The Comparison of Vitamin D Levels in Thai Adults Between Patients with Vitiligo and the Healthy Controlled Groups

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Abstract

Background: Vitiligo is an autoimmune skin disease that is associated with multiple pathogenesis and is characterized by the destruction of melanocytes, triggering hypopigmented macules or patches. A low level of serum vitamin D was associated with many autoimmune diseases in several studies. The vitamin D receptor was found in melanocytes; therefore, lower vitamin D status might affect melanocyte activities. Objective: To compare the level of serum 25-hydroxyvitamin D between Thai patients diagnosed with vitiligo and healthy controls and to assess the relationship between vitamin D status and the severity of vitiligo and different types of vitiligo. Material and Method: This cross-sectional study included 56 participants. The study included 28 patients and 28 healthy controls. The level of serum vitamin D was measured in all participants by using the chemiluminescent microparticle immunoassay (CMIA) method. The results were compared, and statistical analysis was done by using SPSS software. Result and Discussion: Fifty-six participants were included. The mean age of the vitiligo cases was 53.36 ± 16.59 years. 53.6% of vitiligo were males. The mean of vitamin D levels in vitiligo groups and healthy controls were 24.50±6.94 ng/ml and 23.75±10.32 ng/ml, respectively (p-value=0.750). There was no statistically significant median difference in VASI score between insufficient vitamin D and sufficient vitamin D, with p-value of 0.152 (95% CI; -7.18, 1.18). In addition, there was no significant difference in the Vitiligo Area Scoring Index (VASI) i for vitamin D deficiency compared to vitamin D sufficiency with p-value = 0.400 (95% CI; -6.81, 2.81). Twenty-two generalized vitiligo cases, divided by 27.3%, had vitamin D sufficiency, 50% of cases had insufficiency, and 22.7% of cases had vitamin D deficiency. All four segmental cases presented with insufficient vitamin D, and both patients of the focal type had deficient vitamin D. However, there was no significant relationship between vitamin D status and the different types of vitiligo (p-value = 0.074). Conclusion: In this study, there was no significantly different mean serum vitamin D level between the vitiligo patients and the healthy controls. In addition, there was no statistically significant relationship between vitamin D status and severity as well as the different types of vitiligo.

Keywords**:** *Vitamin D, Vitiligo, Thai*

1. Introduction

Vitiligo is an acquired depigmentary skin disorder characterized by the development of depigmented macules and patches secondary to the autoimmune destruction of melanocytes (Seneschal, Boniface, D'Arino, & Picardo, 2021).Vitiligo can affect all genders, skin types, and any area of the body. The prevalence was 1-2% of the world population (Bergqvist & Ezzedine, 2020). The pathogenesis of vitiligo was not clearly understood, but several factors are involved in melanocyte destruction, such as oxidative stress, autoimmunity, environmental factors, and genetic predisposition (Riding, & Harris, 2019; Rodrigues et al., 2017). Even though, vitiligo is not lethal, this disease profoundly impacts quality of life and socio-psychology because of cosmetic issues (Ezzedine et al., 2021; Noh et al., 2013).

Vitamin D is a steroid hormone synthesized in the skin from sunlight exposed mainly to UVB radiation ranging from 290nm to 320nm and is only slightly acquired by food intake (Borel, Caillaud, & Cano, 2015). The active form, 1,25-dihydroxy vitamin D3, is the hormone that regulates calcium and bone metabolism, controls cell proliferation, and exhibits certain immunoregulatory functions. Vitamin D may affect innate and adaptative immune responses through B and T lymphocytes, macrophages, and dendritic cells (Mostafa, & Hegazy, 2015). Some recent studies have been published on the relationship between low

serum vitamin D and autoimmune diseases, including systemic lupus erythematosus, diabetes mellitus, rheumatoid arthritis, multiple sclerosis, and alopecia areata (Lizarondo et al., 2021; Umar et al., 2018). Additionally, vitamin D receptors are found on the melanocytes, which operate in the increase of tyrosinase activity and melanogenesis (AlGhamdi, Kumar, & Moussa, 2013). Due to this knowledge, topical and oral vitamin D have been used to treat vitiligo as an adjunctive treatment (Grimes, & Nashawati, 2017; Parsad & Kanwar, 2009). However, there needs to be more studies on the relationship between vitamin D l levels in Thai Vitiligo patients.

There are numerous previous studies addressing the significant relationship between vitamin D levels and vitiligo (Upala, & Sanguankeo, 2016). A pilot study by (Silverberg et al., 2010) measured 25 hydroxy vitamin D levels in patients with vitiligo vulgaris to determine an association, and they found that patients with comorbid autoimmune disease were likelier to have low levels of vitamin D (Silverberg et al., 2010). There is a notable gap in knowledge between vitamin D status and the type of and severity of vitiligo. The goal of this study is to compare the serum vitamin D levels of Thai populations diagnosed with vitiligo and healthy controls.

2. Objective

This study aimed to compare the level of serum 25-hydroxyvitamin D between Thai patients diagnosed with vitiligo and healthy controls, as well as assess the relationship between vitamin D status and the severity of vitiligo and different types of vitiligo.

3. Materials and Methods

A cross-sectional study was conducted. Twenty-eight patients attending the outpatient department at the Institute of Dermatology, Bangkok, Thailand, were included from January 2022 to September 2023. Full history taking and a full body examination were done in the patient groups, and the diagnosis was confirmed by two expert dermatologists. Additionally, 28 healthy controls were matched by age group, gender, and Fitzpatrick skin type for the comparison. All vitiligo patients included in the study were classified into three types: generalized type, focal type, and segmental type. All those cases included Thai males and females, aged 18 years old or older, with any type and severity of vitiligo. The vitiligo patients who had a history of prior using topical or oral vitamin D supplements, phototherapy within the last three months, a history of the previous diagnosis of vitamin D insufficiency or deficiency, and a history of previously using vitamin D affecting medication for at least six months (Bisphosphonate of calcium). Systemic of corticosteroid, anti-retroviral, anti-estrogens, and cytostatic agents), currently on any photosensitivity medication, pregnancy, and lactation women, all other hypopigmentation diseases, all autoimmune diseases, and chronic liver and kidney diseases, were excluded. The control groups included healthy volunteers who were visitors, staffs, or patients who came to the outpatient clinic for other reasons.

The blood samples were withdrawn from the antecubital of the right or left hand around 3 to 5 ml by using a 5 ml syringe with 22 gauges and one-inch-long needle taken by the laboratory technician. The serum of vitamin D was measured using the CMIA method (Chemiluminescent microparticle immunoassay) in the laboratory at the Institute of Dermatology. Accordingly, with the vitamin D level, the Vitamin D status was classified as sufficiency (>30ng/ml), insufficiency (20-30ng/ml), and deficiency (<20ng/ml). All the values were used as references in the laboratory where they were analyzed. All the participants were required to sign a consent form before participating in the study. This study was approved by the institute review board committee, IRB/IEC 006/2023.

3.1 Statistical analysis

The statistical analysis was performed on SPSS software version 28.0 (IBM Corp., Armonk, NY, USA). The mean, standard deviation, and percent were described in the descriptive data. In addition, the data was analyzed using an independent t-test, Fisher's exact test, univariable and multivariable regression analysis, and median regression analysis. A P-value <0.05 was considered statistically significant.

4. Result

All 28 patients and 28 controls were enrolled in the study. The mean age of the vitiligo was 53.36±16.59 years, 46.4% of all participants were females and 53.6% were males. For the controls, the mean age was 52.96±15.35 years, 60.7% of this group were females, and 39.3% were males. In the main demographic features, there were no significant differences between the patient and controls regarding age, gender, employment status, daily outdoor duration, underlying diseases, sunscreen, or family history, except for the weekly outdoor duration, as shown in Table 1. The mean serum vitamin D level in vitiligo patients was 24.50±6.94 ng/ml, while this in healthy groups was 23.75±10.32 ng/ml. The mean vitamin D level was demonstrated to be higher in vitiligo patients than controls for 0.75 ng/ml; however, there was no statistically significant difference between both groups with a p-value=0.748 (Table 2 and Figure 1).

From Table 3, vitamin D insufficiency was illustrated for 53.6% from all vitiligo cases, whereas there was 25% in the controls. Furthermore, vitamin D deficiency was 25% in vitiligo and 39.3% in controls. No statistically significant difference was shown between vitiligo and controls (p-value = 0.091).

The analysis examined the relationship between vitamin D deficiency and vitiligo disease using univariable analysis by simple logistic regression analysis. There revealed that vitamin D deficiency was not statistically significantly associated with vitiligo. Individuals with vitamin D insufficiency had a 3.57 times higher likelihood of developing vitiligo compared to those with normal vitamin D levels (unadjusted OR = 3.57, 95% CI: 0.92 -13.81, p-value = 0.065). Conversely, individuals with vitamin D deficiency had a 1.06 times higher chance of developing vitiligo compared to those with normal vitamin D levels (unadjusted OR = 1.06, 95% CI: 0.27 - 4.24, p-value = 0.934) (Table 4).

The multivariable analysis conducted using multiple logistic regression analysis, while controlling for influential factors such as age, gender, occupation, comorbidities, duration of outdoor activities and sunlight exposure per day and per week, sunscreen use, and family history of vitiligo, indicated that vitamin D deficiency was not statistically significantly associated with the occurrence of vitiligo. Individuals with vitamin D insufficiency had a 5.07 times higher likelihood of developing vitiligo compared to those with normal vitamin D levels (adjusted OR = 5.07, 95%CI: 0.90 - 28.63, p-value = 0.066). Conversely, individuals with vitamin D deficiency had a 1.25 times higher likelihood of developing vitiligo compared to those with normal vitamin D levels (adjusted OR = 1.25, 95% CI: 0.24 - 6.42, p-value = 0.792) (Table 4).

Of note, the relationship between serum vitamin D status and severity of vitiligo disease using the Vitiligo Area Scoring Index (VASI), which was estimated by median regression analysis, was not statistically significant in the median difference of VASI between insufficient vitamin D and sufficient vitamin D with a p-value of 0.152 (95% CI; -7.18, 1.18). In addition, there was no significant difference in VASI in vitamin D deficiency compared to vitamin D sufficiency, with a p-value of 0.400 (95% CI; -6.81, 2.81) (Table5).

Moreover, table 6 demonstrated that a total of 22 patients of generalized type were divided by 27.3% of cases, had vitamin D sufficiency, 50% of cases had insufficiency, and 22.7% of cases had vitamin D deficiency. All four segmental cases presented with insufficient vitamin D, and both patients of the focal type had deficient vitamin D. Although, there was no significant relationship between vitamin D status and the different types of vitiligo (p-value = 0.074) using Fisher's exact test.

Table 1 Demographic and clinical characteristics of participants

Characteristics	Patients (n = 28)	Control (n = 28)	p-value
Age (years), Mean ± SD	53.36 ± 16.59	52.96 ± 15.35	0.927
Min. – Max.	(19 - 81)	(23 - 77)	
<60	15 (53.6)	16 (57.1)	0.788
≥60	13 (46.4)	12 (42.9)	
Sex			
Female	13 (46.4)	17 (60.7)	0.284
Male	15 (53.6)	11 (39.3)	
Employment status			
Employee	22 (78.6)	20 (71.4)	0.537
Unemployed/Retirement	6 (21.4)	8 (28.6)	
Underlying disease	11 (39.3)	13 (46.4)	0.589
Hypertension	7 (25.0)	5 (17.9)	0.515
Diabetes Mellitus	2 (7.1)	2 (7.1)	1.000
Dyslipidemia	3 (10.7)	6 (21.4)	0.469
Myocardial infarction	1 (3.6)	0 (0.0)	1.000
HIV	1 (3.6)	0 (0.0)	1.000
Gout	1 (3.6)	0 (0.0)	1.000
Asthma	0 (0.0)	2 (7.1)	0.4

Allergic Rhinitis	0	(0.0)	2	(7.1)	0.491
Outdoor duration day per week					
1-3	12	(42.9)	20	(71.4)	0.031
4-7	16	(57.1)	8	(28.6)	
Outdoor duration minute per day					
<30	15	(53.6)	16	(57.1)	0.570
30-60	3	(10.7)	5	(17.9)	
>60	10	(35.7)	7	(25.0)	
Sunscreen					
Yes	13	(46.4)	14	(50.0)	0.383
No	15	(53.6)	14	(50.0)	
Family history					
Yes	1	(3.6)	1	(3.6)	1.000
No	27	(96.4)	27	(96.4)	
Onset (years), Median (IQR)	4.5	(1.5 - 6.5)			
Min. – Max.	(0.33 - 20)				
<5	14	(50.0)			
≥5	14	(50.0)			
Fitzpatrick skin type					
3	3	(10.7)			
4	10	(35.7)			
5	15	(53.6)			
Type of Vitiligo					
Generalized	22	(78.6)			
Segmental	4	(14.3)			
Focal	2	(7.1)			
VASI score, Median (IQR)	2.63	(1.25 - 5)			
Min. – Max.	(0.25 - 35)				
Current medication					
Tacro	16	(57.1)			
Clobe	15	(53.6)			
Beta	9	(32.1)			
Mometha	4	(14.3)			

Data are presented as number (%), mean ± standard deviation or median (interquartile range).
P-value corresponds to independent samples t-test, Mann-Whitney U test, Chi-square test or Fisher's exact test.

Table 2 Comparison of vitamin D levels in Thai adults between patients with vitiligo and the healthy controlled group

Outcome	Patients (n = 28) Mean ± SD	Control (n = 28) Mean ± SD	Mean difference (95%CI)	p-value	Mean difference (95%CI)	p-value
25-hydroxyvitamin D (ng/ml)	24.50 ± 6.94	23.75 ± 10.32	0.75 (-3.97, 5.48)	0.750	0.75 (-3.85, 5.36)	0.748

P-value corresponds to independent samples t-test.
* Significant at p-value<0.05

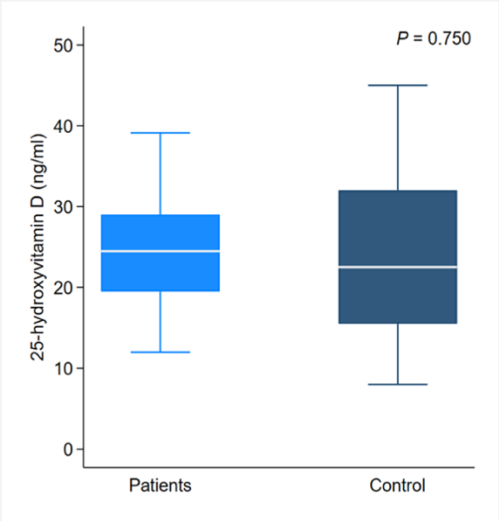

Figure 1 The comparison of the level of serum 25-hydroxyvitamin D between Thai patients diagnosed with vitiligo and healthy controls, which is not statistically significant.

Table 3 Comparison of vitamin D levels in Thai adults between patients with vitiligo and the healthy controlled group

Vitamin D status	Patients (n = 28)		Control (n = 28)		p-value
	n	(%)	n	(%)	
Sufficiency	6	(21.4)	10	(35.7)	0.091
Insufficiency	15	(53.6)	7	(25.0)	
Deficiency	7	(25.0)	11	(39.3)	

Table 4 Multiple logistic regression analysis for the association between vitamin D deficiency and vitiligo

Variables	Patients (n = 28)		Control (n = 28)		p-value	Univariable analysis			Multivariable analysis			Multivariable analysis		
						OR_1	95%CI	p-value	OR_{adj}[2]	95%CI	p-value	OR_{adj}[2]	95%CI	p-value
Vitamin D status														
Sufficiency	6	(21.4)	10	(35.7)	0.091	1.00	Reference		1.00	Reference		1.00	Reference	
Insufficiency	15	(53.6)	7	(25.0)		3.57	(0.92 - 13.81)	0.065	5.07	(0.90 - 28.63)	0.066	4.76	(1.09 - 20.84)	0.038
Deficiency	7	(25.0)	11	(39.3)		1.06	(0.27 - 4.24)	0.934	1.25	(0.24 - 6.42)	0.792	1.27	(0.29 - 5.56)	0.753
Age (years)														
<60	15	(53.6)	16	(57.1)	0.788	1.00	Reference		1.00	Reference				
≥60	13	(46.4)	12	(42.9)		1.16	(0.40 - 3.32)	0.788	2.28	(0.40 - 12.99)	0.355			
Sex														
Female	13	(46.4)	17	(60.7)	0.284	1.00	Reference		1.00	Reference				
Male	15	(53.6)	11	(39.3)		1.78	(0.62 - 5.16)	0.286	1.26	(0.31 - 5.11)	0.746			
Employment status														
Employee	22	(78.6)	20	(71.4)	0.537	1.47	(0.43 - 4.97)	0.538	4.17	(0.70 - 24.78)	0.116			
Unemployed/Retirement	6	(21.4)	8	(28.6)		1.00	Reference		1.00	Reference				
Underlying disease														
Yes	11	(39.3)	13	(46.4)	0.589	0.75	(0.26 - 2.16)	0.590	0.39	(0.07 - 2.07)	0.268			
No	17	(60.7)	15	(53.6)		1.00	Reference		1.00	Reference				
Outdoor duration day per week														
1-3	12	(42.9)	20	(71.4)	0.031	1.00	Reference		1.00	Reference		1.00	Reference	
4-7	16	(57.1)	8	(28.6)		3.33	(1.10 - 10.12)	0.034	4.92	(0.96 - 25.30)	0.057	4.11	(1.22 - 13.82)	0.022
Outdoor duration minute per day														
<60	18	(64.3)	21	(75.0)	0.570	1.00	Reference		1.00	Reference				

>60	10	(35.7)	7	(25.0)		1.67	(0.53 - 5.28)	0.385	1.58	(0.28 - 8.95)	0.606
Sunscreen											
Yes	13	(46.4)	14	(50.0)	0.383	0.87	(0.30 - 2.47)	0.789	0.58	(0.14 - 2.32)	0.437
No	15	(53.6)	14	(50.0)		1.00	Reference		1.00	Reference	
Family history											
Yes	1	(3.6)	1	(3.6)	1.000	1.00	(0.06 - 16.82)	1.000	6.71	(0.22 - 200.85)	0.273
No	27	(96.4)	27	(96.4)		1.00	Reference		1.00	Reference	

Abbreviations: CI, confidence interval; OR, odds ratio; NA, data not applicable.

Table 5 Relationship between vitamin D status and vitiligo severity

Vitamin D status	N	VASI score		p-value	Median Difference (95%CI)		p-value
		Median	(IQR)				
Sufficiency	6	5	(0.75 - 10)	0.638	Ref.		
Insufficiency	15	2	(1.5 - 4)		-3	(-7.18, 1.18)	0.152
Deficiency	7	3	(1 - 6)		-2	(-6.81, 2.81)	0.400

Kruskal–Wallis test

Median difference estimated by Median regression analysis.

Table 6 Relationship between vitamin D status and type of vitiligo.

Vitamin D status	Type of vitiligo						p-value
	Generalized (n = 22)		Segmental (n = 4)		Focal (n = 2)		
	n	(%)			n	(%)	
Sufficiency	6	(27.3)	0	(0.0)	0	(0.0)	0.074
Insufficiency	11	(50.0)	4	(100)	0	(0.0)	
Deficiency	5	(22.7)	0	(0.0)	2	(100)	

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5. Discussion

Vitiligo is an autoimmune disease that is involved in multiple factors. Also, there has been found the association with many abnormalities of the immune system. Several immune systems are expressed by the vitamin D receptor (VDR) on the cell wall as well as melanocyte. Therefore, low levels of serum vitamin D might interfere with these metabolisms and activities (Sîrbe, Rednic, Grama, & Pop, 2022).

Upala, and Sanguankeo (2016) have reported a systemic and meta-analysis, that has demonstrated strong evidence of significantly associated between vitiligo and serum vitamin D levels. On the other hand, Alshiyab et al. (2019) who investigated 100 Jordanian cases equally to control, found no statistically significant vitamin D level between those two groups. The main finding of our investigation revealed that Thai vitiligo patients had no significantly different vitamin D levels compared to Thai healthy populations. Most vitiligo cases and controls in the study had vitamin D insufficiency status, and there was no significant difference in vitamin D status between the two groups.

A meta-analysis by Zhang et al., which included 17 studies, demonstrated that there is a positive relationship between serum vitamin D deficiency and the incidence of vitiligo (Zhang et al., 2018). Although, our study showed no statistically significant difference between vitamin D deficiency and the incidence of vitiligo, whereas the results illustrated that vitamin D insufficiency status tended to develop vitiligo at a higher than insufficient vitamin D level for 3.57 time with univariable analysis by simple logistic regression analysis. In addition, vitamin D insufficiency had a 5.07 times higher likelihood causing an incidence of vitiligo compared to those with normal vitamin D levels when we analyzed with multiple logistic regression analysis and controlled for confounding factors.

In a study by Mahmmood, and Ismael (2021) has reported that there was no direct association between vitamin D level and the Vitiligo Extent Index (VETI) score, which is similar to the results of our study. We found no significant correlation between vitamin D status and the severity of vitiligo, as measured by VASI. In addition, our study explored the relationship between vitamin D status and different types of vitiligo. However, the results showed no drastic correlation between vitamin D status and the type of vitiligo, similar to the study by Alshiyab et al. (2019), this may be due to the fact that our study was conducted with a small number of patients.

Based on our study, since most of our participants are likely aged, this is a possible explanation for the lower vitamin D level in both groups. Also, a small number of participants contributed no significant contribution to all aspects of the study; however, our results showed – a trend of increasing the incidence of vitiligo in vitamin D insufficiency. Further study with a larger number of populations and a variety of ages of participants is recommended.

There are several limitations to our study. The result of the study could be limited due to the small number of study participants. Another limitation is that we recruited study participants at a single center. The prevalence of vitamin D insufficiency or deficiency was high in the normal population, which might interfere with this study.

6. Conclusion

We discovered that vitamin D levels were generally low in both vitiligo and controls in the Thai population. There was no significant difference between vitamin D levels and Thai vitiligo patients, neither in type nor severity of vitiligo.

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8. References

AlGhamdi, K., Kumar, A., & Moussa, N. (2013). The role of vitamin D in melanogenesis with an emphasis on vitiligo. *Indian Journal of Dermatology, Venereology and Leprology*, *79*(6), 750–758. https://doi.org/10.4103/0378-6323.120720

Alshiyab, D. M., Al-Qarqaz, F. A., Heis, L. H., Muhaidat, J. M., Eddin, W. S., & Atwan, A. A. (2019). Assessment of Serum Vitamin D Levels in Patients with Vitiligo in Jordan: A Case-Control Study. *Dermatology Research and Practice*, *2019*, 2048409. https://doi.org/10.1155/2019/2048409

Bergqvist, C., & Ezzedine, K. (2020). Vitiligo: A Review. *Dermatology (Basel, Switzerland)*, *236*(6), 571–592. https://doi.org/10.1159/000506103

Borel, P., Caillaud, D., & Cano, N. J. (2015). Vitamin D bioavailability: State of the art. *Critical Reviews in Food Science and Nutrition*, *55*(9), 1193–1205. https://doi.org/10.1080/10408398.2012.688897

Ezzedine, K., Eleftheriadou, V., Jones, H., Bibeau, K., Kuo, F. I., Sturm, D., & Pandya, A. G. (2021). Psychosocial Effects of Vitiligo: A Systematic Literature Review. *American Journal of Clinical Dermatology*, *22*(6), 757–774. https://doi.org/10.1007/s40257-021-00631-6

Grimes, P. E., & Nashawati, R. (2017). The Role of Diet and Supplements in Vitiligo Management. *Dermatologic Clinics*, *35*(2), 235–243. https://doi.org/10.1016/j.det.2016.11.012

Lizarondo, F. P. J., Gervasio, M. K. R., Chamberlin, C. V. S., Gnilo, C. M. S., & Silva, C. Y. (2021). Determination of serum 25-hydroxyvitamin D levels in patients with alopecia areata and their comparison with levels in healthy controls: A cross-sectional study. *JAAD International*, *5*, 78–84. https://doi.org/10.1016/j.jdin.2021.07.008

Mahmmod, Z., & Ismael, D. K. (2021). Vitamin D Deficiency in Patients With Vitiligo: A Cross-Sectional Study From Basrah, Iraq. *Cureus*, *13*(12), e20733. https://doi.org/10.7759/cureus.20733

Mostafa, W. Z., & Hegazy, R. A. (2015). Vitamin D and the skin: Focus on a complex relationship: A review. *Journal of Advanced Research*, *6*(6), 793–804. https://doi.org/10.1016/j.jare.2014.01.011

Noh, S., Kim, M., Park, C. O., Hann, S.-K., & Oh, S. H. (2013). Comparison of the psychological impacts of asymptomatic and symptomatic cutaneous diseases: Vitiligo and atopic dermatitis. *Annals of Dermatology*, *25*(4), 454–461. https://doi.org/10.5021/ad.2013.25.4.454

Parsad, D., & Kanwar, A. J. (2009). Topical vitamin D analogues in the treatment of vitiligo. *Pigment Cell & Melanoma Research*, *22*(4), 487–488. https://doi.org/10.1111/j.1755-148X.2009.00579.x

Riding, R. L., & Harris, J. E. (2019). The Role of Memory CD8+ T Cells in Vitiligo. *Journal of Immunology (Baltimore, Md.: 1950)*, *203*(1), 11–19. https://doi.org/10.4049/jimmunol.1900027

Rodrigues, M., Ezzedine, K., Hamzavi, I., Pandya, A. G., Harris, J. E., & Vitiligo Working Group. (2017). New discoveries in the pathogenesis and classification of vitiligo. *Journal of the American Academy of Dermatology*, *77*(1), 1–13. https://doi.org/10.1016/j.jaad.2016.10.048

Seneschal, J., Boniface, K., D'Arino, A., & Picardo, M. (2021). An update on Vitiligo pathogenesis. *Pigment Cell & Melanoma Research*, *34*(2), 236–243. https://doi.org/10.1111/pcmr.12949

Silverberg, J. I., Silverberg, A. I., Malka, E., & Silverberg, N. B. (2010). A pilot study assessing the role of 25 hydroxy vitamin D levels in patients with vitiligo vulgaris. *Journal of the American Academy of Dermatology*, *62*(6), 937–941. https://doi.org/10.1016/j.jaad.2009.11.024

Sîrbe, C., Rednic, S., Grama, A., & Pop, T. L. (2022). An Update on the Effects of Vitamin D on the Immune System and Autoimmune Diseases. *International Journal of Molecular Sciences*, *23*(17), 9784. https://doi.org/10.3390/ijms23179784

Umar, M., Sastry, K. S., Al Ali, F., Al-Khulaifi, M., Wang, E., & Chouchane, A. I. (2018). Vitamin D and the Pathophysiology of Inflammatory Skin Diseases. *Skin Pharmacology and Physiology*, *31*(2), 74–86. https://doi.org/10.1159/000485132

Upala, S., & Sanguankeo, A. (2016). Low 25-hydroxyvitamin D levels are associated with vitiligo: A systematic review and meta-analysis. *Photodermatology, Photoimmunology & Photomedicine*, *32*(4), 181–190. https://doi.org/10.1111/phpp.12241

Zhang, J.-Z., Wang, M., Ding, Y., Gao, F., Feng, Y.-Y., Yakeya, B., Wang, P., Wu, X.-J., Hu, F.-X., Xian, J., & Kang, X.-J. (2018). Vitamin D receptor gene polymorphism, serum 25-hydroxyvitamin D levels, and risk of vitiligo: A meta-analysis. *Medicine*, *97*(29), e11506. https://doi.org/10.1097/MD.0000000000011506