International Journal of Current Research and Review
DOI: https://doi.org/10.31782/IJCRR.2024.162002

Research Article

IJCRR
Section: Life Sciences

Vitamin D Status of Children Attending the Well Child Clinic of a Private Hospital in Yangon

Phyu Phyu Win[1], Myat Moe Thwe Aung[2], Thuza Aung[1]

[1]Consultant Pediatrician, Pediatric Department, Ar Yu International Hospital, Kyaik Ka San Road, Tamwe Township, 11211 Yangon, Myanmar; [2]Medical Lecturer, Faculty of Medicine, University Sultan Zainal Abidin Medical Campus, Jalan Sultan Mahmud, 20400 Kuala Terengganu, Terengganu Darul Iman, Malaysia

ABSTRACT

Introduction: Vitamin D is essential for the healthy development and maintenance of bones, particularly in childhood and adolescence. We aimed to figure out the vitamin D concentrations among children who were 4 to 15 years and came to health check-up clinics of a private hospital in Yangon.

Methods: This is a retrospective record review study over 1 year which included a total of 99 well children aged 4 to15 years. We collected demographic and clinical details as well as blood samples including (25 (OH) D and alkaline phosphatase. For statistical analysis, we applied IBM SPSS 25.0.

Results: Among 99 participants, 43 (43.4%) were found to have vitamin D deficiency. The average serum 25 (OH) D level among all subjects was 21.77±7.03 ng/mL, while those with deficiency had an average level of 15.53±3.32 ng/mL. Notably, a higher percentage of obese children, 10 out of 16 (62.5%) were affected with vitamin D deficiency. There was a statistically significant age difference between the vitamin D deficient group (mean age 10.07±3.16 years) and their sufficient counterparts (mean age 7.70±2.71 years).

Conclusions: A significant incidence of vitamin D deficiency was detected among healthy children. It appears to escalate with age, implying an inverse relationship between age and vitamin D levels. The association between low serum 25 (OH) D and obesity in children underscores the significance of dietary pattern, lifestyle modification, and sunlight exposure in attaining optimal vitamin D levels. These measures may lessen the risk of multiple disease states related to low vitamin D.

Key Words: Hypovitaminosis D, Seasonal vitamin D status, 25 (OH) D levels, Children and adolescents, Alkaline phosphatase, Obese children

INTRODUCTION

It is indisputable that vitamin D takes part an intrinsic task in the development and maintenance of bones, regulating calcium and phosphorus levels crucial for bone strength, particularly in childhood and adolescence. Moreover, it contributes significantly to the proper function of extra skeletal tissues.[1] Vitamin D deficiency can trigger conditions like osteomalacia and rickets due to compromised bone mineralization.[1] Furthermore, research has documented regarding the diminished level of vitamin D in association with the existence of autoimmune disorders, diabetes mellitus, metabolic syndromes and certain types of cancer. [2,3,4,5]

In research conducted in the United States, relatively 15% of children are identified as experiencing either an insufficiency or deficiency of vitamin D, as entitled by studies measuring serum 25(OH)D concentrations below 20 ng/mL (50 nmol/L).[6,7,8] Additionally, around 1 to 2 percent of children have level below 10 ng/mL. [7,8] However, these rates vary significantly across countries and different groups within the population due to variations in risk factors, especially skin color, the length of contact with sunshine, and amount of vitamin D consumed.

Over the past few decades, teenagers have shown increased vulnerability to hypovitaminosis D, largely attributed to sedentary indoor lifestyles, accompanied by extensive use of electronic devices such as computers, televisions, and smartphones.[9,10] In more recent times, the COVID-19 pandemic has exacerbated this issue, with prolonged periods of indoor confinement for both adults and children. This confinement has significantly reduced exposure to sunlight, particularly among urban populations, resulting in decreased synthesis

Corresponding Author:
Phyu Phyu Win, Consultant Pediatrician, Ar Yu International Hospital, 400, Kyaik Ka San Road, Tamwe Township, Yangon 11211, Myanmar; Email: drppwin@gmail.com

ISSN: 2231-2196 (Print) **ISSN:** 0975-5241 (Online)

Received: 28.07.2024 **Revised:** 02.10.2024 **Accepted:** 23.10.2024 **Published:** 30.10.2024

of cholecalciferol underneath the skin, which being the primary origin of vitamin D across all age groups. Due to the necessary lockdown measures imposed, children have spent more time confined to homes during the era of COVID 19. Epidemiological studies have reported alterations in vitamin D concentrations among preschool and school going-aged youngster during the disastrous COVID-19 pandemic. [11,12]

Globally, the screening for vitamin D levels is increasingly integrated into standard laboratory tests requested by primary care physicians, regardless of specific reasons prompting this.[13,14,15,16] Despite a global increase in research on vitamin D deficiency among children, there remains a paucity of data on its prevalence among children in Myanmar. Myanmar, the northernmost country in Southeast Asia, spans from latitude 10° N to approximately 28° 30′ N. We aimed to figure out the vitamin D concentrations among 4 to 15 years old children who attended health check-up clinics at a private hospital located in an urban area of Yangon.

MATERIALS AND METHODS

A) Subjects

The study was conducted among patients aged 4 to 15 who attended the healthy child clinic of the Pediatric Department at Ar Yu International Hospital, from December 2022 to November 2023. The study focused on individuals who visited the healthy child clinic for developmental assessment, who were free from any recent illnesses on the day they visited. There are 99 subjects who met the inclusion criteria. Children with chronic conditions such as hypothyroidism, epilepsy, nephrotic syndrome and those undergoing treatment for vitamin D deficiency were excluded. As for classification, in regards to BMI, normal weight was categorized as falling between the 3rd and 84th percentiles in regard to BMI, while overweight was categorized as falling between the 85th and 94th percentiles. Obesity was determined if individual's BMI falls above the 95th percentile.[17]

B) Study design

Examination of the medical records of the surveyed subjects was done to retrieve information relating to their age, gender, height, weight, the month when the blood sample was undertaken, and their serum levels of alkaline phosphatase (ALP) and 25-hydroxyvitamin D (25(OH)D).

C) Laboratory measurements

The electrochemiluminescence binding assay developed by Roche Diagnostics, Indianapolis, Indiana, USA), was utilized to determine the serum 25(OH)D levels. Subjects were categorized into two clusters depending on the serum 25(OH)D levels. The participants whose 25(OH)D concentrations below 20 ng/mL were categorized in the deficiency group, whereas, those whose 25(OH)D level 20 ng/mL and above in the sufficiency group, complying with the recommendations made by the US Institute of Medicine (IOM) regarding vitamin D status.[18]

D) Statistical analysis

For the interpretation of data, IBM SPSS Statistics 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) was utilized. The chi-square test was employed for categorical variables, whereas the independent t-test for continuous variables. which were explicited as the mean values with their corresponding standard deviations. The significant level was stipulated at p-values below 0.05.

E) Ethical Clearance

This study was approved by the Research Review Board of Ar Yu International Hospital Ethical Committee (letter no.2/2024).

RESULTS

The particulars of the 99 participants were tabulated in **Table 1**. Out of 99 participants, 62 (62.6%) were boys and 37 (37.4%) girls. Of these participants, 43 (43.4%) were identified as having vitamin D deficiency while 56 (56.6%) were identified as vitamin D sufficient. **Table 2** exhibited the attributes of the children and their vitamin D concentrations. It is noted that the mean level of serum 25(OH)D for the deficiency cluster at 15.53 ± 3.32 ng/mL, while for the sufficiency cluster, it was 26.56 ± 5.10 ng/mL. Although gender difference did not demonstrate statistical significance, it is noteworthy that a higher percentage of girls (51.4%) had vitamin D deficiency compared to boys (38.7%). The average age of the participants was 8.73 ± 3.13 years. Notably, children in the vitamin D deficiency group were older (10.07 ± 3.16 years) than their vitamin D-sufficient counterparts (7.70 ± 2.71 years). This age distinction revealed a significant statistical difference (p-value <0.001), indicating inverse connection between age and level of vitamin D. While the observation between the two groups based on BMI classifications (normal, overweight, and obese) did not yield statistical significance, the percentage of vitamin D deficiency was far up among obese participants (62.5%) compared to those classified as normal (40.6%) or overweight (36.8%). The analysis of standard deviation scores (SDS) for weight and height did not demonstrate any obvious discrepancy in the two groups statistically. Seasonal comparisons indicated that the distribution of participants across summer (30.3%), rainy season (45.5%), and winter (24.2%) did not significantly affect vitamin D concentrations. The mean ALP (alkaline phosphatase) levels in the vitamin D deficiency cluster (229.30 ± 98.39 IU/L) and the vitamin D sufficiency group (221.21 ± 66.50

IU/L (p-value = 0.644). Hence, a statistically significant difference was not identified. **Figure 1** illustrates distribution of vitamin D deficiency according to gender. It is obvious that the percentage is higher in girls (51.4%) compared to boys (38.7%). **Figure 2** demonstrates the distribution of vitamin D deficiency according to BMI (normal, overweight and obesity). It can be clearly seen that the percentage is highest in obesity group.

Table 1: Characteristics of the study participants (n = 99)

Gender	
Male	62 (62.6)
Female	37 (37.4)
Age (year)	8.73 ± 3.13
BMI categories	
Normal (<85th percentile)	64 (64.6)
Overweight (85th -94th percentile)	19 (19.2)
Obesity (≥ 95 percentile)	16 (16.2)
ALP (mg/dL)	224.73 ± 81.53
Season	
Summer (Mar–June)	30 (30.3)
Rainy Season (July-October)	45 (45.5)
Winter (Nov – February)	24 (24.2)
Vitamin D (25[OH]D)	
Deficiency (<20 ng/mL)	43 (43.4)
Sufficiency (≥20 ng/mL)	56 (56.6)

mean ± standard deviation.

Table 2: Characteristics of participants according to vitamin D status (n =99)

Characteristics	Total	Vit D deficiency	Vit D sufficiency	p-value
No. of participants	99 (100.0)	43 (43.4)	56 (56.6)	
Serum 25(OH) D (ng/mL)	21.77 ± 7.03	15.53 ± 3.32	26.56 ± 5.10	<0.001[a]
Gender				
Male	62 (62.6)	24 (38.7)	38 (61.3)	0.220[b]
Female	37 (37.4)	19 (51.4)	18 (48.6)	
Age (year)	8.73 ± 3.13	10.07 ± 3.16	7.70 ± 2.71	<0.001[a]
BMI categories				
Normal (<85th percentile)	64 (64.6)	26 (40.6)	38 (59.4)	0.234[b]
Overweight (85th -94th percentile)	19 (19.2)	7 (36.8)	12 (63.2)	
Obesity (≥ 95 percentile)	16 (16.2)	10 (62.5)	6 (37.5)	
ALP (mg/dL)	224.73 ± 81.53	229.30 ± 98.39	221.21 ± 66.50	0.644[a]
Season				
Summer (Mar–June)	30 (30.3)	13 (43.3)	17 (56.7)	0.976[b]
Rainy Season (July-October)	45 (45.5)	20 (44.4)	25 (55.6)	
Winter (Nov – February)	24 (24.5)	10 (41.7)	14 (58.3)	
Weight SDS	33.46 ± 14.96	41.01 ± 17.30	27.66 ± 9.56	<0.001[a]
Height SDS	134.69 ± 20.75	142.48 ± 19.44	128.7 ± 19.86	0.001[a]
BMI SDS	17.83 ± 3.80	17.83 ± 3.80	16.74 ± 2.81	0.001[a]

[a]Independent t-test; [b]Pearson chi-square test; Values are presented as number (%) or mean±standard deviation.

25(OH)D, 25-hydroxyvitamin D; ALP, alkaline phosphatase; BMI, body mass index.

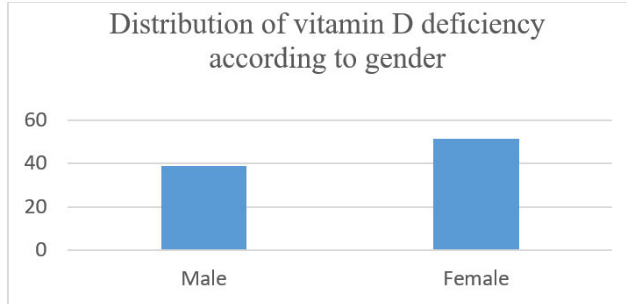

Figure 1: Percentage of vitamin D deficiency based on gender

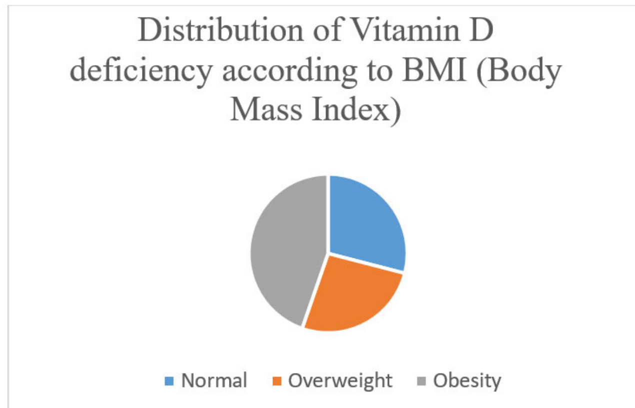

Figure 2: Distribution of vitamin D deficiency in accordance with BMI (Body Mass Index)

DISCUSSION

Globally, suboptimal vitamin D level is an imminent challenge to the community. Extensive efforts are being made to assess the vitamin D levels in various populations, including various age and ethnic groups over the past few decades.[19] In this research, serum vitamin D concentrations were evaluated in 99 children aged four to fifteen. It revealed that 43 of these children, making up 43.4%, were found to have hypovitaminosis D. One of the discoveries from the cross-sectional study done in Thailand, Indonesia, Malaysia and Vietnam in 2010-2011 on children was that 45.8% of the studied children had vitamin D deficiency [20] which is not much different from our finding (43.4%). Likewise, the research conducted in Korea involving children aged 4 to 16 years, which revealed a reported prevalence of 59.1%.[21] Research conducted across various regions of India has documented a prevalence range of 53.0% to 94.0% for vitamin D deficiency among school-going children.[22-27]

In the present study, even though no statistically relevant differences observed based on gender, it is noteworthy that the percentage of girls exhibiting inadequate level of vitamin D (51.4%) was considerably higher when compared to boys (38.7%). Likewise, studies conducted in South Korea[28] the United Kingdom[29], and Finland[30] indicated that girls have tendency of getting lower levels of 25-OHD compared to boys. It is postulated that this observation might be attributed to decreased sunlight exposure among women, potentially resulting from wearing traditional clothing, restricted outdoor tasks and the use of sunblock lotions for cosmetic purposes.[31] Conversely, in a Canadian study on children revealed that females exhibiting a lower rate of hypovitaminosis D compared to males.[32] On the other hand, Karonova et al. reported that there was no remarkable distinction in the 25(OH)D concentrations depending on gender.[33]

The average serum 25(OH)D level among individuals with deficient vitamin D was 15.53±3.32 ng/mL, whereas that among all subjects was 21.77±7.03 ng/mL. The result we discovered was consistent with other studies. In an earlier investigation conducted in Korea, Lee et al. documented the average serum 25(OH)D level in teenagers and younger kids as 17.42±8.95 ng/mL.[34] In research undertaken on seemingly healthy children aged from 3 months to 12 years, belonging to the upper socioeconomic status, in Chandigarh in India, the average serum 25(OH)D level among the children was 27.48 nmol/mL (15.99 ng/mL).[35] According to research conducted by Durmaz et al. in another province in India, the average level of vitamin D among participants aged 18 years and below were recorded at 16.3 ng/mL.[36]

Notably, children in the vitamin D inadequacy cluster were older, in comparison to their counterparts with sufficient vitamin D levels. This age difference demonstrated a significant distinction statistically (p-value <0.001), suggesting the vitamin D status with a contrary relationship to age. The research undertaken in Bahrain[37] and Turkey[38] furthermore found a reverse relation between vitamin D concentrations and age. The incidence of vitamin D inadequacy rose with increasing age, looming among teenagers.[37,38] However, research conducted in Korea, the United Arab Emirates, and the USA indicated that there was no notable distinction in age among children suffering from vitamin D deficiency in comparison to their counterpart with adequate vitamin D.[21,39,40]

Although no significant distinction was demonstrated statistically regarding BMI status, obese participants exhibited a bigger proportion of vitamin D inadequacy in contrast to individuals classified as normal or overweight. Anuradha Khadilkar and colleagues, in their research involving Indian children and adolescents, also found that overweight individuals have greater propensity to develop hypovitaminosis D.[41] The widely recognized negative correlation between BMI and concentrations of vitamin D is attributed to diminished availability of vitamin D, as it gets accumulated in a greater amount of body fat.[3]

In various studies, it's commonly observed that vitamin D deficiency peaks during winter or spring. Latitude and insufficient sunlight exposure during winter are the primary factors believed to contribute to these seasonal fluctuations in vitamin D levels.[42,43,44] In this current study, comparisons between seasons revealed that the distribution of participants throughout summer, the rainy season, and winter did not demonstrate a remarkable effect on their status of vitamin D. El-Hajj Fuleihan et al. discovered that during winter, 65% of individuals in Beirut suffered from vitamin D inadequacy, which decreased to 40% by the end of summer.[45] Research conducted in Turkey illustrated that the proportion of deficiency in vitamin D was 93% in the spring while 71% in the autumn.[43] Our research findings may be attributed to the relatively moderate temperature variations experienced in Yangon, Myanmar, throughout the summer, rainy season, and winter, owing to its tropical climate, which contrasts with the more extreme temperature fluctuations observed in some other regions globally.

CONCLUSIONS

The widespread occurrence of hypovitaminosis D in both adults and children is well known. This recent research found an exceptionally high rate of hypovitaminosis D (43.4%) among otherwise healthy children. This deficiency appears to escalate with age, implying a contrary relationship between age and the levels of serum vitamin D. The probable link observed between obesity and suboptimal levels of vitamin D in children underscores the significance of dietary pattern, lifestyle modification, and sunlight exposure in attaining optimal vitamin D levels. These measures probably lessen the risk of multiple disease states related to hypovitaminosis D. Additionally, we recommend updating the guidelines on vitamin D intake to better align with our specific circumstances. Additional research is required to ascertain the prevalence and contributing causes of vitamin D deficiency in children across diverse territory of the country, Myanmar.

Study limitations

One of the constraints in the study is that it is conducted within the hospital setting, with the majority of patients residing in Yangon. So, the data may not accurately reflect the entire population of Myanmar children. Another limitation is being not able to include the length that the individual being exposed to sunshine and dietary history, including vitamin D intake.

Conflict of interest

No potential conflict of interest declared

Acknowledgments

We would like to thank to Ar Yu Hospital Executive Committee for giving a chance to conduct this study. We also offer our gratitude to the children and their parents. Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

Source of Funding:

This research did not receive any funding.

Authors' Contribution

The first author was involved in developing the protocol, writing, processing and correspondence of the article. The second author took part in data analysis and writing the article. The third author was involved in data collection and writing the article.

REFERENCES

1. Wacker M, Holick M. Vitamin D — Effects on Skeletal and Extra skeletal Health and the Need for Supplementation. Nutrients. 2013; 5(1): 111–148. https://doi.org/10.3390/nu5010111
2. Chambers ES, Hawrylowicz CM. The impact of vitamin D on regulatory T cells. Curr Allergy Asthma Rep. 2011 Feb;11(1):29-36. doi: 10.1007/s11882-010-0161-8
3. Holick MF. Vitamin D deficiency. N Engl J Med. 2007; 357(3): 266–281. https://doi.org/10.1056/NEJMra070553
4. Hypponen E, Laara E, Reunanen A, Jarvelin MR, Virtanen SM. Intake of vitamin D and risk of type 1 diabetes: a birth-cohort study. Lancet. 2001; 358(9292): 1500–1503. https://doi.org/10.1016/S0140-6736(01)06580-1
5. Muhe L, Lulseged S, Mason KE, Simoes EA. Case-control study of the role of nutritional rickets in the risk of developing pneumonia in Ethiopian children. Lancet. 1997; 349(9068): 1801–1804. https://doi.org/10.1016/S0140-6736(96)12098-5
6. Gordon CM, Feldman, HA, Sinclair L, Williams AL, Kleinman PK, Perez-Rossello J et al. Prevalence of Vitamin D Deficiency among Healthy Infants and Toddlers. Arch Pediatr Adolesc Med. 2008 Jun;162(6):505-12. doi: 10.1001/archpedi.162.6.505
7. Mansbach JM, Ginde AA, Camargo CA. Jr. Serum 25-hydroxyvitamin D levels among US children aged 1 to 11 years: do children need more vitamin D? Pediatrics. 2009; 124 (5): 1404-1410. https://doi.org/10.1542/peds.2008-2041
8. Saintonge S, Bang H, Gerber LM. Implications of a new definition of vitamin D deficiency in a multiracial US adolescent population: the National Health and Nutrition Examination Survey III. Pediatrics.2009; 123(3): 797-803. https://doi.org/10.1542/peds.2008-1195
9. Cesareo R, Attanasio R, Caputo M, Castello R, Chiodini I, Falchetti A et al. Italian Association of Clinical Endocrinologists (AME) and Italian Chapter of the American Association of Clinical Endocrinologists (AACE) Position Statement: Clinical Management of Vitamin D Deficiency in Adults. Nutrients. 2018; 10(5): 546. https://doi.org/10.3390/nu10050546
10. Vierucci F, Del Pistoia M, Fanos M, Gori M, Carlone G, Erba P, et al. Vitamin D status and predictors of hypovitaminosis D in Italian children and adolescents: a cross-sectional study. Eur J. Pediatr. 2013; 172(12): 1607–1617. https://doi.org/10.1007/s00431-013-2119-z
11. Bertoldo F, Cianferotti L, Di Monaco M, Falchetti A, Fassio A, Gatti D, et al. Definition, assessment, and management of Vitamin D inadequacy: Suggestions, recommendations, and warnings from the Italian society for osteoporosis, mineral metabolism and bone diseases (SIOMMMS). Nutrients. 2022; 14(19): 4148. https://doi.org/10.3390/nu14194148
12. Beyazgül G, Bağ Ö, Yurtseven İ, Coşkunol F, Başer S, Çiçek D, et al. How Vitamin D Levels of Children Changed during COVID-19 Pandemic: A Comparison of Pre-Pandemic and Pandemic Periods. Journal of Clinical Research in Pediatric Endocrinology (JCRPE). 2022; 14(2): 188-195. https://doi.org/10.4274/jcrpe.galenos.2022.2021-10-6
13. LeFevre ML. Screening for vitamin deficiency in adults: U.S. preventive services task force recommendation statement. Ann Intern Med. 2015; 162(2): 133–140. https://doi.org/10.7326/M14-2450
14. Rockwell M, Kraak V, Hulver M, Epling J. Clinical Management of Low Vitamin D: A Scoping Review of Physicians' Practices. Nutrients. 2018; 10(4): 493. https://doi.org/10.3390/nu10040493
15. Taylor CL, Rosen, CJ, Dwyer, JT. Considerations in Dietetic Counseling for Vitamin D. Journal of the Academy of Nutrition and Dietetics (JAND). 2019; 119(6):901–909. https://doi.org/10.1016/j.jand.2018.04.013
16. Taylor CL, Thomas, PR, Aloia JF, Millard PS, Rosen CJ. Questions about Vitamin D for Primary Care Practice: Input From an NIH Conference. Am J Med, 2015; 128(11): 1167–1170. https://doi.org/10.1016/j.amjmed.2015.05.025
17. Ogden CL, Kuczmarski RJ, Flegal KM, Mei Z, Guo S, Wei R, et al. Centers for Disease Control and Prevention 2000 Growth Charts for the United States: Improvements to the 1977 National Center for Health Statistics Version. Pediatrics, 2002; 109(1): 45–60. https://doi.org/10.1542/peds.109.1.45
18. Ross AC, Manson JE, Abrams SA, Aloia JF, Brannon PM, Clinton SK, et al. The 2011 Report on Dietary Reference Intakes for Calcium and Vitamin D from the Institute of Medicine: What Clinicians Need to Know. The Journal of Clinical Endocrinology & Metabolism (JCEM). 2011; 96(1): 53–58. https://doi.org/10.1210/jc.2010-2704
19. Holick MF. The vitamin D deficiency pandemic: Approaches for diagnosis, treatment and prevention. Rev Endocr Metab Disord. 2017;18(2): 153–165. https://doi.org/10.1007/s11154-017-9424-1
20. Nguyen Bao K, Sandjaja S, Poh B, Rojroongwasinkul N, Huu C, Sumedi E, et al. The Consumption of Dairy and Its Association with Nutritional Status in the South East Asian Nutrition Surveys (SEANUTS). Nutrients. 2018; 10(6): 759. https://doi.org/10.3390/nu10060759
21. Roh YE, Kim BR, Choi WB, Kim YM, Cho MJ, Kim HY, et al. Vitamin D deficiency in children aged 6 to 12 years: single center's experience in Busan. Annals of Pediatric Endocrinology & Metabolism (APEM). 2016; 21(3): 149-154. https://doi.org/10.6065/apem.2016.21.3.149
22. Bailey DA, Martin AD, McKay HA, Whiting S, Mirwald R. Calcium accretion in girls and boys during puberty: a longitudinal analysis. Journal of Bone and Mineral Research(JBMR). 2000; 15(11): 2245–2250. https://doi.org/10.1359/jbmr.2000.15.11.2245
23. Basu S, Gupta R, Mitra M, Ghosh A. Prevalence of vitamin D deficiency in a pediatric hospital of Eastern India. Indian J Clin Biochem. 2015; 30(2): 167–173. https://doi.org/10.1007/s12291-014-0428-2
24. Ekbote VH, Khadilkar AV, Mughal MZ, Hanumante, N, Sanwalka, N, Khadilkar, VV, et al. Sunlight exposure and development of rickets in Indian toddlers. Indian Journal of Pediatrics (IJP). 2010; 77(1): 61–65. https://doi.org/10.1007/s12098-009-0263-2

25. Harinarayan CV, Ramalakshmi T, Prasad UV & Sudhakar D. Vitamin D status in Andhra Pradesh: a population-based study. Indian J Med Res. 2008; 127(3): 211–218.
26. Marwaha RK, Tandon N, Reddy DHK, Agrawal R, Singh R, Sawhney RC, et al. Vitamin D and bone mineral density status of healthy school children in northern India. Am J Clin Nutr. 2005; 82(2): 477–482. https://doi.org/10.1093/ajcn.82.2.477
27. Vasudevan J, Reddy GMM, Jenifer AST, Devi UMR. Prevalence and Factors Associated with Vitamin D Deficiency in Indian Children: A Hospital Based Cross Sectional Study. Pediatric Oncall. 2014; *11*(3): 71-76. https://doi.org/10.7199/ped.oncall.2014.47
28. Kim SH, Oh MK, Namgung R, Park MJ. Prevalence of 25-hydroxyvitamin D deficiency in Korean adolescents: association with age, season and parental vitamin D status. Public Health Nutr. 2014; 17(1): 122–130. https://doi.org/10.1017/S1368980012004703
29. Absoud M, Cummins C, Lim MJ, Wassmer E, Shaw N. Prevalence and Predictors of Vitamin D Insufficiency in Children: A Great Britain Population Based Study. PLoS ONE. 2011; 6(7): e22179. https://doi.org/10.1371/journal.pone.0022179
30. Pekkinen M, Viljakainen H, Saarnio E, Lamberg-Allardt C, Mäkitie O. Vitamin D Is a Major Determinant of Bone Mineral Density at School Age. PLoS ONE. 2012; 7(7): e40090. https://doi.org/10.1371/journal.pone.0040090
31. Wacker M, Holick M. Vitamin D — Effects on Skeletal and Extra skeletal Health and the Need for Supplementation. Nutrients. 2013; *5*(1): 111–148. https://doi.org/10.3390/nu5010111
32. Roth DE, Martz P, Yeo R, Prosser C, Bell M, Jones AB. Are national vitamin D guidelines sufficient to maintain adequate blood levels in children? Canadian J Public Health, 2005; 96(6): 443–449. https://doi.org/10.1007/BF03405185
33. Karonova T, Andreeva A, Nikitina I, Belyaeva O, Mokhova E, Galkina, O, et al. Prevalence of Vitamin D deficiency in the North-West region of Russia: A cross-sectional study. J Steroid Biochem Mol Biol. 2016; 164: 230–234. https://doi.org/10.1016/j.jsbmb.2016.03.026
34. Lee YA, Kim HY, Hong H, Kim JY, Kwon HJ, Shin CH, Yang SW. et al. Risk factors for low vitamin D status in Korean adolescents: the Korea National Health and Nutrition Examination Survey (KNHANES) 2008–2009. Public Health Nutr. 2014; 17(4): 764–771. https://doi.org/10.1017/S1368980013000438
35. Angurana SK, Angurana RS, Mahajan G, Kumar N, Mahajan V. Prevalence of vitamin D deficiency in apparently healthy children in north India. Journal of Pediatric Endocrinology & Metabolism (JPEM). 2014; 27(11-12): 1151-1156. https//doi.org/10.1515/jpem-2013-0387
36. Durmaz ZH, Demir AD, Tiryaki M, Delibas N. Vitamin D levels of individuals in Amasya Region. Bozok Med J. 2015; 5(3): 26–32.
37. Isa H, Almaliki M, Alsabea A, Mohamed A. Vitamin D deficiency in healthy children in Bahrain: do gender and age matter? Eastern Mediterranean Health Journal (EMHJ). 2020; 26(3): 260–267. https://doi.org/10.26719/emhj.19.084
38. Erol M, Yiğit Ö, Küçük SH, Bostan Gayret Ö. Vitamin D Deficiency in Children and Adolescents in Bağcılar, İstanbul. J Clin Res Pediatr Endocr. 2015; 7(2): 134–139. https://doi.org/10.4274/jcrpe.1888
39. Gordon CM, Feldman HA, Sinclair L, Williams AL, Kleinman PK, Perez-Rossello J, Cox, JE. et al. Prevalence of Vitamin D Deficiency Among Healthy Infants and Toddlers. Arch Pediatr Adolesc Med. 2008a 162(6), 505. https://doi.org/10.1001/archpedi.162.6.505
40. Muhairi SJ, Mehairi AE, Khouri AA, Naqbi MM, Maskari FA, Kaabi J. Al, et al. Vitamin D deficiency among healthy adolescents in Al Ain, United Arab Emirates. BMC Public Health. 2013; 13(1): 33. https://doi.org/10.1186/1471-2458-13-33
41. Khadilkar A, Kajale N, Oza C, Oke R, Gondhalekar K, Patwardhan V, et al. Vitamin D status and determinants in Indian children and adolescents: a multicentre study. Scientific Reports. 2022; 12(1): 16790. https://doi.org/10.1038/s41598-022-21279-0
42. Chlebna-Sokól D, Konstantynowicz J, Abramowicz P, Beata KR, Marek N, Anna O et al. Evidence of a significant vitamin D deficiency among 9-13-year-old Polish children: results of a multicentre study. Eur J Nutr. 2019; 58(5): 2029–2036. https://doi.org/10.1007/s00394-018-1756-4
43. Karagüzel G, Dilber B, Çan G, Ökten A, Değer O, Holick MF. Seasonal Vitamin D Status of Healthy School children and Predictors of Low Vitamin D Status. J Pediatr Gastroenterol Nutr. 2014; 58(5): 654–660. https://doi.org/10.1097/MPG.0000000000000274
44. Smyczynska J, Smyczynska U, Stawerska R, Domagalska-Nalewajek H, Lewinski A, Hilczer M. et al. Seasonality of vitamin D concentrations and the incidence of vitamin D deficiency in children and adolescents from central Poland. Pediatr Endocrinol Diabetes Metab. 2019; 25(5): 54–59. https://doi.org/10.5114/pedm.2019.85814
45. G El-Hajj F, Nabulsi M, Choucair M, Salamoun M, Hajj Shahine C, Kizirian A, et al. Hypovitaminosis D in healthy schoolchildren. Pediatrics. 2001; 107(4): e53. https://doi.org/10.1542/peds.107.4.e53