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REVIEW ARTICLE

Does sunscreen block vitamin D synthesis? A literature review

Czy krem z filtrem blokuje syntezę witaminy D? Przegląd piśmiennictwa

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Abstract

Introduction and Objective. Cholecalciferol has known positive biological properties, including protection against osteoporosis, facilitating the absorption of certain elements, stimulating insulin secretion, participating in the process of building bones and teeth, and is even suspected of having an impact on preventing depression. Nowadays, due to the multitude of sources, opponents of using sunscreens as protection against cancer development question the necessity of using them precisely because of the fear of impaired vitamin D production. The aim of the study is to analyze the effect of using sunscreens on the synthesis of vitamin D in the body.

Brief description of the state of knowledge. Ultraviolet radiation can affect the skin both positively and negatively. The advantages of UV radiation include participation in the synthesis of vitamin D3 and the production of melanin that protects against sunburn, a beneficial effect on well-being, protection against the development of selected autoimmune processes, and a wide application in the treatment of dermatological diseases. The negative sides of UV action are sunburn, photo-aging and a factor in the development of non-cancers. In order to minimize the negative effects of solar radiation, it is necessary to use broadly understood photoprotection, including primarily creams with a filter.

Summary. All publications undeniably emphasize the carcinogenic effects of radiation on human skin and the need for photoprotection. No article, however, mentions the need to ban or reduce the use of sunscreen due to vitamin D deficiencies. The benefits of photoprotection far outweigh the potential reduction in vitamin D, which can be easily regulated by supplementation.

Key words

vitaminum D, cholecalciferol, sunscreen, photoprotection, SPF

Streszczenie

Wprowadzenie i cel pracy. Znane są pozytywne właściwości biologiczne witaminy D, takie jak: ochrona przed osteoporozą, ułatwianie wchłaniania niektórych pierwiastków, stymulacja wydzielania insuliny, udział w procesie budowania kości i zębów, a nawet podejrzewa się ją o to, że wspomaga zapobieganie depresji. W dzisiejszych czasach z uwagi na mnogość źródeł przeciwnicy używania kremów z filtrem jako ochrony przed powstawaniem nowotworów podają w wątpliwość konieczność ich stosowania właśnie z uwagi na obawę przed upośledzeniem procesu produkcji witaminy D. Celem pracy była analiza wpływu stosowania kremów z filtrem na syntezę witaminy D w organizmie.

Opis stanu wiedzy. Promieniowanie ultrafioletowe może wpływać na skórę zarówno pozytywnie, jak i negatywnie. Zalety promieniowania UV to udział w syntezie witaminy D3 oraz wytwarzaniu melaniny chroniącej przed oparzeniem słonecznym, korzystny wpływ na samopoczucie, obrona przed rozwojem wybranych procesów autoimmunologicznych; promieniowanie UV znajduje również szerokie zastosowanie w leczeniu chorób dermatologicznych. Negatywne strony jego działania to oparzenie słoneczne i fotoaging, promieniowanie to jest także silnym czynnikiem rozwoju nowotworów. Aby zminimalizować negatywne skutki promieniowania słonecznego, niezbędne jest stosowanie szeroko pojętej fotoprotekcji – przede wszystkim używanie kremów z filtrem.

Podsumowanie. Wszystkie publikacje bezsprzecznie podkreślają kancerogenny wpływ promieniowania UV na skórę człowieka i konieczność stosowania fotoprotekcji. Żaden artykuł nie wspomina o konieczności wprowadzenia zakazu lub zmniejszenia ilości stosowania kremu z filtrem z uwagi na niedobory witaminy D. Korzyści z fotoprotekcji są zdecydowanie większe niż potencjalne obniżenie ilości witaminy D, które w prosty sposób można uregulować suplementacją.

Słowa kluczowe

witamina D, cholekalcyferol, krem z filtrem, fotoprotekcja, SPF

INTRODUCTION

Ultraviolet radiation (UVR) constitutes a small portion of the electromagnetic radiation emitted by the sun (approximately 7%) and is composed of three wavelength ranges: UVC (200–290 nm), UVB (290–320 nm), and UVA (320–400 nm).

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UVA radiation is further divided into two subtypes: UVA1 (340–400 nm) and UVA2 (320–340 nm). The ozone layer in the Earth's atmosphere absorbs 100% of UVC radiation and approximately 90% of UVB radiation, while it has no significant effect on UVA levels at the Earth's surface [1].

Ultraviolet radiation can have both positive and negative effects on the skin. Positive effects include its role in vitamin D3 synthesis, the production of melanin that protects against sunburn, enhanced mood through increased endorphin release, defence against certain autoimmune processes, and extensive use in treating dermatological conditions (e.g., psoriasis, vitiligo). Negative effects primarily include sunburn, photoaging, its contribution to the development of non-melanoma skin cancers, and an increased risk of melanoma. To minimize the adverse effects of solar radiation, broad-spectrum photoprotection is essential [1].The main type of photoprotection used on a large scale is a cream with a UV filter. The efficacy of sunscreens can be measured by different methods, involving *in vitro, ex vivo*, or *in vivo* techniques. There is a need for a worldwide standardization of these methods to avoid misunderstanding and confusion among sunscreen users. The clinical benefits of sunscreens have been demonstrated in randomized controlled trials that established the role of sunscreens in the prevention of actinic keratoses, squamous cell carcinomas, nevi, and melanomas. Sunscreens also prevent photoimmunosuppression and signs of photoaging. Continued efforts in public education on the proper application of sunscreens and the practice of photoprotection in general are needed [2].

This raises the question: since vitamin D synthesis in the skin depends on sun exposure, specifically UVB radiation, does photoprotection – particularly sunscreen use – block or hinder this synthesis? Vitamin D is the 'sunshine vitamin' for good reason. During exposure to sunlight, the ultraviolet B photons enter the skin and photolyze 7-dehydrocholesterol to previtamin D3 which, in turn, is isomerized by the body's temperature to vitamin D3. Most humans have depended on the sun for their vitamin D requirement. Skin pigment, sunscreen use, aging, time of day, season, and latitude dramatically affect previtamin D3 synthesis. Vitamin D deficiency was thought to have been conquered, but it is now recognized that more than 50% of the world's population is at risk for vitamin D deficiency [3]. The beneficial biological properties of cholecalciferol, including its protective role against osteoporosis, facilitation of calcium and phosphorus absorption, stimulation of insulin secretion, involvement in bone and tooth formation, and its suspected role in preventing depression, are well-known. In the current era, the proliferation of information has led to critics questioning the necessity of sunscreen use as a cancer-preventive measure due to concerns about impaired vitamin D production. The authors conducted a literature review to address these concerns.

MATERIALS AND METHOD

Three authors conducted a review of articles retrieved from accessible medical literature databases such as PubMed and Google Scholar. They searched for the terms 'sunscreen impact on vitamin D', 'sunscreen photoprotection and vitamin status', and 'effect of sunscreen on vitamin D'.

RESULTS

The largest review to date, conducted by Neale et al. in 2019 [4], covered the period from 1970 – 2017 and included four experimental studies, three field studies (two of which were randomized controlled trials), and 69 observational studies. Observational studies mostly found no association or suggested that sunscreen use alone was associated with higher levels of 25(OH)D. For the first time, the study systematically reviewed all experimental, field trial, and observational research. While experimental studies confirmed the theoretical risk that sunscreen use might influence vitamin D synthesis, evidence from field studies and observational research suggested that the risk is low. However, the review highlighted a lack of evidence regarding the use of sunscreens with very high sun protection factor (SPF), as the studies included in the review primarily used sunscreens with moderate SPF (~16). Such high-SPF sunscreens are now widely recommended and used [4].

Similar conclusions were reached by Passeron et al. [5], who also confirmed that most published studies to date have not found an association between sunscreen use and vitamin D deficiency, even with regular application of sunscreens with SPF > 15. Some studies even demonstrated a positive association between sunscreen use and 25(OH) D3 levels, suggesting that sunscreen use might increase overall sun exposure. Indeed, time spent outdoors and body surface area (BSA) exposed to sunlight are positively correlated with vitamin D status. It was also suggested that other photoprotection behaviours, such as seeking shade, wearing protective clothing, and using long sleeves, might have a greater impact on vitamin D levels than sunscreen use.

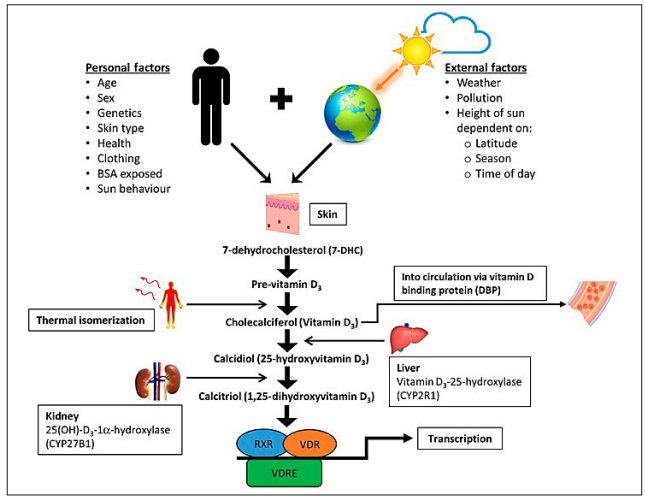

Figure 1. Factors that affect the synthesis of vitamin D3.
Many factors determine vitamin D3 production. The most important external factor is UVB dose, which is the product of UVB intensity (irradiance) and exposure time. Cutaneous pre-vitamin D3 is synthesized from 7-dehydrocholesterol after UVB exposure. Thermally converted into vitamin D3, it then binds to vitamin D binding protein (DBP) in the blood to be activated sequentially by the liver and kidney. Cytochrome P450 (CYP) enzymes are crucial for the synthesis of biologically active vitamin D3 (calcitriol), which binds to intracellular vitamin D receptor (VDR) in most cells in the body.
Source: Adapted from Passeron et al.[5]

The study conducted by Young et al. [6] aimed to determine whether sunscreen use negatively affected the production of 25(OH)D. Participants vacationing in Tenerife were assigned to one of four categories. The first group (control

group), remained in Poland and did not go on the trip. The second group was instructed to use sunscreen at their discretion. The third group received SPF 15 sunscreen with low UVA protection, while the fourth group received SPF 15 sunscreen with high UVA protection. The last two groups were instructed to apply the cream consistently.

When serum 25(OH)D levels were measured, the control group in Poland experienced a decrease of 2.5 ± 5.6 nmol. This drop in 25(OH)D indicates that dietary or exogenous vitamin D did not contribute to serum vitamin D levels or that the consumed food was not fortified with vitamin D. Overall, the lack of UV exposure in the control group demonstrated a positive correlation between vitamin D levels and UV exposure in the entire experiment [6, 7].

The three sunscreen groups showed an improvement in 25(OH)D levels after the vacation. In the group that applied sunscreen at their discretion, the level increased by 28.0 ± 16.5 nmol, but this was accompanied by sunburns and an increased risk of melanoma. In the high-UVA protection group, 25(OH)D levels rose by 19.0 ± 14.2 nmol, compared to 13.0 ± 11.4 nmol in the low-UVA protection group. By increasing UVA protection, UVB radiation may penetrate deeper into the skin and induce higher endogenous vitamin D production. This study quantifies the benefits of UV exposure during sunscreen use. Using SPF during high UV exposure protects against erythema and dermatoses but does not affect endogenous vitamin D production. The researchers suggested that healthy individuals should use broad-spectrum UVA-protective sunscreens to optimally suppress UVB while maintaining vitamin D levels [7].

In the review by Kannan et al. [8], it was stated that sunscreens applied at the recommended density of 2 g/cm² reduce vitamin D synthesis. However, in practice, sunscreen use does not lead to lower vitamin D levels. Other sun protection methods, such as avoiding the sun, wearing long sleeves, and having darker skin phototypes, may result in insufficient serum vitamin D levels; hence, vitamin D supplementation should be considered for these at-risk groups. This is supported by Diehl et al. [9], who analyzed various factors, both atmospheric and individual, that influence vitamin D synthesis. The publication highlighted that avoiding sunlight lowers serum 25(OH)D levels, and sunscreen use potentially weakens skin synthesis of vitamin D3 and may even completely block it. However, this was observed only under laboratory conditions and never had clear clinical consequences. Outside controlled experiments, sunscreen use was not shown to negatively correlate with vitamin D levels. It was concluded that sunscreen use might be a marker of sun exposure, but it is generally not used effectively. Furthermore, since many factors affect the amount of available UVB and the potential response of the body, it is difficult to formulate general statements correlating sun exposure duration with vitamin D status. It was also emphasized that the risk of sun damage and skin cancer with excessive UV exposure and the availability of oral vitamin D supplementation, further complicate the establishment of guidelines for optimal and safe levels of sun exposure required to maintain adequate vitamin D levels [8].

In the review by Raymond-Lezman [10], the authors concluded that by avoiding sunburn and using high-quality sunscreens, it is possible to achieve higher vitamin D levels while minimizing the risks associated with UV exposure. The authors also noted that several factors, including the density of sunscreen application, influence vitamin D synthesis. They suggested that patients do not follow guidelines regarding the amount of sunscreen applied, which positively affects the vitamin D synthesis process.

Passeroni et al. [5] hypothesized that UVB sun exposure increases vitamin D production and that sunscreen use significantly inhibits vitamin D status. However, this hypothesis was not confirmed. Passeroni et al. [5] confirmed that sun protection reduces UV exposure and decreases vitamin D production. However, even with a sun protection factor of 15, 15.6% of UV radiation still penetrates and is absorbed by the skin. In a study comparing individuals who regularly used sunscreens with those who did not, sunscreen users did not have vitamin D deficiencies compared to the control group. Daily sunscreen use reduces the risks of melanoma, skin cancer, aging, and immunosuppression while maintaining vitamin D levels. However, less is known about methods of application. The recommended amount of sunscreen application is 2 g/cm², but a study conducted in Egypt observing vacationers showed their average application was only 0.79 g/cm². This raises questions about the impact of sunscreen on vitamin D status since application density was not always known in previous studies [5].

Springbett et al. reviewed the impact of photoprotection strategies and pigmentation on vitamin D levels. They concluded, similarly to previously discussed publications, that clothing can be highly effective in inhibiting vitamin D synthesis, whereas sunscreens are effective in theory. However, most studies show little to no effect, likely because sunscreens are not applied in the manner required to achieve their labelled sunburn protection factor [11].

Photoprotection refers to a set of actions aimed at protecting the skin from harmful solar radiation. These actions include, not only the use of sunscreen, but also, as emphasized in the literature, avoiding sunlight and wearing clothing with long sleeves or wide-brimmed hats [1, 12]. The recommendations of the Polish Dermatological Society [1, 12] for Photoprotection advise that an adult exposed to sunlight during the spring and summer period should apply 30–35 ml of sunscreen per full-body application. Protective creams should be applied both to the skin exposed to UVR and covered by clothing. In spring and summer, it is advisable to use products with SPF ≥ 30, and during autumn and winter with SPF ≥ 15. The first application of the product should take place 15–30 minutes before leaving the house and sunscreen application should be repeated every 2 hours, and always after bathing, sweating, or drying the skin with a towel. Proper photoprotection should meet all the above points, which seems difficult to achieve in daily practice, as demonstrated by the studies mentioned above. As shown in some of the discussed publications, the negative effect on vitamin D synthesis is confirmed only in studies conducted in laboratory conditions with exposure to artificially generated radiation [1, 12].

Globally, there are differing needs for photoprotection, including the use of sunscreens. There are environmental, genetic, and socio-economic factors (collectively known as exposome) that can influence the need for photoprotection. These include the place of residence (latitude and pollution), time of year, occupation, recreational activities, a proper understanding of the side- effects of sun exposure, or the financial ability to purchase photoprotective clothing and sunscreens. There are also personal, circumstances:

age, genetics, the capacity to get sunburn known as skin phototype, the constitutive colour of the skin, the existence of some dermatoses, presence of photodermatoses, intake of photosensitizing medications, impairment of the skin barrier, and physiological states such as pregnancy. All these circumstances make it necessary to adapt the photoprotective behaviour and the sunscreen based on the specific needs of each individual, a concept of personalize and customized photoprotection [14].

Wulf et al. examined the implications of using sunscreen photoprotection on 25(OH)D formation and determined the best photoprotective method to reduce the risk of skin cancer caused by ultraviolet radiation (UVR). Based on previous studies on 25(OH)D formation after use of different amounts of sunscreen and different doses of UVR for approximately one week to different body areas, it is possible to estimate the amount of 25(OH)D formed after a week's holiday in Southern and Northern Europe. The conclusion is: the best method of photoprotection by sunscreen is two consecutive applications before sun exposure, ensuring the use of sufficient amounts of sunscreen and minimizing the unprotected skin areas. The double application method simultaneously ensures a high photoprotection against erythema from sun exposure. Despite the use of sunscreen, the calculated serum 25(OH) D levels clearly increase to similar levels as those measured after vacations in the sun [15].

Interestingly, a publication from Australia, which annually reports approximately 10,000 new cases of melanoma and over 1,000 deaths from this cancer [13], draws different conclusions. In a study conducted on 1,113 volunteers in 1996, it was confirmed that staying in the shade was independently associated with vitamin D levels, and no other sun protection variables were associated with this vitamin level. Most sun protection methods can be used without affecting vitamin D levels [16].

Stege et al. [17] discuss the widespread vitamin D deficiency observed in a high percentage of the population. As as known, vitamin D can be produced in the skin through ultraviolet B (UVB) radiation, and it is possible to raise low levels of vitamin D3 through UVB exposure. However, UVB, classified as a carcinogen, causes skin cancer. Therefore, UVB should not be used to stimulate the synthesis of vitamin D3. Sun protection, particularly wearing appropriate clothing, seeking shade, and proper use of sunscreens, correlates with reduced D3 levels. The authors emphasize that oral supplementation can easily replenish its deficiencies and without significant side-effects. The risk-benefit analysis shows that oral supplementation of vitamin D3 is far superior to UVB/sunlight exposure for increasing serum vitamin D3 levels [17].

DeLong et al. [18] in their study indicate that there is still no clear understanding of the relationship between vitamin D levels and photoprotection measures. Their research found no association between serum 25(OH)D levels and adherence to photoprotection measures in individuals with skin cancer, as assessed through the use of sunscreen (clothing, hats, sunglasses, and umbrellas/shade) using a sun protection habits index. However, it was evident that individuals who took oral vitamin D supplements had higher serum 25(OH)D levels than those who did not. The study population showed a high prevalence of vitamin D deficiency and insufficiency, emphasizing the importance of assessing vitamin D status and recommending oral vitamin D supplementation when necessary [18].

In a 2022 study by Tsugawa et al. [19], data on the vitamin D status in young Japanese women were analyzed to assess the impact of their lifestyle, including changes caused by the COVID-19 pandemic, on vitamin D levels. These studies suggest that avoiding sunlight due to the COVID-19 pandemic and frequent sunscreen use may have contributed to low vitamin D levels.

Photodermatoses. Photodermatosis is an abnormal skin inflammatory reaction to light. The major classifications of photodermatoses are idiopathic photodermatoses – photodermatoses due to exogenous or endogenous agents, photo-exacerbated dermatoses, and photosensitive genodermatoses. Idiopathic photodermatoses, a spectrum of diseases with abnormal responses to ultraviolet radiation (UVR), include polymorphous light eruption, actinic prurigo, hydroa vacciniforme, chronic actinic dermatitis, and solar urticaria. Drug-induced photodermatoses can be classified into phototoxic and photoallergic drug reactions. Certain drug-induced photodermatoses may mimic other dermatoses. For instance, drug-induced lupus erythematosus (LE) should be considered if an elderly person is diagnosed with LE, but had a poor response to standard treatments [20, 21].

Patients with these conditions require meticulous sun protection and often absolute avoidance of sun exposure. Sunscreens are an integral component of photoprotection in the management of photodermatoses [14]. Due to the potential risk of vitamin D deficiency, supplementation should be considered. Cusack et al. [22] focused on patients with cutaneous lupus erythematosus (LE), which represents a spectrum of inflammatory autoimmune diseases comprising varying clinical entities ranging from primary cutaneous to systemic disease[23]. Cusack found that 25(OH)D levels were significantly lower among those who avoided the sun and used sunscreen daily, whereas significantly higher levels were observed among individuals taking cholecalciferol (vitamin D3) supplements. Low levels were also noted in individuals with kidney diseases despite vitamin D3 supplementation [22]. The authors suggested that patients with cutaneous lupus erythematosus often have suboptimal 25(OH)D levels, which are significantly increased by supplementation with at least 400 IU/day of cholecalciferol. They also recommended supplementation with an active vitamin D analog for subgroups of patients with kidney diseases [22]. Another study on patients with lupus erythematosus [24] compared a group of healthy individuals with a group of patients with lupus erythematosus using photoprotection. Serum 25-hydroxyvitamin D levels were lower, and vitamin D deficiency was more frequent in patients using photoprotection, compared to healthy individuals during both warm and cold seasons ($P < 0.05$). The study once again emphasized the importance of diagnosing vitamin D deficiency and the necessity of oral supplementation in patients with photodermatoses who use photoprotection.

DISCUSSION

In 2024, a society with access to unlimited verified and unverified information, primarily via the Internet, was inundated with emotionally charged slogans, 'clickbaits' and amateur videos posted on platforms by self-proclaimed

experts in various fields which could credibly encourage the adoption of unverified and health-threatening methods of treating specific diseases or the abandonment of necessary preventive measures against other risks. This contributed to the reason for writing this article. Believing such messages can have dangerous consequences, exemplified by the lack of preventive measures against skin cancers, such as melanoma or basal and squamous cell carcinoma. It turns out that promoting only verified sources of information, such as medical journals, could help people avoid many diseases. However, determining how many individuals would truly benefit from such an approach will be the subject of further deliberations by the authors.

SUMMARY

All publications unequivocally emphasize the negative, primarily carcinogenic effects of ultraviolet radiation on human skin and the necessity of photoprotection, including the use of sunscreen. Most studies indicate that numerous external and internal factors influence the proper concentration of vitamin D in the body, making it difficult to formulate general statements correlating sun exposure time with vitamin D status. No article suggests the need to ban or reduce the use of sunscreen due to concerns about vitamin D deficiency. The benefits of photoprotection far outweigh the potential reduction in vitamin D levels, which can be easily managed through supplementation.

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