey in order to determine the current state of knowledge on the suitability of sunscreen to prevent skin cancer. A further-reaching goal was to derive from these findings a recommendation for the position to be adopted by the German Berufsgenossenschaften (BGs).



3 Procedure

To determine the current state of knowledge, an Internet survey was carried out. To this end, the German words "Sonnenschutzmittel" (sunscreen) and "Hautkrebs" (skin cancer) were entered as search terms in the Google search engine. The documents retrieved were evaluated from the point of view of the suitability of sunscreen to prevent skin cancer. The Internet survey was also carried out in English and French, with the search terms "sunscreen"/"crème solaire" and "skin cancer"/"cancer cutané" being entered. A total of 60 Internet publications were investigated in German, ten in English and ten in French.

50 German documents and all of the foreign-language documents obtained from the Internet survey were concerned with the investigated issue. Most of these documents are of an advisory nature and refer to a small number of primary publications, which are also listed in the literature survey (see Annex 1, page 31).

In addition to the Internet survey, a literature survey was carried out. The relevant literature was selected from the findings of the Internet survey, from quotations in the specialized literature and on the basis of personal contacts with experts¹. Annex 1 (see page 31) lists the literature evaluated, and the results of the Internet survey can be found in Annex 2 (see page 37).

¹ Information on literature sources was supplied by the BG Research Institute for Occupational Medicine (Berufsgenossenschaftliches Forschungsinstitut für Arbeitsmedizin, BGFA), Bochum, and by the INSERM Fondation Rothschild, Paris.



4 Results

4.1 Overview

The results of the survey do not show a uniform pattern in terms of sunscreen's efficacy, and there are conflicting views on whether sunscreen is suitable of preventing skin cancer. Some sources expressly recommend the use of sunscreen to prevent sunburn and skin cancer. Others consider sunscreen to have only limited suitability or no suitability at all to prevent skin cancer. According to these sources, sunscreen's suitability is limited among other things for the following reasons:

- Sunscreen does not provide protection from all types of skin cancer or provides different degrees of protection from the various types of skin cancer.
- The protective effect depends on the radiation's wavelength.
- The sun protection factor (SPF) does not refer to protection from skin cancer.
- Sunscreen is difficult to use correctly and demands a consistent approach. In practice, lower protection is therefore achieved than would be possible with careful application.

Because of the non-uniformity of the results, no definite answer can be given, on the basis of the present state of knowledge, to the question whether sunscreen is capable of preventing skin cancer. A certain efficacy cannot be ruled out, but there does not seem to be a fundamental capacity, particularly as a sole protective measure.

The findings of the most important studies are presented in the following.

4.2 Sunscreen as protection from squamous cell carcinoma

The working group of *Thompson* et al. [2] showed in its study that the regular application of sunscreen with a high sun protection factor (SPF 17) significantly reduces the formation of new actinic keratosis. The study of the working group of *Naylor* et al. [3]



comes to the same conclusion. Since actinic keratosis develops into squamous cell carcinoma in up to 10% of cases within ten years [4], the use of sunscreen would appear to reduce the incidence of squamous cell carcinoma. This relationship was also confirmed in the study by *Green et al.* [5].

4.3 Suitability of sunscreen as protection from basal cell carcinoma

In the study by *Green et al.* [5], the role of sunscreen in the prevention of basal cell carcinoma was also investigated. No significant effect was ascertained. *Kricker et al.* [6] carried out a case-control study on basal cell carcinoma in Australia. The authors came to the conclusion that there is little indication that sunscreen prevents the formation of basal cell carcinoma.

4.4 Suitability of sunscreen as protection from malignant melanoma

There are conflicting views over sunscreen's suitability to provide protection from malignant melanoma. The study by *Autier et al.* [7] suggests that the use of sunscreen may encourage the formation of new pigment marks (moles, naevi). Since the number of moles increases the risk of developing malignant melanoma, the use of sunscreen would thus appear to favour the development of malignant melanoma. Furthermore, the study by *Westerdahl et al.* [8] shows an increase in the incidence of malignant melanoma when sunscreen is used. The authors discovered in particular that the risk of developing malignant melanoma is increased further if sunscreen is used for tanning or to extend the time spent in the sun.

The study by *Gallagher et al.* [9] conducted in 2000 shows, on the other hand, that the number of moles on light-skinned children who regularly used sunscreen was lower than on children who did not use sunscreen. This suggests a reduction in the risk of developing malignant melanoma. Moreover, the study by *Holly et al.* [10] reveals a significant reduction in the melanoma risk for women aged 25 to 59 who use sunscreen.



4.5 Protective effect in relation to wavelength

In the investigation by *Sanders* et al. [11], three different sunscreens with a high sun protection factor (SPF 20) were applied to pieces of donated skin and exposed to UV light with an intensity similar to that of sunlight. Sunscreen was selected that also claimed to provide protection from UVA radiation. With the aid of electron spin resonance spectroscopy, the quantity of free radicals generated by the skin during irradiation was measured.

The result was then compared to the quantity of free radicals generated in irradiated skin that was not treated with sunscreen. The tests showed, firstly, that sunscreen prevented the “burning” of the skin. Secondly, the investigation also showed that application of a sunscreen film at least 2 mg/cm² thick reduced the formation of free radicals by 55%. From the result, a “free radical protection factor” of 2 was derived. This contrasts sharply with the SPF of 20, which refers to protection from sunburn. The authors pointed out that this discrepancy between the protection factors may encourage sunscreen users to spend longer in the sun and cause a disproportionately high increase in UVA exposure. Consequently, there is an increase in the risk of skin damage associated with UVA radiation exposure (see section 6, page 21).

4.6 The sun protection factor is not a “cancer protection factor”

The sun protection factor of sunscreen so far only relates to protection from the development and aggravation of skin erythema (see section 6, page 21). Although the sun protection factor supplies the user with information on the product’s protective effect against sunburn, it does not provide a quantitative statement about protection from skin cancer. Often, however, the sun protection factor is interpreted precisely as a “cancer protection factor”. Users thus assume they can extend their time in the sun by precisely this factor, thus increasing the risk of developing skin cancer.



4.7 Age-relatedness of the skin cancer risk

The skin of children and adolescents is particularly sensitive to the action of solar radiation. Excessive UV radiation exposure and frequent sunburn in childhood increase the risk of developing skin cancer as an adult ("The skin doesn't forget"). Intensive UV irradiation of the skin can increase the number of moles. Since a large number of moles is a risk factor for the development of malignant melanoma, the skin cancer risk also grows with the number of moles. The earlier and more frequently the skin is damaged by UV exposure, the greater the risk of contracting skin cancer at a later date. Since children have received a large proportion of their life-time UV radiation dose by the age of 18, sufficient protection from the sun is particularly important for children and adolescents. This also means that skin cancer prevention in adulthood, e.g. for employees working outdoors, is still necessary, but the effect may be lower if the skin has been damaged in childhood.

4.8 Proper use of sunscreen

Protection equivalent to the given sun protection factor can only be achieved with sunscreen if the product is applied with great care. The following points should be borne in mind:

Apply a sufficient amount

So that a sunscreen can achieve its full effect, it is necessary to apply a sufficient amount to the skin. In the standardized measurement procedure [12] used for determining the UVB sun protection factor, a film thickness of 2 mg/cm² is applied. To obtain the same protective effect, users must apply the same film thickness to the skin. When applying a sunscreen to the whole body (approximately 2 m² of skin), this amounts to a quantity of roughly 40 g or about a quarter of a conventional 150 ml bottle of sunscreen. Since such large amounts are not usually applied in practice, the given sun protection factor is not achieved as a rule.



Complete and uniform coverage of all exposed areas of skin

To achieve complete protection, sunscreen has to be applied uniformly to all exposed areas of skin. With the aid of a fluorescence test, the German Consumers' Association "Stiftung Warentest" [13] showed that people did not in practice uniformly cover all exposed areas of the skin although they believed they had done so. The thickness of the applied film varied and some areas were not treated at all. The protection from the sun was thus uneven and in places non-existent.

Early application of sunscreen

Users should apply sunscreen well before exposure to the sun so that its chemical filters can spread evenly on the horny layer of the skin and achieve their full effect. In practice, this point is often neglected. The sunscreen is frequently applied at the start of exposure, so there is initially insufficient protection.

Repeated application

If a long time is spent in the sun, the protective film should be regularly renewed after the first application. In the common guides (see results of the Internet survey in Annex 2, page 37), a time span of two hours is quoted. A new film of sunscreen should be applied above all after bathing or after strong perspiration. However, multiple application does not increase the protection factor and hence the period of protection.

No extension of exposure time

When using sunscreen, there is a danger of justifying longer stays in the sun with sunscreen's protective effect against sunburn. The study by *Autier* et al. [7] shows that the use of sunscreen by adolescents results in an increase in the number of moles. The reason given for this is the extension of UV exposure time when sunscreen is used. To prevent an increase in the skin cancer risk, the exposure time when sunscreen is used should not be extended beyond the skin's own tolerance period.



□ Choice of suitable sunscreen

Several tests of sunscreen carried out by Stiftung Warentest [13; 14] have shown that the sun protection factor is not correctly stated on all products. On some of the products, the sun protection factor given was too high. Deviations of over 20% were noted, and in one extreme case of up to 47%. Since a false sense of security is thus conveyed, this can have consequences for the user's health. Also of importance is the sunscreen's photostability. The absorption of UV radiation may initiate photochemical reactions, causing the sunscreen to degrade. A lack of photostability can give rise to phototoxic and photoallergic reactions on the skin and also reduce the effectiveness of the sunscreen. The choice of sunscreen should be limited to those whose sun protection factor and photostability have been confirmed in tests.

From the above it is obvious that when sunscreen is used, the level of protection from erythema expressed by the sun protection factor is rarely achieved in practice. Some manufacturers of sunscreen have meanwhile taken the consequences and graded their products in five rough categories ranging from "basic" to "ultra-high" [14].



5 Summary

In the context of a project, the BG Institute for Occupational Safety and Health (BGIA) carried out an Internet and literature survey. The goal was to determine whether the application of sunscreen is a suitable measure for the prevention of skin cancer.

The search failed to yield a uniform picture. Conflicting views are expressed in the literature over whether sunscreen is capable of preventing skin cancer. Some sources recommend the application of sunscreen as protection from sunburn and skin cancer and do not question sunscreen's suitability to prevent skin cancer. Other sources consider sunscreen to have limited or no suitability to prevent skin cancer.

This limited suitability or unsuitability is explained in the evaluated sources with the following reasons:

- ❑ A number of studies show that sunscreen reduces the risk of developing various types of skin cancer to different degrees. The regular use of sunscreen can significantly reduce the incidence of squamous cell carcinoma. On the other hand, its effect in preventing basal cell carcinoma is only slight or not at all verifiable. Whether sunscreen offers protection from malignant melanoma is a matter of dispute. While some studies show a reduction in the melanoma risk, other studies even claim an increase in the risk of melanoma when sunscreen is used.
- ❑ Frequently, the desired protection is not achieved due to incorrect application. It is not easy to use sunscreen correctly and a systematic approach is called for. This is usually neglected.
- ❑ The protection factors given by manufacturers refer not to protection from skin cancer but to protection from sunburn. The sun protection factors obtained with methods unrepresentative of actual sunscreen use are unrealistically high. In practice, the protection factors actually achieved with sunscreen are significantly lower than those given for the products.



- ❑ By using sunscreen, users are given a false sense of security. People often spend longer in the sun than the skin can tolerate. This again increases the risk of skin cancer.

At this point it is worth quoting the statement of *Jean-Pierre Cesarini*, the internationally acknowledged and distinguished expert on skin damage due to solar radiation: *“The effectiveness of suntan lotions in preventing skin cancer is a matter of huge importance. This issue is regularly addressed in the medical science literature and has been the subject of many debates without a definite outcome. Even if there is sufficient proof of efficacy in animal tests, the situation for human beings is less certain. The uncertainty between beneficial and detrimental effects is due to the difference in the aetiology between melanoma and basal cell carcinoma on the one hand, which are associated with intermittent overexposure of the body, and squamous cell carcinoma on the other, which is associated with constant exposure of the face, neck and hands. For instance, various epidemiological studies have shown a heightened risk of melanoma due to the frequent use of sunscreen. At the same time, there are confounding factors, as the proportion of the population susceptible to melanoma is more sensitive to solar aggression and therefore needs more protection. Furthermore, users of sunscreen use such products not in order to reduce solar aggression, but so that they can stay longer in the sun.”* [15].

Summing up, it can be said that, on the basis of the current state of knowledge, a certain effect for preventing skin cancer is ascribed to sunscreen products. However, this effect is not beyond dispute and does not seem to be comprehensive. Negative effects cannot be ruled out. The use of sunscreen as the sole protective measure for preventing skin cancer due to exposure to the sun is certainly not advisable on the basis of the current state of knowledge.

According to the surveys, further scientific investigations would probably not come to a different conclusion. In practice, however, the skin and eyes must be sufficiently protected from harm due to solar radiation. It would therefore make sense to proceed pragmatically and combine a variety of measures:



- avoidance of exposure to strong solar radiation,
- application of technical protection measures to reduce exposure,
- wearing suitable clothing with sufficient protection of the skin and head,
- application of sunscreen to exposed areas of skin,
- adoption of sun protection measures at the workplace and during leisure,
- determining one's personal risk on the basis of skin type,
- personal disease prevention by studying the skin for critical changes,
- use of sunglasses.



6 Background and explanatory information on sunscreen and skin cancer

6.1 Solar radiation

The radiation emitted by the sun covers a wide spectral range. It extends from warming infrared radiation and visible light through to short-wave ultraviolet (UV) radiation. Most of the UVA radiation and a small portion of the UVB radiation reach the earth's surface [16].

6.2 Sunscreen

Sunscreen contains substances that prevent or reduce the penetration of UV radiation into the skin. It was developed to prevent sunburn (erythema). Sunscreen effectiveness is expressed by the sun protection factor (SPF) [17]. Since erythema is mainly caused by UVB radiation, the SPF relates to UVB radiation. The SPF states how many times longer the skin coated with sunscreen can be exposed to the sun to achieve the same reddening as skin exposed without sunscreen. In Europe, the SPF has been determined since 1997 in accordance with the standard of the umbrella organization of the cosmetics industry, the European Cosmetic Toiletry and Perfumery Association (COLIPA), with measurements based on the fair complexion of a Northern European [18].

So that the protective effect of sunscreen for the UVA radiation range can be measured as well, a standardized method has been recently published. The German standard DIN 67502 [19] of February 2005 describes a method for determining the so-called in-vitro PPD (Persistent Pigment Darkening) protection factor. This is based on in-vitro transmission measurements of UVA radiation through sample films of the sunscreen being investigated. The PPD protection factor obtained gives an indication of the sunscreen's ability to suppress the skin's long-term tendency to tan.



6.3 Skin cancer

6.3.1 Risk classes

People's skins differ greatly, and so do their ability to develop pigmentation and provide protection from UV radiation. On the basis of their tanning capacity and sun sensitivity, six different skin types have been distinguished [20], with the first four types being relevant for Europe (Table 1). The classification in Table 1 refers primarily to acute reactions of the skin. To characterize the risk of contracting skin cancer, the classification presented in Table 2 was recently introduced [21].

Table 1:
Characterization of different skin types in Europe [20]

Skin type	Characteristics
1	Fair complexion, freckles, fair or red hair, blue or green eyes, no or little tanning capacity, extreme disposition to sunburn
2	Fair complexion, fair hair, blue or green eyes, low tanning capacity, high disposition to sunburn
3	Light-brown complexion, dark hair, dark eyes, good tanning capacity, low disposition to sunburn
4	Brown skin, dark or black hair, brown eyes, good and fast tanning capacity, hardly any disposition to sunburn

Table 2:
Classification of the skin into three skin cancer risk classes

Risk class	Characteristics
Melano-compromised skin	No tanning without sunburn (skin types 1 and 2)
Melano-competent skin	Good tanning capacity, moderate disposition to sunburn (skin types 3 and 4)
Melano-protected skin	Low to no disposition to sunburn, high tanning capacity (skin types 5 and 6)



6.3.2 Carcinogenesis

Frequent or year-long exposure to solar radiation carries an elevated risk of developing skin cancer [22]. In the course of the multi-stage process of carcinogenesis, genetic mutations take place within the cells. For instance, UV-induced, irreversible DNA damage caused primarily by UVB radiation can lead to uncontrolled growth of the affected skin cells and thus to the formation of skin tumours [23]. A distinction is made between three types of cancer: basal cell carcinoma, squamous cell carcinoma and malignant melanoma.

6.3.3 Basal cell carcinoma

Basal cell carcinoma, or basalioma, is the most frequently encountered type of skin cancer [23]. Each year, about 80,000 people in Germany develop this form of skin cancer for the first time [24]. The main cause of basal cell carcinoma is considered to be excessive exposure of the skin to the sun [23], with the cumulative life-time dose being the main risk factor [25]. Basal cell carcinoma tends to occur in equal numbers of men and women over the age of 60; young people are rarely affected [25]. The risk of basal cell carcinoma is highest among people with a very fair complexion and blue eyes [23].

Basal cell carcinoma develops mainly on parts of the skin comparatively quite often exposed to the sun, e.g. the face and neck. It grows very slowly over a period of months or years and leads to superficially visible changes in the skin [26]. Without treatment, basal cell carcinoma grows steadily in extension and depth and can destroy adjacent tissue. Basal cell carcinoma does not usually develop metastases (secondary tumours) in the body. For this reason the tumours are also termed "semi-malignant" [22].

6.3.4 Squamous cell carcinoma

Squamous cell carcinoma, also known as epithelioma, is the second most frequent form of skin cancer [23]. In Germany, about 22,000 people contract it per year [24]. Like basal cell carcinoma, squamous cell carcinoma mainly arises in old age, with the



average age of the affected persons being about 70 [27]. Particularly at risk are people with fair complexions and vocational groups working outdoors. The main cause of the development of squamous cell carcinoma is considered to be chronic prior damage to the skin accompanied by genetic mutation. Squamous cell carcinoma can be triggered by chronic skin inflammation, contact with carcinogenic substances and exposure of the skin to solar radiation [28].

Squamous cell carcinoma arises chiefly on areas of the skin exposed to the sun on the face, e.g. nose, lips and ears [27]. Excessive UV exposure can give rise to prickle cell proliferation, which can result in an early form of squamous cell carcinoma, actinic or solar keratosis. This early form is not malignant, but if left untreated it can develop into malignant squamous cell carcinoma [22]. Unlike basal cell carcinoma, metastases can form, with the probability of metastatic spread growing with the increasing size of the squamous cell carcinoma.

6.3.5 Malignant melanoma

Malignant melanoma is the most dangerous form of skin cancer. Each year, about 11,400 people in Germany contract malignant melanoma [24] and there are over 2,000 fatalities. The number of new cases per year is increasing at a rate of 6 to 7% [24].

The development of malignant melanoma is attributed to risk factors that are either dispositional or expositional [29]. According to the present state of epidemiological investigations, the dispositional factors are particularly prominent. These include skin type, hair colour and freckles. People with a very fair complexion have a tenfold greater risk of contracting malignant melanoma than those with a dark complexion [29]. Of even higher predictive value than skin type is the occurrence of naevi (moles) [29], a factor described with great consistency in all epidemiological studies as a risk factor. Moles are only in rare cases innate or present on newborn babies [30]. They are acquired in the course of childhood and their number increases with increasing age [31]. The most significant risk factor for the occurrence of malignant melanoma is the number of acquired moles. For people with about 100 moles, relative risks of



10 are given in most studies [29]. Current studies suggest that moles must be regarded for the most part as acquired risk factors and are correlated with previous UV exposure. For this reason, key contributors to the development of malignant melanoma are not only dispositional factors, but also UV radiation as one of the expositional factors [32]. As a special form of melanoma, lentigo maligna melanoma mainly develops as a consequence of excessive UV exposure. For other forms of malignant melanoma, the relationship between frequent UV radiation and melanoma formation is not as obvious [22]. The risk of contracting melanoma is not increased by the cumulative UV radiation dose, but by intermittent exposure to solar radiation, i.e. by repeated brief but intense exposure [33]. The number of painful sunburns can serve as a measure of intermittent exposure to the sun [33].

Malignant melanoma can occur anywhere on the skin. It often occurs on areas of the skin that are not exposed repeatedly to the sun [22]. The cancer cells grow non-uniformly, penetrate deep into the skin and, if untreated, can enter the blood stream. In this case, metastatic proliferation is possible in any part of the body. Malignant melanoma is thus a life-threatening disease.



7 Literature

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