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Vitamin D Levels in Children During Winter and the Relationship Between Sunscreen and Sun Protection Behaviors

Burcu Tugrul[1], Hatice Gamze Demirdag[2], Aysin Hanli Sahin[3]

1 Ankara Bilkent City Hospital, Department of Dermatology, Ankara, Turkey
2 Private Practice, Dermatology Clinic, Ankara, Turkey
3 Health Science University, Ankara Oncology Training and Research Hospital, Department of Pediatrics, Ankara, Turkey

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Corresponding Author: Hatice Gamze Demirdag, Private Practice, Dermatology Clinic, Ankara, Turkey.
E-mail address: demirdaggamze@gmail.com

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ABSTRACT

Introduction: Sunlight is the major source of vitamin D, thus, the use of sunscreens could result in vitamin D insufficiency or deficiency.

Objectives: Our study aimed to assess serum vitamin D levels in healthy children aged 0-18 years in the winter season and determine the association between sunscreen use and sun protection behaviors on vitamin D status.

Methods: The demographic data, clothing style, skin type, history of sunburn, history of visiting seaside towns in summer, sun protection behaviors including sunscreen use, wearing sunglasses and hats, and further detailed information about sunscreen use were recorded. Vitamin D status was assessed by measuring blood levels of total 25(OH)D during winter.

Results: Three hundred seventy-six children (172 boys and 204 girls) with a mean age of 128.38±56.39 months were enrolled. The mean serum level of 25(OH)D was 15.32±8.64 ng/mL. The mean values of vitamin D were associated with age, sex, traditional clothing style, having a sunburn history, and sunscreen use ($P < 0.05$). Adolescents and girls had vitamin D deficiency and inadequacy more than younger children and boys ($P < 0.05$). Sunscreen use in the adequacy group was lower than in the inadequacy and deficiency groups ($P = 0.001$). There was no significant difference between vitamin D status according to the sunscreen details (sun protection factor, product source, season, and body areas) ($P > 0.05$).

Conclusions: Sunscreen use appears to reduce vitamin D levels measured in winter. Children, especially girls and adolescents, should be exposed to sufficient sunlight to maintain normal serum vitamin D levels. Vitamin D supplementation should be given to children, especially during winter.

Introduction

The prevalence of vitamin D deficiency and insufficiency among different pediatric age groups was evaluated by several studies and high percentages of hypovitaminosis D were reported worldwide [1-3]. Exposure of the skin to sunlight is the major source of vitamin D. Only some food including oily fish such as salmon, swordfish, tuna, cod liver oil, and sun-dried mushrooms naturally contain adequate vitamin D [3]. Vitamin D-fortified milk and orange juice provide another food source for vitamin D [5]. The main reason for vitamin D deficiency is inadequate exposure to sunlight [1-6].

When the human skin is exposed to sunlight, most of this UVB radiation is absorbed in the epidermis and most vitamin D is produced in the living cells in the epidermis [7,8]. Sunlight exposure-induced vitamin D synthesis is influenced by many important variables including the season of the year, time of day, latitude, altitude, air pollution, skin color, age, area of skin exposed, clothing habits, sunscreen use, sunlight passing through glass and plastic, and aging [8,9].

Sun protection is widely recommended from childhood to prevent both melanoma and non-melanoma skin cancer as ultraviolet radiation (UVR) causes sunburn and UVR is defined as a carcinogen. Sunscreens were designed to absorb solar UVB radiation. Concerns have been expressed about the negative effects of limiting UVB exposure on vitamin D status because vitamin D production is associated with direct sunlight exposure [7,10]. The role that sunscreens play in reducing vitamin D synthesis is still unclear [1]. Although experimental studies suggest a theoretical risk that sunscreen use may affect vitamin D, there are no randomized controlled trials or longitudinal studies reporting that sunscreens significantly suppress cutaneous vitamin D synthesis [9,11].

There are only limited real-life studies evaluating the relationship between sunscreen use and serum levels of vitamin D in children in the recent literature. Less is known about the association between other recommended sun protection behaviors (such as wearing a hat and sunglasses) and vitamin D levels.

Objectives

Our study aimed to assess serum vitamin D levels in healthy children aged 0-18 years in the winter season and determine the association between sunscreen use and sun protection behaviors on vitamin D status.

Methods

The study was conducted in dermatology and pediatrics outpatient clinics between December 2021 and March 2022 in a Training and Research Hospital in Ankara. The study period was chosen as winter, with minimum ultraviolet exposure in the middle region of Türkiye, taking into account the differences in serum levels of vitamin D that may be shown by the season and sun exposure. Institutional review board protocol approval was obtained from the hospital ethics and scientific committee (Approval date: 08.07.2021, Decision number: 2021-07/1273), and written informed consent was obtained from the parents of all the children. This research was conducted in compliance with the principles of the Declaration of Helsinki.

The participants in this study were randomly selected from Caucasian children who were admitted to pediatric outpatient clinics for routine examinations. Healthy children aged 0-18 years, both girls and boys, were enrolled in the study. Adolescence is the life stage between childhood and adulthood, between the ages of 10 and 19 years; our study groups are classified according to age groups as children aged under 10 years, and adolescents as age 10 years and older.

The demographic data, clothing style, history of sunburn, history of visiting seaside towns to swim in summer, and sun protection behaviors including sunscreen use and wearing sunglasses and hats were obtained from each parent and child through face-to-face interviews. Detailed information about sunscreen use, whether sunscreen products were bought from pharmacies or supermarkets, sun protection factor (SPF) levels (SPF ≤ 30 or SPF 50), applying sunscreen to the face and/or body, and applying sunscreen in the summertime, sunny days or all seasons were also recorded. The weight and height of the participants were assessed using a standard protocol, and body mass index (BMI) was calculated as weight (kg)/height (m)^2. The clothing style of participants who wore long sleeves and pants/skirts all year was expressed as traditional clothing. The children's skin color was classified using the Fitzpatrick skin phototype classification, which was based on the skin's response to ultraviolet light [12].

Vitamin D status is assessed by measuring blood levels of total 25(OH)D. Serum levels of 25(OH)D were measured using a Roche Cobas E601 Modular Diagnostic System. Data were recorded from the laboratory results in the hospital data system. We used the widely used cut-off points as suggested by Munns et al [13]. According to their criteria, vitamin D deficiency was defined as a serum 25(OH)D level of <12 ng/mL (<30 nmol/L) and insufficiency as a 25(OH)D level between 12 and 20 ng/mL (30-50 nmol/L). Twenty-five(OH)D levels >20 ng/mL (50 nmol/L) were accepted as adequate.

The exclusion criteria were intake of vitamin D supplements during the previous year, risk factors for the development of vitamin D deficiency, known metabolic bone disease, diseases or medicines known to affect vitamin D or calcium metabolism, acute diseases during the past two months, and chronic health conditions, e.g., diabetes mellitus, obesity. Additionally, children with excessively high and toxic levels of 25(OH)D were excluded.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) for Windows version 20.0 software package. Descriptive statistics are presented as numbers and percentages for categorical variables, and mean ± standard deviation and minimum-maximum values for numerical variables. In the analysis of numerical data, compliance with normal distribution was examined using the Kolmogorov-Smirnov test, and because all numerical variables did not show normal distribution, the Mann-Whitney U test was used in the comparison of two independent groups, and the Kruskal-Wallis H test was used in the comparisons of more than two groups. Analyses of categorical variables were performed using the Chi-square test. P values less than 0.05 were considered statistically significant.

Results

After 44 children who were under supplement treatment were excluded, the study group consisted of 376 children (172 boys and 204 girls) with a mean age of 128.38 ± 56.39 months and median age of 132 (min 9-max 216) months. The mean serum level of 25(OH)D was 15.32 ± 8.64 ng/mL. The mean BMI of the children was 19.22 ± 10.99 kg/m^2 and the median was 18.66 kg/m^2. The percentages of data and comparisons of demographic data and mean values of vitamin D are presented in Table 1. The most seen skin type was Fitzpatrick type 4 with 50%. Fitzpatrick skin types 1 and 6 were not found in the study group. Some 12.5% of children had a history of sunburn, and 4.8% wore traditional clothing. Nearly 60% of the children regularly visited a seaside town in summer, 64.4% of children wore a hat under the sun, and 31.1% wore sunglasses. More than half of the children (58.5%) did not use sunscreens. The mean values of vitamin D were low in children aged over 10 years old, girls, those who wore traditional clothing, had a sunburn history, and sunscreen users (P < 0.05).

Table 2 presents the details of sunscreen use in the group that used sunscreen; 55% of the group preferred sunscreens with SPF ≤30. Sunscreen products were bought almost equally from both pharmacies and supermarkets. Of the children who used sunscreen, half used sunscreens only in summer and nearly 95% of children applied sunscreen both to the face and body. There was no significant difference between the details of sunscreen use and vitamin D levels (P > 0.05).

Vitamin D deficiency was recorded in 33.5% (N = 126) of the children and inadequacy was in 46% (N = 173). Seventy-seven (20.5%) patients had adequate levels of vitamin D. There was a significant difference among age groups and sex in terms of adequacy of vitamin D (P = 0.003 and P < 0.001, respectively). Adolescents and girls had vitamin D deficiency and inadequacy more than younger children and boys. There was a statistically significant difference in terms of vitamin D levels according to sunscreen use (P = 0.001). The rate of sunscreen use in the adequacy group was lower than in the inadequacy and deficiency groups. There was no significant difference between vitamin D deficiency/inadequacy/adequacy groups according to the sunscreen SPF, product source, in which season sunscreen was used, and areas of the body it was used (P > 0.05) (Table 3).

Conclusions

The present study evaluated the relationship between vitamin D status and sun protection behaviors and sunscreen use in a Turkish pediatric series. It revealed that 79.5% of the patients had deficient and inadequate levels of vitamin D. Adolescents, girls, and sunscreen users had lower serum levels of vitamin D causing deficiency and inadequacy. History of sunburn and traditional clothing had only a lowering

Table 1. Demographic data and vitamin D levels in the study group (N = 376).

	N (%)	Vitamin D Mean±SD	P value
Age, years			<0.001
<10	153 (40.7)	17.49±10.58	
>=10	223 (59.3)	13.93±6.54	
Gender			0.001
Male	172 (45.7)	16.64±8.27	
Female	204 (54.3)	14.32±8.73	
Skin type			0.772
Type 2	29 (7.7)	15.47±5.14	
Type 3	119 (31.6)	15.75±10.43	
Type 4	188 (50.0)	15.26±8.19	
Type 5	40 (10.6)	14.80±6.18	
Clothing style			0.023
Veiled	18 (4.8)	11.53±5.30	
Normal	358 (95.2)	15.58±8.68	
History of sunburn			0.020
Yes	47 (12.5)	12.95±5.95	
No	329 (87.5)	15.73±8.85	
History of visiting seaside in summer regularly			0.792
Yes	224 (59.6)	15.06±7.36	
No	152 (40.4)	15.86±10.13	
Wearing a hat			0.864
Yes	242 (64.4)	15.06±7.11	
No	134 (35.6)	15.97±10.76	
Wearing sunglasses			0.484
Yes	117 (31.1)	14.58±6.85	
No	259 (68.9)	15.74±9.25	
Sunscreen usage			0.030
Yes	156 (41.5)	14.13±6.54	
No	220 (58.5)	16.27±9.70	

SD = standard deviation.

Table 2. The details of sunscreen usage in the group using sunscreen (N =156) and vitamin D levels.

	N (%)	Vitamin D Mean±SD	P value
Sunscreen SPF			0.625
SPF 30/less than 30	86 (55.1)	14.37 ± 6.23	
SPF 50	70 (44.9)	13.84 ± 6.95	
Usage season			0.337
Only summer	84 (53.8)	13.51 ± 6.14	
Sunny days	35 (22.4)	14.01 ± 5.48	
All seasons	37 (23.7)	15.67 ± 8.10	
Product source			0.385
Market	79 (50.6)	13.67 ± 6.22	
Pharmacy	77 (49.4)	14.61± 6.96	
Areas used			0.149
Only face	8 (5.1)	17.48 ± 7.53	
Face and body	148 (94.9)	13.95 ± 6.47	

SD = standard deviation; SPF = sun protection factor.

Table 3. Vitamin D deficiency, inadequacy, and adequacy according to demographic characteristics, sun protection behaviors and sunscreen details.

	Deficiency <12 (N =126) N (%)	Inadequacy 12-20 (N=173) N (%)	Adequacy >20 (N=77) N (%)	P value
Age, years				
<10	42 (27.5)	67 (43.8)	44 (28.8)	0.003
>=10	84 (37.7)	106 (47.5)	33 (14.8)	
Gender				
Male	50 (29.1)	71 (41.3)	51 (29.7)	<0.001
Female	76 (37.3)	102 (50)	26 (12.7)	
Skin type				
Type 2	8 (27.6)	17 (58.6)	4 (13.8)	0.737
Type 3	36 (30.3)	57 (47.9)	26 (21.8)	
Type 4	67 (35.6)	81 (43.1)	40 (21.3)	
Type 5	15 (37.5)	18 (45)	7 (17.5)	
Clothing style				
Veiled	9 (50)	7 (38.9)	2 (11.1)	0.279
Normal	117 (32.7)	166 (46.4)	75 (20.9)	
History of sunburn				
Yes	19 (40.4)	24 (51.1)	4 (8.5)	0.090
No	107 (32.5)	149 (45.3)	73 (22.2)	
History of visiting seaside in summer regularly				
Yes	72 (32.1)	112 (50)	40 (17.9)	0.130
No	54 (35.5)	61 (40.1)	37 (24.3)	
Wearing a hat				
Yes	81 (33.5)	110 (45.5)	51 (21.1)	0.921
No	45 (33.6)	63 (47)	26 (19.4)	
Wearing sunglasses				
Yes	42 (35.9)	51 (43.6)	24 (20.5)	0.777
No	84 (32.4)	122 (47.1)	53 (20.5)	
Sunscreen usage				
Yes	53 (34)	85 (54.5)	18 (11.5)	0.001
No	73 (33.2)	88 (40)	59 (26.8)	
Sunscreen details in suncreen usage group (n=156)				
	Deficiency <12 (N=53) N (%)	**Inadequacy 12-20 (N=85) N (%)**	**Adequacy >20 (N=18) N (%)**	**P value**
Sunscreen SPF				
SPF 30/less than 30	27 (31.4)	49 (57)	10 (11.6)	0.743
SPF 50	26 (37.1)	36 (51.4)	8 (11.4)	
Usage season				
Only summer	32 (38.1)	44 (52.4)	8 (9.5)	0.432
Sunny days	10 (28.6)	22 (62.9)	3 (8.6)	
All seasons	11 (29.7)	19 (51.4)	7 (18.9)	
Product source				
Market	27 (34.2)	47 (59.5)	5 (6.3)	0.105
Pharmacy	26 (33.8)	38 (49.4)	13 (16.9)	
Areas used				
Only face	1 (12.5)	5 (62.5)	2 (25)	0.277
Face and body	52 (35.1)	80 (54.1)	16 (10.8)	

SPF = sun protection factor.

effect on mean serum levels of vitamin D but not the adequacy of vitamin D status in children.

The prevalence of vitamin D deficiency observed varied from 24% to 99% in different studies and regions [14,15]. In Türkiye, the prevalence of vitamin D deficiency for children was 39.8% in a meta-analysis review [4]. In this study, vitamin D deficiency was found similarly at 33.5%. In a study with children aged 6-9 years, according to values measured throughout the year, vitamin D deficiency was observed in 5.6% of children and insufficiency in 18.6% [16]. We found a deficiency in 27.5% and inadequacy in 43.8% of those aged less than 10 years. The higher rate in our results may be due to the season. The study was conducted in winter when most children stay indoors. The average temperature in Ankara is 1.4°C and the mean duration of sunshine is 3 hours per day during winter [17]. Researchers found that vitamin D levels increased in summer [15,18] and decreased in winter [16,19-22]. Outdoor physical activities are also limited in winter. Thus, vitamin D deficiency continues to be a severe problem, especially in non-sunny seasons.

Vitamin D deficiency increased with age in our study. In recent studies, older children and adolescents had lower median vitamin D levels than younger children, compatible with our results [6,15,18,22-25]. In the current study, the prevalence of vitamin D deficiency in adolescents was 65.1% and insufficiency was 58.1%. By contrast, the prevalence of low concentrations of 25(OH)D in adolescents was found as 75% in Feketea et al study [6]. In adolescents from Kuwait, 81% and 15% of adolescents were vitamin D deficient or vitamin D insufficient, respectively [24]. Vitamin D deficiency was highly prevalent (61.6%) in Qatari adolescents aged 11-16 years. Older skin seems to synthesize less vitamin D than younger skin [23].

The serum levels of vitamin D were significantly lower among girls compared with boys in our study, in line with most other studies [14,15,18,19,22-26]. In contrast to these results, some studies found no significant difference between the sexes in mean levels of vitamin D [6,16,21,26,27]. Al-Taiar et al. supposed that an indoor lifestyle might be more common in girls and may exacerbate vitamin D deficiency [24]. Taking into account this sex disparity, improving vitamin D levels among adolescents should focus on girls by supporting safe sunlight exposure and/or intake of vitamin D-rich foods and supplements [24].

We found lower mean vitamin D levels in children who wore traditional clothing. Vitamin D status was affected by a covered style of dress that prevented exposure to direct sunlight [4,10,14]. Vitamin D insufficiency and deficiency were found more common among Turkish adolescent girls, particularly those wearing concealing clothing [28]. In Sherief et al study among healthy Egyptian adolescents, all females were wearing hijabs and all had vitamin D deficiency [8,14]. Conflictingly, Pulungan et al [27] found no significant difference between vitamin D insufficient and vitamin D sufficient children related to types of clothing, among whom all girls wore hijabs (long sleeves, long skirts, and headscarves).

Vitamin D levels were lower in children with a sunburn history; however, no significant difference was found between vitamin D deficiency, inadequacy, and adequacy among children with a sunburn history. Having sunburn previously may direct to more sun protection behaviors, therefore, vitamin D levels may decrease. Linos et al found that sunscreen was more frequently used in subjects who were more likely to get sunburn [29].

To protect against UVR, almost all medical associations and societies recommend seeking shade during midday hours and wearing protective clothing, a hat with a wide brim, and sunglasses, besides using broad-spectrum sunscreens [29,30]. Although there was no relationship between vitamin D levels and wearing a hat and sunglasses, sunscreen users had lower levels of serum vitamin D. Wearing a sunhat or using sunscreen was not associated with lower vitamin D status in some studies [10,29]. In Hansen et al study, seeking shade and wearing protective clothing were significantly associated with lower vitamin D status in adults but not in children [10]. In another study, Danish school children who used hats rarely/never had 12.1 nmol/L higher vitamin D levels compared with school children who always/often used hats [31]. There is no clear relationship between vitamin D concentrations and sun exposure guidelines because, in real life, there is no certainty if children pay attention to sun protection [6].

Sunscreens limit the absorption of UVB radiation over the skin and applying sunscreens is encouraged in time to prevent sunburn, skin aging, and skin cancer development [9,32]. Using sunscreens and their effect on vitamin D synthesis still seems to be confusing. Some studies showed that sunscreen agents caused a defect in the cutaneous synthesis of vitamin D [33-35]. Sunscreen use on the entire body blocked ultraviolet-induced vitamin D synthesis, if >19% of total body surface area was not applied with sunscreen, vitamin D levels increase significantly [35]. Similarly, Holick et al reported that daily application of sunscreen with SPF 8 on all sun-exposed body areas decreased vitamin D production by the skin [3]. Individuals with low sun exposure and regular use of sunscreens had an odds ratio of hypovitaminosis D [21]. Some studies found that sunscreens did not prevent the production of sufficient vitamin D. Vitamin D production can be reduced by the strict use of sunscreens at recommended concentrations of 2 mg/cm^2; however, their inadequate application (<2mg/cm^2), mostly done by average users, does not lead vitamin D deficiency [5,9]. Marks et al [36] concluded that sufficient exposure to the sun was achieved during the Australian summer to allow adequate vitamin D production in subjects who regularly applied sunscreens. Farrerons et al [37] showed that 1,25(OH)2D levels did not change significantly in either the sunscreen user group or the control groups with the season of the year. Serum 25(OH)D concentrations in winter decreased by 17–40% in sunscreen users and by 31–35% in the controls. The use of sunscreen was not associated with vitamin D deficiency even when analyses were restricted to adult subjects using sunscreens with SPF >15 or SPF >30 [29]. Some studies showed that the use of oral vitamin D supplements was associated with higher vitamin D levels compared with sunlight exposure [38,39]. Most (65%) observational studies found no association between sunscreen and vitamin D concentration [33]. Results from existing trials and observational studies support the low risk.

In this current study, children who used sunscreens had low adequate vitamin D levels. In the sunscreen users group, SPF, product source, season, and body areas were not related to vitamin D status. Mortensen et al [31] found a tendency towards a negative effect on serum 25(OH)D with the use of sunscreen having SPF ≥30, which became significant with parental education or week of measurement. Contrary to our results, Feketea et al [6] found higher vitamin D levels in children who used sunscreens than in those who did not. Pulungan et al [27] showed that more healthy children from 7-12 years of age in the vitamin D sufficient group did not use sunscreen (59 versus 27, P = 0.02), but this finding was inconsistent with their multivariate analysis. Several longitudinal studies of sunscreen users and controls showed similar end-of-summer levels of vitamin D, indicating that infrequent sunscreen use or sufficient amounts of UVB passed the sunscreen barrier and/or unprotected skin parts might also contribute to this result [30]. The measurement times of vitamin D levels in winter months may play a role in low vitamin D levels regardless of the sunscreen use details in this study.

Because it is thought that visiting seaside towns to swim in summer may affect the sun exposure time, this question was asked of participants. No relationship was found between visiting seaside towns and vitamin D levels. Some studies showed that the duration of time spent under the sun was longer in children with vitamin D sufficiency [23,27].

Outdoor physical activity and/or total time spent outside were not questioned in the present study, which may affect vitamin D levels. In a study, autumn vitamin D status in 4–8-year-old Danish children was associated with physical activity habits [31]. Seasonal changes for vitamin D levels that allow seasonal comparisons were not researched in this study. Seeking shade, one of the recommended sun protection behaviors in guidelines, was not questioned of the families. Staying in the shade was found to be related to lower vitamin D status [29]. The sunscreen use details and sun protection behaviors were evaluated according to the self-reports of parents. However, validation of self-reported sun protection habits has been evaluated and confidence was reported in self-reports of these behaviors in questionnaires and intervention research [40].

In conclusion, keeping the risk of sunburn and skin cancer in mind, children should benefit from the sun adequately during the winter. Special attention should be given to girls and adolescents because they have more vitamin D inadequacy and deficiency. Vitamin D supplementation should be given to children, especially during winter. Further studies including vitamin D measurements from various cities and all seasons are required to clarify the effects of sun-protective behaviors on vitamin D levels.

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