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Changes in Vitamin D Level After Sun Exposure in Egyptian School Children

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ABSTRACT

Background: Vitamin D is a fat-soluble vitamin found in blood, muscle, liver, fat, and other tissues. The regulation of calcium phosphorus balance and bone health are two of vitamin D's main roles. However, studies on both humans and animals suggest that vitamin D may play a part in the emergence of a number of endocrine disorders.

Objective: The aim of the current work was to determine the baseline state of 25-hydroxyvitamin D levels in a sample of Egyptian schoolchildren and to assess how sun exposure affects vitamin D status.

Subjects and methods: This cross-sectional study included a total of 50 apparently healthy schoolchildren, aged from 6 to 11 years, and performed at swimming pool center, in Benha, Egypt, between May 2018 and the end of September 2018 Vitamin D was measured twice, the first time in May, and the second time in September with good exposure to the sun three times/per week one hour before swimming.

Results: Pre exposure mean vitamin D level was 26.9, while it was 27.1 after exposure, with no statistically significant difference between pre and post exposure levels. Vitamin D was sufficient in 40%, insufficient in 44%, deficient in 16%. No change was found in vitamin D status post exposure. Pre and post exposure vitamin D levels showed significant positive correlation with total calcium, ionized calcium, and significant negative correlation with body mass index (BMI). Darker skin, fast food, higher centile, BMI, formula feeding, lower sun exposure, activity level, total, ionized calcium was associated with risk of lower vitamin D status.

Conclusion: It could be concluded that vitamin D deficiency and insufficiency are highly prevalent in sunny Egypt. To increase vitamin D status and reduce the risk of its deficiency, vitamin D supplementation, consumption of vitamin D-rich food, and the encouraging of outdoor activities should be considered. Our findings indicate that, despite receiving a lot of sun exposure, some children exhibit varied responses to ultraviolet Blight (UVB) light, which results in poor vitamin D status.

Keywords: Vitamin D, Cholecalciferol, Egyptian children, Sun exposure.

INTRODUCTION

Vitamin D is a fat-soluble vitamin, it comes in a variety of shapes. Ergocalciferol (Vit.D2) and cholecalciferol (Vit.D3) are regarded as the two main forms of vitamin D **(1)**.

1,25-Dihydroxyvitamin D, a form of vitamin D that is hormonally active, affects the expression of numerous genes whose byproducts are not only involved in calcium and bone metabolism but also have the ability to interact with a variety of non-traditional organs and target tissues, such as the heart, liver, and pancreas **(2)**. It has been shown that vitamin D plays a crucial role in cell division, differentiation, and immunomodulation **(3)**.

More studies have revealed a direct link between vitamin D deficiency and a number of diseases, including cancer, infections, autoimmune disorders, metabolic syndrome, insulin resistance, cardiovascular disease (CVD), and non-alcoholic fatty liver disease **(4)**. The Institute of Medicine's (IOM) and the Endocrine Society's guidelines for vitamin D consumption in the diet can be used to support that conclusion. Infants and kids alike need at least 400 IU each day. Both organizations recommend giving kids at least 600 IU per day. The Endocrine Society indicated that all adults require 1500–2000 IUs of vitamin D per day for the health of their musculoskeletal systems, however the IOM did not make a distinction between children and adults up to the age of 70. In contrast to the IOM's recommendation of 800 IU/day for people over 70, the

Endocrine Society did not distinguish between adults' vitamin D needs depending on age. According to the Endocrine Society, persons with a high body mass index (BMI >30) need two to three times as much vitamin D as healthy, normal-weight people **(5)**.

Vitamin D deficiency, according to the Endocrine Society, is defined as levels below 20 ng/mL (50 nmol/L), and vitamin D insufficiency as levels between 21 and 29 ng/mL (52.5-72.5 nmol/L). The biological indication of vitamin D status is serum 25 hydroxy vitamin D, which measures vitamin D insufficiency. The current permissible level of vitamin D, which is 30 ng/mL (75 nmol/L), is indicative of vitamin D insufficiency, whereas vitamin D deficiency is indicated by a blood 25 hydroxyvitamin D level of 20 ng/mL (50 nmol/L) **(6)**.

Along with the typical rickets symptoms and growth delay, children with vitamin D deficiency also experience these conditions **(7)**. Adults who don't get enough vitamin D are more likely to develop osteomalacia, osteoporosis, and fractures **(8)**.

The key factor affecting vitamin D level in infancy is the maternal vitamin D status. Even though it is technically difficult, all pregnant women should have their 25(OH)D levels checked throughout the first trimester of pregnancy. If they are inadequate, they

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should receive 400 IU once day until their 25(OH)D level is more than >20 ng/dL (recommended treatment range: 3000-5000 IU) [9].

It's debatable whether or not all pregnant women should receive routine vitamin D supplements. The anti-rachitic effect of breastmilk is increased when breast-feeding mothers get high doses of vitamin D (400–6400 IU) daily without the mother developing hypervitaminosis. Preterm newborns should get 400–800 IU/day of supplements starting at birth. It has been suggested that universal supplementation, especially for breastfed newborns, be taken into account [10]. For newborns who are exclusively breastfed, a minimum daily dosage of 400 IU/day should be begun within a few days of birth. Unless they consume more than 1000 mL of formula per day, most baby formulas contain 400 IU/L, therefore formula-fed infants also require supplementation [11].

The aim of the current work was to determine the baseline state of 25-hydroxyvitamin D levels in a sample of Egyptian schoolchildren and to assess how sun exposure affects vitamin D status.

SUBJECTS AND METHODS

This cross-sectional study included a total of 50 apparently healthy schoolchildren, aged from 6 to 11 years, and performed at swimming pool center, in Benha, Egypt. This study was conducted between May 2018 and the end of September 2018 Vitamin D was measured twice, the first time in May, and he second time in September with good sun exposure three times/per week, one hour before swimming.

Exclusion criteria

Children with limited sun exposure, disabled children and those who spent limited time outdoors, those having persistent, incapacitating disorders, endocrine or hereditary obesity, those who had used anticonvulsants or systemic glucocorticoids, children consumed calcium and vitamin D supplements, vegan or vegetarian, or those who consumed foods high in phytates, such as chapattis.

All participants were subjected to:

Complete history taking, including name, age, sex, place of residence, history of sun exposure, unique medical habits, any complaint expressed by the child's parents in their own words. History of drugs, trauma, and hospital admissions.

The newest Institute of Medicine (IOM) recommendations [6] classified nutritional history as dietary vitamin D intakes as low, fair, or good: Poor for 200 IU/day, Fair for 600 IU/day, and Good for >600 IU/day. The use of calcium and vitamin D supplements was indicated by the letters "yes" when taken, and "no" when not.

International Physical Activity Questionnaire (IPAQ) [12]:

The 31-item long form (IPAQ-LF) and the 9-item short form (IPAQ-SF) of the IPAQ were created to assess adult populations' levels of health-improving physical exercise. In this study, the assessment of physical activity during the previous 7 days was done using the Arabic version of the IPAQ short form. The patient was asked to answer questions on how much time they had spent exercising over the previous seven days, even if they did not believe themselves to be physically active. We asked them to consider the things they did while at work, to take care of their homes and yards, to get about, and in their leisure time for fun, exercise, or sports.

All participants were conducted to complete physical examination including, general appearance, weight, height, skin color, locomotor examination with examination of joints of upper and lower limbs, neurological examination with examination of cranial nerves and reflexes.

Laboratory investigations were done, which included complete blood picture, routine kidney function, liver functions, serum Ca.

Estimation of the serum D (serum 25-hydroxyvitamin D (25(OH) D) level was done using ELISA, the following ranges for the classification of 25-OH vitamin D status were considered: Deficiency; <20ng /ml, Insufficiency; 21-30 ng/ml, Sufficiency; 31-100 ng/ml, Toxicity; > 100ng/ml, according to Endocrine Society.

***Ethical Consideration*:**

This study was ethically approved by Benha University's Research Ethics Committee. Written informed consent of all the participants' parents was obtained after being informed of the study purpose. The study protocol conformed to the Helsinki Declaration, the ethical norm of the World Medical Association for human testing.

Statistical analysis

SPSS 2017 from IBM Corp. Version 25.0, was used to examine, tag, and tabulate the gathered data. Data were supplied, and the kind of data that was correctly analysed for each parameter that was gathered. The Shapiro-Wilk test was applied to determine if the data distribution was normal. The statistical significance of the difference between the means of the two research groups was assessed using the Student T Test.

The statistical significance of a difference between two research groups for a non-parametric variable was assessed using the Mann Whitney Test (U test).

To assess the association between two qualitative variables, the Chi-Square test was applied. The Fisher's exact test was employed to investigate the link between two qualitative variables when the projected count was less than 5 in more than 20% of the cells.

To determine how closely two quantitative variables are connected to one another, correlation analysis was utilised. The variables influencing vitamin D levels were predicted using regression analysis. At a 95% confidence level, a p value of 0.05 is regarded as significant.

RESULTS

Participants mean age was (9.0±2.0) years, and 36 (72.0%) were females and 14 (28.0%) were males. The skin color varies between; white, followed by brown and then light brown. all participants had 3 meals per day, only one third had excess diet rich in vit D and consume fast food. 68% of cases were exposed to sun for 60 -150 minutes, 3 times per week.

They received natural feeding; source of ca intake was natural for all participants.

No one of the participants had a history of vitamin D and ca intake, chronic disease, sunscreen use or mother supplement use. All participants wear swimming suits. 12 child (24%) had high activity, 29 child (58%) had moderate activity and 9 children (18%) had low activity (**Table 1).**

Table (1): Pre exposure characters of the studied subjects.

			Subjects N=50
Age (years)		**Mean ± SD; Median (Range)**	9.0±2.0 9.1 (6-12)
Gender	**Female**	**N (%)**	36(72.0%)
	Male	**N (%)**	14(28.0%)
Skin color	**White**	**N (%)**	28(56.0%)
	Light brown	**N (%)**	10(20.0%)
	Brown	**N (%)**	12(24.0%)
Dietary habits	**3 meals/ day**	**N (%)**	50(100.0%)
Excess diet rich in vit D	**No**	**N (%)**	34(68.0%)
	Yes	**N (%)**	16(32.0%)
Fast food intake	**Fast food**	**N (%)**	34(68.0%)
	No fast food	**N (%)**	16(32.0%)
duration of exposure to sun	**30-60 min.**	**N (%)**	16(32.0%)
	60-150 min.	**N (%)**	34(68.0%)
BMI (kg/m^2)		**Mean ± SD; Median (Range)**	17.4±2.84;17.3 (13.6-24.6)
Centile		**Mean ± SD; Median (Range)**	55.4±35.3;60 (3098)
Total Ca (mg/dL)		**Mean ± SD**	9.1 ± 0.2
Ionized Ca (mg/dL)		**Mean ± SD**	1.24 ± 0.15
Phosphorus (mg/dL)		**Mean ± SD**	4.75 ± 0.75
ALP (U/L)		**Mean ± SD**	269.9 ± 64.7
PTH (U/L)		**Mean ± SD**	35.1 ± 5.3
25 (OH) Vit D (ng/mL)		**Mean ± SD**	26.9±6.1
25 (OH) Vit D	**Sufficient**	**N (%)**	20(40%)
	Insufficient	**N (%)**	22(44%)
	Deficient	**N (%)**	8(16%)

Pre exposure, mean vitamin D level was 26.9 (ng/mL), while it was 27.1 (ng/mL) after exposure, with no significant difference between pre and post exposure levels (p>0.05). Vitamin D was sufficient in 40%, insufficient in 44%, deficient in 16%. No change was found in vitamin D status post exposure when compared to pre exposure status (**Figures 1, 2)**

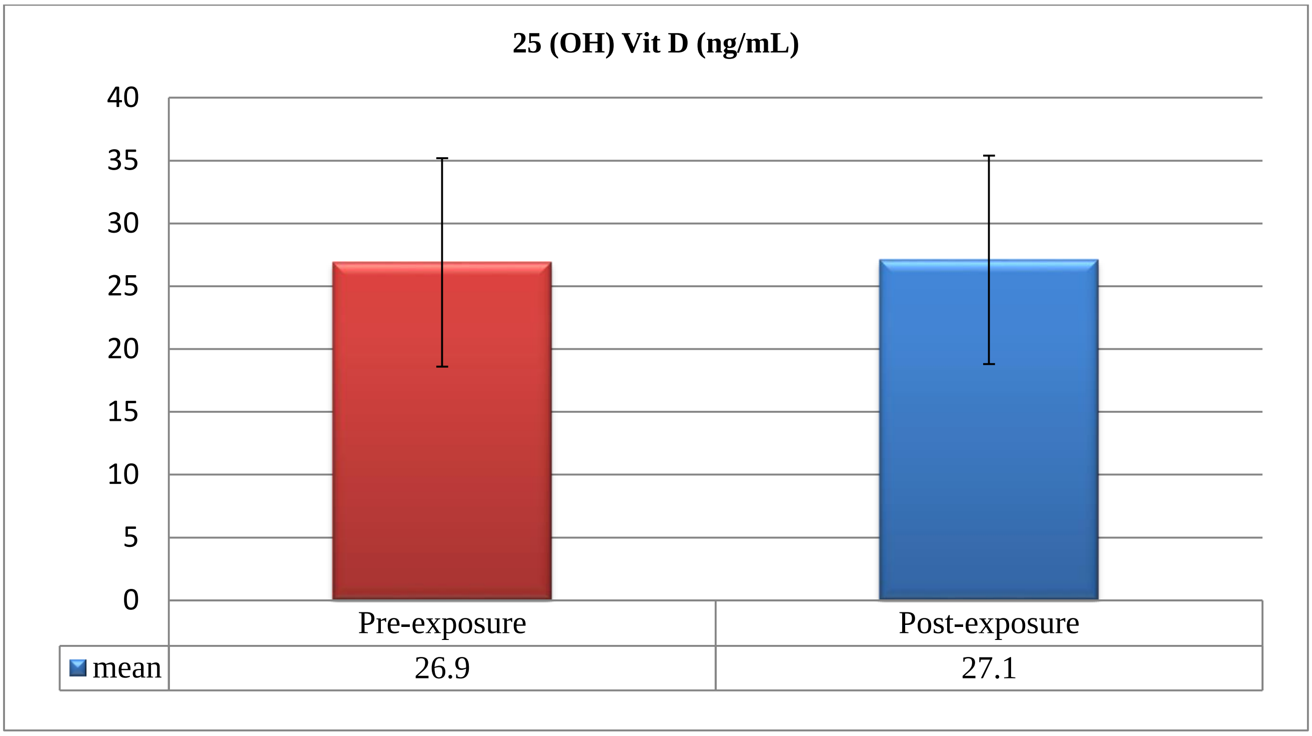

Figure (1): Vit D level pre and post exposure.

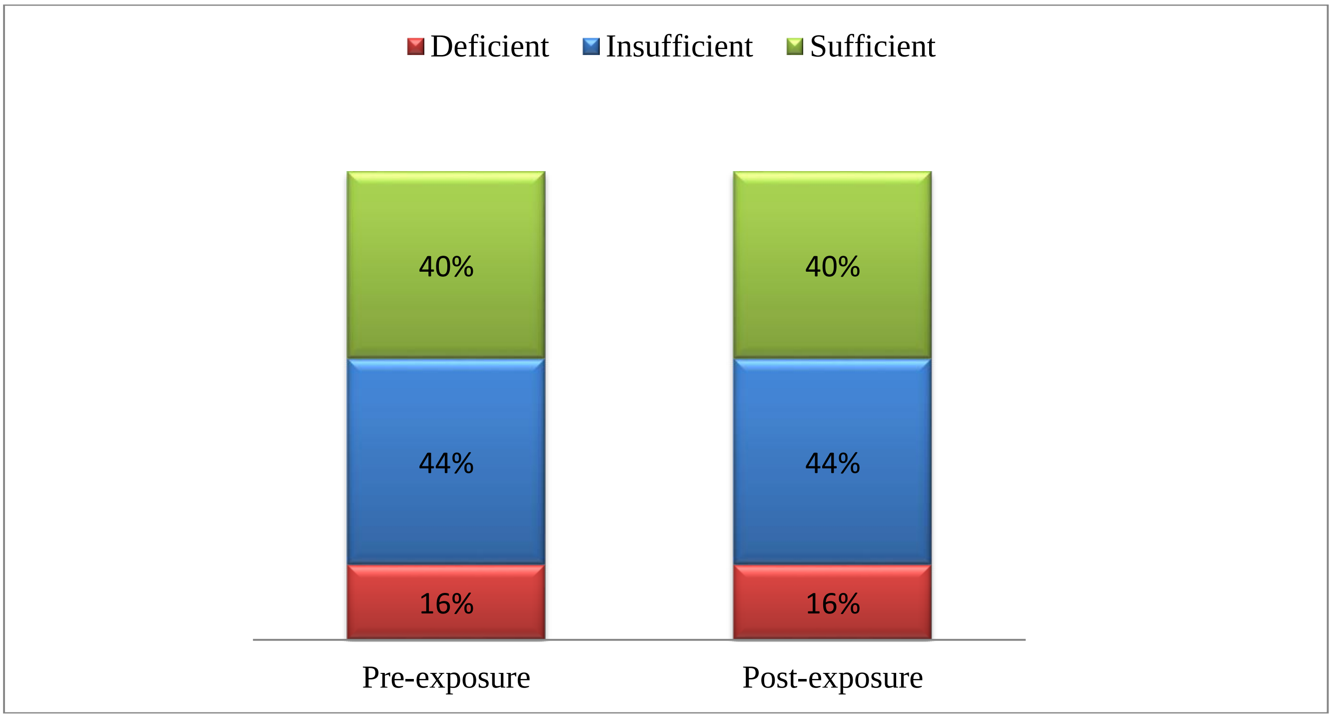

Figure (2): Vitamin D status pre and post exposure.

Pre as well as post exposure vitamin D level and status showed significant increase associated with lighter skin color, excess diet rich in vit D, less consuming Fast food, mixed feeding, decreased BMI, increased time of sun exposure, increasing activity level, but no association was found between pre exposure vitamin D level with age, gender, phosphorus, ALP and PTH (**Tables 2, 3**).

Table (2): Association of pre-exposure vitamin D level according with other studied parameters.

		25 (OH) vit D level							
		Pre exposure			*P*	Post exposure			*P*
		Mean±SD	Median	Range		Mean±SD	Median	Range	
Sex	**Female**	27.5±10.8	32.80	10.5-39.3	0.772	27.9±10.9	33.95	10.2-40	0.671
	Male	26.7±7.2	26.90	8.0-37.5		26.8±7.2	27.15	7.8-38.3	
Skin color	**White**	29.3±5.9	28.35	20.7-39.3	**0.003**	29.4±6	29.60	20.1-40	**0.003**
	Light brown	28.7±8.2	30.80	16.9-37.5		28.9±8	31.15	17.4-37.5	
	Brown	20.2±9.8	18.90	8.0-34.2		20.3±10.1	18.70	7.8-34.9	
Excess diet rich in vit D	**No**	23.1±7.1	23.95	8.0-37.5	**<0.001**	23.3±7.3	24.80	7.8-38.3	**<0.001**
	Yes	35.2±2.4	35.45	31.5-39.3		35.2±2.8	35.45	31.1-40	
Fast food	**Fast food**	24.7±8.4	25.65	8.0-38.1	**0.004**	24.9±8.5	25.60	7.8-40	**0.004**
	No fast food	31.7±5.6	32.80	22.0-39.3		31.9±5.5	32.20	23.1-38.5	
Type of feeding	**Formula**	22.2±9.2	23.60	8.0-38.1	**0.004**	22.4±9.5	23.85	7.8-40	**0.005**
	Mixed	29.2±6.9	30.05	13.1-39.3		29.3±6.8	30.80	13.8-38.5	
BMI category	**Under weight**	27.2±3	27.75	22.40-30.60	**<0.001**	26.8±3.2	26.90	21.7-30.6	**<0.001**
	Normal	30.5±6.5	32.25	16.90-39.30		30.8±6.5	31.75	17.4-40	
	Over weight	19.7±7.1	21.65	8.00-26.60		19.9±7.4	22.20	7.8-27.2	
	Very over weight	12.7±2.1	12.50	10.50-15.40		12.9±2.4	12.85	10.2-15.7	
According to sun exposure	**30-60 min**	21.7±6.7	22.80	10.50-30.60	**0.001**	21.8±6.7	22.85	10.2-30.6	**0.001**
	60-150 min	29.5±7.8	31.90	8.00-39.30		29.6±7.9	31.30	7.8-40	
Activity	**High**	30.8±5.7	32.55	22.0-38.1	**0.001**	31.4±6.3	32.50	21.7-40	**0.006**
	Moderate	27.5±8.1	27.20	10.5-39.3		27.5±7.9	27.20	10.2-38.5	
	Low	20.3±8.3	20.70	8.0-30.6		20.1±8.3	20.10	7.8-30.6	

Table (3): Association between vitamin D deficiency status and other studied parameters.

Variable		25 (OH) vit D						p
		Sufficient		Insufficient		Deficient		
		N=20		N=22		N=8		
		No	%	No	%	No	%	
Age		9.6	2.1	8.7	1.7	10.4	1.6	0.207
Sex	**Male**	8	40.0%	2	9.1%	4	50.0%	0.087
	Female	12	60.0%	20	90.9%	4	50.0%	
Skin color	**White**	13	65.0%	15	68.2%	0	0.0%	0.002
	Light brown	5	25.0%	3	13.6%	2	25.0%	
	Brown	2	10.0%	4	18.2%	6	75.0%	
Excess diet rich in vit D	**No**	4	20.0%	22	100.0%	8	100.0%	<0.001
	Yes	16	80.0%	0	0.0%	0	0.0%	
Fast food	**Fast food**	10	50.0%	16	72.7%	8	100.0%	0.030
	No fast food	10	50.0%	6	27.3%	0	0.0%	
Type of feeding	**Formula**	3	15.0%	7	31.8%	6	75.0%	0.012
	Mixed	17	85.0%	15	68.2%	2	25.0%	
Centile		49.0	31.1	47.1	36.7	94.5	3.7	0.002
BMI		16.7	1.6	16.5	2.6	21.8	1.8	<0.001
BMI category	**Under weight**	1	5.0%	5	22.7%	0	0.0%	<0.001
	Normal	19	95.0%	11	50.0%	2	25.0%	
	Over weight	0	0.0%	6	27.3%	2	25.0%	
	Very over weight	0	0.0%	0	0.0%	4	50.0%	
Level of activity	**Highly active**	7	35.0%	5	22.7%	0	0.0%	0.046
	Moderately active	12	60.0%	13	59.1%	4	50.0%	
	Low active	1	5.0%	4	18.2%	4	50.0%	
According to sun exposure	**30-60 min**	1	5.0%	9	40.9%	6	75.0%	0.001
	60-150 min	19	95.0%	13	59.1%	2	25.0%	
Total Ca (mg/dL)		9.3	0.1	9.0	0.1	8.8	0.1	<0.001
Ionized Ca (mg/dL)		1.3	0.2	1.2	0.02	1.1	0.02	<0.001
Phosphorus (mg/dL)		4.6	0.8	4.9	0.7	5.1	0.7	0.276
ALP (U/L)		256.7	62.3	285.8	70.9	327.3	36.5	0.107
PTH (U/L)		35.4	5.7	34.8	5.8	34.8	3.0	0.939

Pre and post exposure vitamin D levels showed significant positive correlation with total Ca, ionized Ca, significant negative correlation with BMI. While no significant correlations were found regarding vitamin D levels with age, weight, height, phosphorus, ALP and PTH (**Figure 3).**

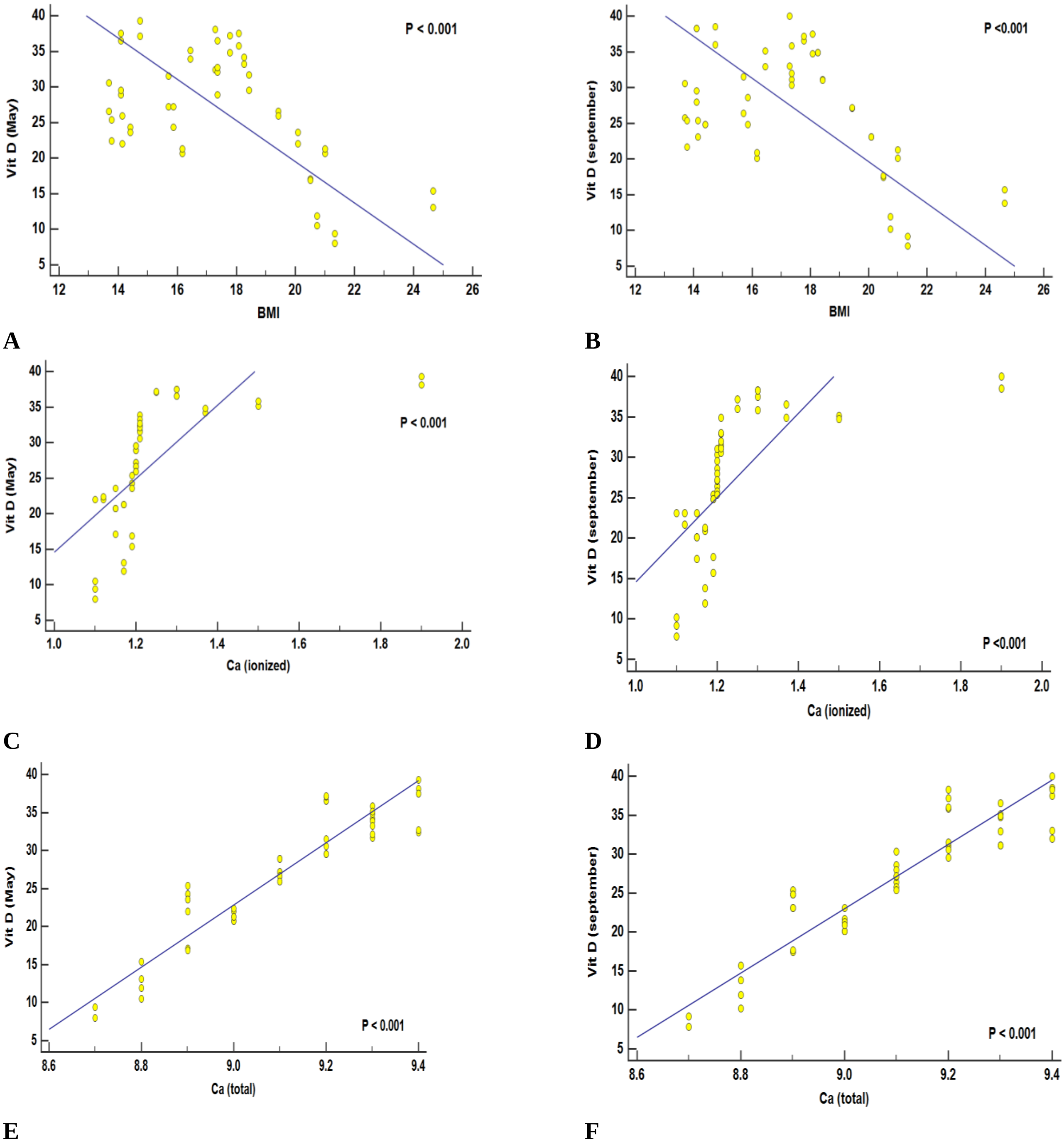

Figure (3): Correlations between pre exposure vitamin D with (A) BMI, (C) ionized Ca, (E), total Ca; post intervention vitamin D with (B) BMI, (D) ionized C, and (F) total Ca.

Darker skin, fast food, higher centile, BMI, formula feeding, lower sun exposure, activity level, total, ionized calcium was associated with risk of lower vitamin D status (**Table 4).**

Table (4): Regression analysis for prediction of worse vitamin D status.

	p	OR	95% CI
Age	0.975	0.998	0.854-1.165
Sex	0.720	1.138	0.560-2.314
Darker skin colour	0.002	1.900	1.269-2.843
Excess diet rich in vit D	0.998	0.993	0.990-.1.027
Fast food	.0070	2.713	1.309-5.622
Centile	0.014	1.012	1.002-1.021
BMI	0.001	1.255	1.103-1.428
Higher sun exposure	<0.001	0.236	0.111-0.500
Formula feeding	0.003	2.851	1.412-5.758
Higher level of activity	0.003	0.208	0.073-0.596
Total Ca	<0.001	0.041	0.027-0.062
Ionized Ca	<0.001	0.101	0.035-0.292
Phosphorus	0.196	1.238	0.963-1.593
ALP	0.127	1.003	0.991-1.005
PTH	0.737	0.994	0.957-1.031

DISCUSSION

Because it is created in the skin when exposed to sunlight, vitamin D is known as the "sunshine vitamin." For the health of the musculoskeletal system, to maintain blood calcium concentration within the normal physiological range, vitamin D is required **[13]**. Vitamin D can be taken orally or produced by the skin when exposed to UV rays. The cutaneous generation of vitamin D is affected by factors that influence the quantity of UVB radiation that reaches the skin **[14]**.

The current investigation found no appreciable variation between vitamin D levels before and after the exposure. According to the current study, 40% of participants had enough vitamin D, 44% lacked it, and 16% were deficient. There were no statistically significant differences in vitamin D level between pre and post exposure status. Our results were nearly agreed with ***Amr and his colleagues'*** findings of a lower prevalence in Egyptian teenage females, 54.7% of whom had VDS, 24% of whom had VDI, and 21.3% of whom had vitamin D deficiency (VDD) **[15]**.

But a different small study based on a population of Egyptians found a significant frequency of VDD (60.9%) and VDI (17.7) **[16]**. Which did not concur with our findings. Several researchers from various nations have demonstrated the high frequency of VDD. In the Middle East, a Kuwaiti research found VDD in 98.7% of the population **[17]**. VDD prevalence in a group from Saudi Arabia was 45.5% **[18].** The current study found that lower levels of vitamin D status related to factors such as darker complexion, fast food, higher centile, BMI, formula feeding, less sun exposure, activity level, total calcium, and ionized calcium. Whereas **Chen *et al.*** **[19]** found no appreciable gender or BMI group differences. However, children in the obese group had the lowest levels of 25(OH)D and the highest frequency of vitamin D insufficiency. In contrast to our findings, a substantial negative connection between the 25(OH) D level and kid age was discovered **[19]**.

While **Sherief *et al.*** **[20]** found that all girls had VDD, 88% of boys had VDD, 8.8% had VDI, and 2.2% had VDS, the frequency of VDD was higher in females than in boys. A study conducted in Bahrain also revealed that girls had considerably lower mean 25(OH)D levels than boys and had a greater frequency of vitamin D insufficiency **[21]**. Our investigation was in agreement with other studies regarding the link between vitamin D insufficiency and a lack of exercise, showing that vitamin D levels rose as physical activity levels increased **[22, 23].**

Contrarily, **Bezuglov *et al.*** **[24]** found that cholecalciferol use at a daily dose of 5000 IU was an efficient and well-tolerated treatment for VDI in adult soccer players, despite their frequent physical activity and high levels of insolation being widely widespread in these areas. It might be argued that even though the amount of time spent in the sun is appropriate, athletes' needs for VD are much higher than those of the general population and cannot be met by routine sun exposure.

Our findings was in agreement with earlier studies regarding the relationship between vitamin D supplements and a vitamin-rich diet, Several studies **[25, 26]** who concurred with our findings and discovered that serum VD was substantially connected with BMI have described the relationship between BMI and VDD.

Limitations of the present study, that it was carried on small sample size in specific period of the year. Therefore, to confirm our findings, a multicenter, national study in Egypt is required.

CONCLUSION

It could be concluded that vitamin D deficiency and insufficiency are highly prevalent in sunny Egypt. To increase vitamin D status and reduce the risk of its deficiency, vitamin D supplementation, consumption of vitamin D-rich food, and the encouraging of outdoor activities should be considered. Our findings indicate that, despite receiving a lot of sun exposure, some children exhibit varied responses to ultraviolet B light (UVB) light, which results in poor vitamin D status.

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Competing interests: Nil.

REFERENCES

1. **Myrto E, Elias S (2015):** Vitamin D: a new player in non-alcoholic fatty liver disease. World J Gastroenterol., 14: 21(6): 1718-1727.
2. **Andersen L, Przybyl L, Haase N *et al.* (2015):** Vitamin D depletion aggravates hypertension and target-organ damage. J Am Heart Assoc., 4: 001417. https://doi.org/10.1161/JAHA.114.001417
3. **Polidoro L, Properzi G, Marampon F *et al.* (2013):** Vitamin D protects human endothelial cells from H(2)O(2) oxidant injury through the Mek/Erk-Sirt1 axis activation. J Cardiovasc Transl Res., 6: 221-231.
4. **Pludowski P, Holick M, Pilz S *et al.* (2013):** Vitamin D effects on musculoskeletal health, immunity, autoimmunity, cardiovascular disease, cancer, fertility, pregnancy, dementia and mortality—a review of recent evidence. Autoimmun Rev., 12: 976–989.
5. **Vieth R, Holick M (2018):** The IOM—endocrine society controversy on recommended vitamin D targets: in support of the endocrine society position. In: Vitamin D. pp. 1091-1107. DOI:10.1016/B978-0-12-809965-0.00059-8
6. **Holick M, Binkley N, Bischoff-Ferrari H *et al.* (2011):** Evaluation, treatment, and prevention of vitamin D deficiency: An Endocrine Society clinical practice guideline. J Clin Endocrinol Metab., 96: 1911–1930.
7. **Misra M, Pacaud D, Petryk A *et al.* (2008):** Vitamin D deficiency in children and its management: review of current knowledge and recommendations. Pediatrics, 122(2):398-417.
8. **Holick M (2007):** Vitamin D deficiency. New England Journal of Medicine, 357(3): 266-281.
9. **Yao P, Bennett D, Mafham M *et al.* (2019):** Vitamin D and Calcium for the Prevention of Fracture: A Systematic Review and Meta-analysis. JAMA Network Open, 2(12): e1917789. doi: 10.1001/jamanetworkopen.2019.17789.
10. **Al-Zohily B, Al-Menhali A, Gariballa S *et al.* (2020):** Epimers of vitamin d: A review. In: International Journal of Molecular Sciences, 21: 470. https://doi.org/10.3390/ ijms 21020470.
11. **Fedakâr A (2019):** Vitamin D Deficiency, Prevalence and Treatment in Neonatal Period. Endocrine, Metabolic & Immune Disorders - Drug Targets, 19(6): 866–873.
12. **Booth M (2000):** Assessment of physical activity: an international perspective. Res Q Exerc Sport., 71(2): 114-120.
13. **Chauhan K, Shahrokhi M, Huecker M (2022):** Vitamin D. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://pubmed.ncbi.nlm.nih.gov/28722941/
14. **Walker G, Ricotti R, Roccio M *et al.* (2014):** Pediatric obesity and vitamin D deficiency: a proteomic approach identifies multimeric adiponectin as a key link between these conditions. PLoS One, 9(1):e83685. doi: 10.1371/journal.pone.0083685.
15. **Amr N, Hamid A, Sheta M *et al.* (2012):** Vitamin D status in healthy Egyptian adolescent girls. Georgian Med News, 210: 65-71.
16. **Karem M, Heiba E, Kamel N *et al.* (2019):** Vitamin D status among children and adolescents in an Egyptian cohort: can we predict vitamin D deficiency? European Society for Paediatric Endocrinology, 92: 303–309.
17. **Alyahya K (2017):** Vitamin D levels in schoolchildren: a cross-sectional study in Kuwait. BMC Pediatr., 17(1): 213. doi: 10.1186/s12887-017-0963-0.
18. **Al-Shaikh G, Ibrahim G, Fayed A *et al.* (2016):** Impact of vitamin D deficiency on maternal and birth outcomes in the Saudi population: a cross-sectional study. BMC Pregnancy Childbirth, 16: 119. doi: 10.1186/s12884-016-0901-4.
19. **Chen Z, Lv X, Hu W *et al.* (2021):** Vitamin D Status and Its Influence on the Health of Preschool Children in Hangzhou. Front Public Health, 9: 675403. doi: 10.3389/fpubh.2021.675403.
20. **Sherief L, Ali A, Gaballa A *et al.* (2021):** Vitamin D status and healthy Egyptian adolescents: Where do we stand? Medicine (Baltimore), 100(29):e26661. doi: 10.1097/MD.0000000000026661.
21. **Isa H, Almaliki M, Alsabea A *et al.* (2020):** Vitamin D deficiency in healthy children in Bahrain: do gender and age matter? East Mediterr Health J., 26:260–7.
22. **Lopes M, Ribeiro P, Ledur P *et al.* (2014):** Vitamin D insufficiency is associated with lower physical function in patients with heart failure and diabetes. J Diabetes Res., 14:320930. doi: 10.1155/2014/320930.
23. **Abdelgadir E, Rashid F, Basheir A *et al.* (2016):** Vitamin D deficiency, the volume of the problem in the United Arab Emirates. A Cohort from the Middle East. J Endocrinol Diab., 3: 1–5.
24. **Bezuglov E, Tikhonova A, Zueva A *et al.* (2019):** Prevalence and Treatment of Vitamin D Deficiency in Young Male Russian Soccer Players in Winter. Nutrients, 11(10):2405. doi: 10.3390/nu11102405.
25. **Vierucci F, Del Pistoia M, Fanos M *et al.* (2014):** Prevalence of hypovitaminosis D and predictors of vitamin D status in Italian healthy adolescents. Ital J Pediatr., 40:54. doi: 10.1186/1824-7288-40-54
26. **Shady M, Youssef M, Shehata M *et al.* (2015):** Association of Serum 25-Hydroxyvitamin D with Lifestyle and Dietary Factors in Egyptian Prepubescent Children. Open Access Maced J Med Sci., 3(1):80-84.