VITAMIN D STATUS OF FILIPINO HIGH SCHOOL STUDENTS IN SELECTED SCHOOLS IN QUEZON CITY

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ABSTRACT

BACKGROUND: Vitamin D deficiency has been documented as a frequent problem in almost every region of the world even in the tropical countries and its health consequences are enormous. Infancy and adolescence are age groups particularly at risk of developing vitamin D deficiency. However, there are no data on the Vitamin D status of Filipino adolescents.

OBJECTIVES: To determine the serum 25-hydroxyvitamin D levels in Filipino high school students in selected schools in Quezon City

METHODS: A cross-sectional study of Filipino high school students was undertaken. A total of 97 boys and girls aged 11- 18 years old, attending selected private and public secondary schools in Quezon City participated in the study after parents' consent and students' assent were taken. Serum 25(OH)D levels were determined by electrochemiluminescence immunoassay (ECLIA) using Roche HITACHI Cobas e immunoassay analyzer.

RESULTS: The total serum 25-hydroxyvitamin D levels of the students ranged from 19.92 nmol/L to 88.63 nmol/L with a mean of 52.43 nmol/L. Among the 97 high school students, there was a prevalence of hypovitaminosis D (serum 25 (OH)D <50nmol/L) of 41.2% with 20.6% having deficient (<37.5 nmol/L) and 20.6% insufficient (37.5-<50 nmol/L) serum 25-hydroxyvitamin D levels. In a final multivariate model, low vitamin D intake, BMI Z-score outside the normal range of 0 to <1SD and upper socioeconomic status were significant independent predictors of hypovitaminosis D.

CONCLUSION: Hypovitaminosis D is highly prevalent among Filipino adolescents in secondary school despite abundance of sunlight. Appropriate interventions are needed to address the problem of poor vitamin D status in schoolchildren.

KEYWORDS: hypovitaminosis D, vitamin D deficiency/insufficiency, Filipino, adolescents, serum 25(OH)D levels

INTRODUCTION

Vitamin D, also known as the "Sun Vitamin", is not in a strict sense a vitamin but a pre-pro-hormone which acts via metabolites of which the most active is 1,25 $(OH)_2D$ or 1,25-dihydroxycholecalciferol or calcitriol; this binds to specific receptors, the vitamin D receptors (VDRs) functioning as nuclear transcription factors[1], and as such exerts transcriptional control over a large number of genes. Of great interest is the role it can play in decreasing the risk of many chronic illnesses, including common cancers, autoimmune diseases, infectious diseases, and cardiovascular disease. [2]

The principal functions of vitamin D are for augmentation of intestinal absorption of calcium and promotion of normal bone formation and mineralization.[3] In a vitamin D-sufficient state [25 9OH)D levels of >50 nmol/L (20 ng/mL)], net intestinal calcium absorption is up to 30%, although calcium absorption can reach 60%- 80% during periods of active growth. In a vitamin D-deficient state, intestinal calcium absorption is only ~10%-15% and there is a decrease in the total reabsorption of phosphate.[4] Bone problems such as osteoporosis is a significant health problem today. One of every 3 Filipino women, as well as 1 in 5 Filipino men, is likely to suffer from osteoporosis.[7] These are said to be higher than the number of people succumbing to breast or prostate cancer, and should be given the attention they deserve. Thus strategies to maximize peak bone mass in children have been identified as a priority area for research.[8] This would be of great importance in the prevention of the common and costly public health problem of osteoporosis.

It is widely believed that osteoporosis prevention may be best accomplished during childhood and adolescence, when bones are growing rapidly. As adolescence is a critical period for bone health, the effect of vitamin D status on bone mineral density in adolescents could be of major importance.[9] At least 90% of peak bone mass is obtained by the age of 18 years.[10] A 10% increase in peak bone mass is estimated to reduce the risk of an osteoporotic fracture in adult life by 50%.[11]

Data from national surveys in the UK, USA and New Zealand show that the prevalence of low vitamin D status is less of a concern for children than for adolescents. The prevalence of low vitamin D status appears to increase with age in early life with adolescents being the life-stage with the highest prevalence of low vitamin D status.[9] Although most studies have demonstrated lower vitamin D levels among adolescents, such findings have been predominantly generated from studies conducted in temperate regions. There is limited data on this issue on adolescents in tropical countries. To date, studies on vitamin D status of Filipino children are scarce, and to our knowledge, there are no data on the vitamin D status of the adolescent population in the Philippines.

The best method for determining a person's vitamin D status is to measure the serum 25- hydroxyvitamin D (25 (OH)D).[2] Although a global consensus has not been reached with regard to the biochemical definition of VDD, for children it has been recommended that a serum 25 (OH)-D level of > 50 nmol/L (20 ng/mL) be considered indicative of sufficiency , serum 25-(OH)D concentration of <37.5 nmol/L,or 15ng/ml, as an indication of VDD, and 25-(OH)D level of 37.5- 50 nmol/L,or 15-20 ng/ml, be considered to indicate insufficiency. Severe deficiency is somewhat arbitrarily defined as 25 (OH)-D level of $\leq$ 12.5 nmol/L (5 ng/mL).[4] The cut-off of 50 nmol/L or 20 ng/mL is based on studies that show that levels below this value may be associated with rickets, and impaired bone accrual.

VDD has reemerged as a significant pediatric health issue worldwide. Adolescence is an age group particularly at risk of developing VDD because of the greater mineral demands of their growing skeleton. [18] Recent studies show that 16% to 54% of adolescents have serum 25(OH)D concentrations of $\leq$50 nmol/L.[15]This is why the adolescent period is a very important phase to catch VDD. VDD in adolescent females identifies an increased risk of future infants with VDD.[19] It could also progress to osteoporosis or osteomalacia in adulthood.

To address this concern, the American Academy of Pediatrics (AAP) issued new recommended intakes for healthy pediatric and adolescent population of a minimum of 400 IU/day of vitamin D that replaces the previous recommendation of a minimum daily intake of 200 IU/day of vitamin D supplementation.

In a Cochrane review on Vitamin D supplementation for improving mineral density in children published in 2010, the authors concluded that the available evidence does not support the use of vitamin D supplementation to improve bone health in healthy children with normal vitamin D levels, but does suggest that supplementation given to vitamin D deficient children may have clinically useful benefits for peak bone mass.[20]

With the studies on Vitamin D that are coming out at this time, there is a crucial need for nutritional public health awareness campaigns about the importance of Vitamin D. Evidence from developed countries of the safety and efficacy of vitamin D supplementation for the improvement of musculoskeletal outcomes of those children with hypovitaminosis D renders the institution and implementation of national health policies in developing countries mandatory.[21] These policies however, require revisions based on evidence from locally conducted studies. To date, limited data on Vitamin D are available among Filipino children and no data are available on the vitamin D status in the adolescent group.

This study was done to determine the baseline vitamin D levels of apparently healthy Filipino school-going adolescents so as to determine if further recommendation on supplementation should be needed in order to improve bone health of our children that would impact later in life.

The general objective of this study is to determine the serum 25-hydroxyvitamin D levels of Filipino high school students, 10-18 years of age in selected schools in Quezon City. The specific objectives are: to determine the prevalence of hypovitaminosis D (serum 25-hydroxyvitamin D level of <50 nmol/L) in Filipino high school students in selected schools in Quezon City and to determine the relationship between serum 25-hydroxyvitamin D levels and the factors within the adolescent lifestyle that represent predictors of hypovitaminosis D such as: gender, socioeconomic status, body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), obesity, duration of sun exposure, skin color, clothing style, sunscreen use, and nutrient intake.

METHODOLOGY

This cross-sectional study was conducted in July 2012 in 97 boys and girls aged 11-18 years old living in Metro Manila and attending secondary schools in Quezon City. This age group was chosen based on the study done by CDC/NCHS, National Health and Nutrition Examination Survey (NHANES) from 2001-2006, which showed that the season-adjusted prevalence at risk of hypovitaminosis D by age was lowest in children aged 1-8 years and the risk of deficiency increased significantly with age, until age 30 in males and age 18 in females, after which it did not change significantly with age. The school children came from a government high school, the Flora Ylagan High School, that caters to children of lower socioeconomic status (LSES) and a private school – the St. Paul University of Quezon City, that enroll children of middle to upper socioeconomic status (USES). Socioeconomic stratification of the subjects was based on the type of school attended. Exclusion criteria were chronic disease such as asthma, tuberculosis, IBD, malabsorption, cardiac problem, chronic liver disease, neurologic or renal disease; intake of drugs that interfere with bone mineral metabolism such as glucocorticoids, anticonvulsants, and antituberculous drugs; intake of vitamin D supplement or multivitamins containing Vitamin D; skeletal disease/deformity and signs of vitamin D deficiency such as rachitic rosary rib cage, genu varum (bowlegs),genu valgum (knock-knees),frontal bossing, epiphyseal enlargement of the wrists and knees, etc. as noted on physical examination. An invitation to participate in the study was given to parents and guardians of the students selected by stratified sampling per level and per section of the selected schools. Out of approximately 830 invitation letters accompanied by consent and assent forms that were distributed, 110 consent forms returned, primarily because the parents refused to have blood extraction done on their children. Of those who assented and who obtained parents' written informed consent, a random sampling was done in the primary sampling unit per section. 97 questionnaires were then given to the participants. Using the reported prevalence of VDD of 20% among Filipinos in a study done by Kruger in 2010, a total sample size of 96 was deemed to be sufficient to estimate the prevalence within 8% of the true value, with 95% confidence level.

Data on age, gender, monthly family income, parents' occupation, class schedule, duration of direct sun exposure, style of school uniform, outdoor clothes worn during the day, use of sunscreen, and the type, frequency, and amount of fish and milk intake, were asked through a self-administered pretested questionnaire supervised by the investigator. The questionnaire used was pretested to 40 high school students at San Francisco High School in Quezon City. Review of systems and physical examination was done by the investigator to all the subjects to include the skin color using the Fitzpatrick skin type scale. The estimation of the percentage of skin exposed to the sun was done using Wallace's rule of nines as determined by their clothing style. Weight and height were measured twice using a single calibrated weighing scale and tape measure fixed to the wall. Weight and height were measured with students in their school uniform and without shoes. Weight was measured to the nearest 0.1 kg while the height was measured to the nearest 0.1 cm. BMI was calculated as weight/height^2 by the investigator and classified based on the World Health Organization recommendation. Nutritional assessment and dietary assessment of total energy, protein, carbohydrate, fat, and Vitamin D intake was done by a dietician based on a 3-day (2 weekdays and 1 weekend) dietary recall record of their food intake which were done 3 days prior to the study. The daily dietary prescription for schoolchildren and teenagers adapted from the Recommended Energy & Nutrient Intake, FNRI/DOST,2002 was used as basis for the computation of percentage of caloric intake.

A single blood sample (6mL) was extracted from each of the 97 subjects by registered medical technologists at the school clinic on the same day. Samples were centrifuged at the end of the collection and stored on ice before transporting to the laboratory. All the specimens were processed on the same day by an ISO certified private laboratory not associated to the funding agencies. The serum 25 hydroxyvitamin D levels (both vitamin D_2 and D_3 derivatives) of all the subjects were determined by electrochemiluminescence immunoassay

(ECLIA) using Roche HITACHI Cobas e immunoassay analyzer.

The study protocol was approved by the Institutional Review Board of the Office of Research Development of the Philippine Children's Medical Center.

The definitions of clinical entities (i.e. Hypovitaminosis D, VDI, VDD, etc.) used in the study are shown in Table 1.

Table 1. Definition of terms used in this study for laboratory test results.

Clinical entity	**Test**	**Level**
Vitamin D sufficiency (VDS)	Serum 25-OHD	50- 250 nmol/L[4]
Vitamin D insufficiency(VDI)	Serum 25-OHD	37.5-50 nmol/L
Vitamin D deficiency (VDD)	Serum 25-OHD	<37.5 nmol/L
Severe VDD	Serum 25-OHD	<12.5 nmol/L

*from World J Pediatr 2012; 8:2:145-150

Data were encoded and tallied in SPSS version 10 for Windows. Descriptive statistics were generated for all the variables. For nominal data, frequencies and percentages were computed. For numerical data, mean ± SD were generated. Analysis of the different variables was done using the following test statistics: ANOVA was used to compare more than two groups with numerical data, Kruskal Wallis test which is a non-parametric equivalent of the ANOVA and Chi-square test to compare or associate nominal data. P value <0.05 was considered significant. Multivariate regression analysis was done to determine independent predictors for hypovitaminosis D.

RESULTS

A response rate of 100% was obtained (questionnaires returned and completed). A total of 97 subjects were included in the study including a twin. Table 2 shows the distribution of subjects according to serum 25-hydroxyvitamin D levels. Hypovitaminosis D was documented in 41.2% (40) of the subjects and there's equal percentage (20.6%) of those having vitamin D insufficiency and deficiency. There was no one with severe VDD. The serum 25-(OH)D levels of the twin sisters differ (48.41 nmol/L and 43.61 nmol/L) but still in the insufficient range. The serum 25-(OH)D levels ranged from 19.92 nmol/L to 88.63 nmol/L with a mean of 52.43 nmol/L. Clinical characteristics of the participants are shown in Table 3.

Table 2. Distribution of Subjects According to Serum 25-hydroxyvitamin D Levels

Vit.D status	Frequency N=97(%)	Vitamin D Level (nmol/L)	
		Range	Mean + 1SD
Sufficient	57 (58.8%)	50.25 – 88.63	63.31 ± 10.10
Insufficient	20 (20.6%)	37.72 – 49.75	43.10 ± 3.60
Deficient	20 (20.6%)	19.92 – 36.67	30.74 ± 4.46

Table 3. Clinical Characteristics of the High School Students

	School		Total
	Private	**Public**	
	n=49 (%)	n=48 (%)	n=97 (%)
Sex			
Male	8 (16.3%)	13 (27.1%)	21 (21.6%)
Female	41 (83.7%)	35 (72.9%)	76 (78.4%)
Age, years			
Mean ± SD			14.53 ± 1.32
Range			11 - 18
Nutritional Status			
Obese	4 (8.2%)	0	4 (4.1%)
Overweight	4 (8.2%)	3 (6.3%)	7 (7.2%)
No wasting	39 (79.6%)	37 (77.1%)	76 (78.4%)
Wasted	2 (4.1%)	7 (14.6%)	9 (9.3%)
Severely wasted	0	1 (2.1%)	1 (1.0%)
Duration of Sun Exposure			
<15 mins	9 (18.4%)	21 (43.8%)	30 (30.9%)
15mins – 30mins	27 (55.1%)	21 (43.8%)	48 (49.5%)
>30mins	13 (26.5%)	6 (12.5%)	19 (19.6%)
Clothing style			
Clothes that cover> half of the body	47 (95.9%)	48 (100%)	95 (97.9%)
Clothes that cover the whole body	2 (4.1%)	0	2 (2.1%)
Uses sunblock			
Yes	13 (26.5%)	8 (16.7%)	21 (21.6%)
No	36 (73.5%)	40 (83.3%)	76 (78.4%)
Eat Fish			
Yes	48 (98.0%)	46 (95.8%)	94 (96.9%)
No	1 (2.0%)	2 (4.2%)	3 (3.1%)
Drink Milk			
Yes	44 (89.8%)	38 (79.2%)	82 (84.5%)
No	5 (10.2%)	10 (20.8%)	15 (15.5%)
Had Respiratory Tract Infection >6x/year	3(6.1%)	2 (4.2%)	5 (5.2%)
Yes	46 (93.9%)	46 (95.8%)	92 (94.8%)
No			
Caloric intake	830.04±331.58	1262.23±399.12	

A higher percentage (75%) of those with VDD and VDI have >15 minutes of daily sun exposure as compared to those with <15 minutes (25%) (Table 4). However, results showed that duration of sun exposure is not significantly associated with serum 25-(OH)D levels.

All of those with hypovitaminosis D wear clothes covering more than half of their body, but clothing style was not found to be significantly correlated with vitamin D levels.

Among the sunblock users, 36.4% have VDD and VDI and majority have sufficient vitamin D levels. Results showed that the use of sunblock has no significant association with serum 25-(OH)D levels.

Table 4. Univariate Analysis of Risk Factors for VDD and Association with Serum 25-(OH)D Levels

	Serum 25-hydroxyvitamin D Levels			**Total**	**P value**
	Deficient (n=20)	**Insufficient** (n=20)	**Sufficient** (n=57)		
SES					
Private (USES)	17 (34.7%)	11 (22.4%)	21 (42.9%)	49 (50.5%)	0.0009(S)
Public (LSES)	3 (6.3%)	9 (18.8%)	36 (75%)	48 (49.5%)	
Skin Color*					
Type I -III	4 (20%)	3 (15%)	7 (12.3%)	14(14.4%)	0.70 (NS)
Type IV-VI	16 (80%)	17(85%)	50 (87.7%)	83 (85.6%)	
Duration of Sun Exposure					
<15 mins	5 (25%)	5 (25%)	20 (35.1%)	30 (30.9%)	
>15 mins	15(75%)	15 (75%)	37(64.9%)	67 (69.1%)	0.57 (NS)
Clothing style					
Clothes that cover <50% of the body	0	0	0	0	
clothes that cover >50% of the body	20(100%)	20(100%)	57(100%)	97(100%)	1.00 (NS)
Uses sunblock					
Yes	5 (22.7%)	3 (13.6%)	14(63.6%)	22 (22.7%)	0.65 (NS)
No	15 (20%)	17 (22.7%)	43 (57.3%)	75 (77.3%)	

*based on Fitzpatrick skin type classification scale

On multivariate analysis of risk factors for hypovitaminosis D (Table 5), upper socioeconomic status, BMI Z-score out of the normal range of 0 to 1 SD, and vitamin D intake of less than 5 ug/day are found to be significant predictors of hypovitaminosis D (p values of 0.001,0.012 and 0.019,respectively). Skin color, sun exposure, clothing style, use of sunscreen, gender, obesity, waist circumference, waist-hip ratio, and fish and milk intake are not predictors of hypovitaminosis D. Higher socioeconomic status has 17x risk of having vitamin D insufficiency/deficiency, while those with high or low BMI score are 10x at risk of having VDD/VDI. Vitamin D intake of less than 5 ug/day increases the risk by 28x.

Table 5. Independent Predictors of Hypovitaminosis D

	OR	95 CI	P value
Skin Color (Type IV-VI)	2.531	0.571 – 11.208	0.221 (NS)
Sun exposure (<15 mins)	0.850	0.279 – 2.591	0.775 (NS)
Clothing Style	0.000	0.000	1.00 (NS)
Use sunscreen (Yes)	0.437	0.132 – 1.446	0.175 (NS)
Sex (Female)	1.425	0.382 – 5.318	0.598 (NS)
Socioeconomic status (USES)	17.285	3.327 – 89.810	0.001 (S)
BMI (0 to <1 SD- No)	10.381	1.660 – 64.900	0.012 (S)
Obesity	0.105	0.005 – 2.297	0.152 (NS)
Waist (cm)	1.092	0.837 – 1.423	0.518 (NS)
Waist Hip Ratio	0.554	0.152 – 2.024	0.372 (NS)
Eat fish (no)	1.033	0.045 – 23.677	0.984 (NS)
Drink Milk (No)	0.407	0.090 – 1.840	0.243 (NS)
Vitamin D intake <5ug/day	28.768	1.723 – 480.207	0.019 (S)

Abbreviations: OR,odds ratio; CI,confidence interval

DISCUSSION

This study is the first in the Philippines to investigate the vitamin D status among adolescents. The importance of this study is the unexpected finding of a high prevalence of hypovitaminosis D among apparently healthy Filipino high school students. None of the adolescents have symptoms nor clinical features of vitamin D deficiency as per questioning and physical examination. The presence of asymptomatic Vitamin D deficiency was also observed in 61% of female adolescents in Saudi Arabia [22] and 87% of East African adolescents living in Melbourne, Australia.[19] This finding is congruent with the 42% prevalence of hypovitaminosis D and 24.1% prevalence of VDD in US adolescents [24] and add to the growing data including studies done in the United States, Europe, Middle East, India, Australia, and Asia which suggest that upwards of 30-50% of children and adults are at risk of vitamin D deficiency.[25] Data on the prevalence of hypovitaminosis D among adolescents are scarce and a comparison of serum vitamin D data with other studies may not be entirely appropriate as different studies were conducted at different latitudes, different seasons and different population group. Nevertheless, prevalence this high was not expected to occur in our subjects given that the study was conducted immediately after the students' summer vacation, wherein children were expected to have had abundant sunlight exposure and outdoor activities.

The high prevalence of hypovitaminosis D among high school students may be attributed to several factors. This study found poor vitamin D intake as significantly correlated with prevalent hypovitaminosis D which maybe because generally, only few foods are naturally good sources of vitamin D and foods as well as milk products are usually not fortified with vitamin D in the Philippines because like other Asian and European countries, there are no governmental regulations mandating vitamin D fortification of food products in the country. Vitamin D-rich foods such as salmon, mackerel, herring, cod liver oil and sun dried mushrooms do not belong to the regular staple food of Filipinos and most of the vitamin D-rich fatty fishes except for sardines are not that affordable to most of the population. In our study, we observed that majority of the high school students eat less than 50% of the required caloric requirement for age. This can be partially attributed to the psychological consequence of adolescent/pubertal stage wherein as adolescents pay close attention to their appearance and body image they tend to develop unhealthy behavior for weight control thus resorting to dieting. Lesser intake would lead to lesser vitamin D intake.

Having higher socioeconomic status is another factor found to be significantly correlated with VDD/VDI. This conforms with the study done in South India wherein high prevalence of hypovitaminosis D is found in population with upper socioeconomic status[30] and in contrast with the study in Northern India among adolescent schoolchildren which showed otherwise.[31] Another study in Brazilian children did not find any significant difference in mean vitamin D level between the 2 groups.[32] This could be due to the adolescents' lifestyle changes and poor overall intake, as majority of those in the USES group eat less with lower protein and vitamin D intake than those in the LSES group. Another reason could be inadequate sun exposure as the USES group's sun exposure usually occur before their classes start at 7:30 AM or after their classes at 5 PM. According to studies by Holick and Webb, the angle at which the sun reaches the earth has a dramatic effect on the number of ultraviolet B (UVB) photons that reach the earth's surface. This is why when the zenith angle is increased in the early morning and late afternoon, little if any vitamin D3 synthesis occurs.[33-34] This may partially explain the decreased 25(OH)D levels despite enough duration of sunlight exposure.

This study found BMI z-score outside the normal range of 0 to <1SD as significantly correlated with VDD/VDI. These are the overweight, obese, wasted and severely wasted. Studies have demonstrated inverse associations between body fat and circulating serum 25(OH)D levels, given that vitamin D, being fat soluble, is stored in the body fat, making it more difficult to be bioavailable, leading to deficient state. There are also studies which show reverse-causation- that inadequate vitamin D status could be a risk factor for childhood obesity due to vitamin D's effects on lipolysis and adipogenesis in human adipocytes through its role in regulating intracellular calcium concentrations.[35-36] This raises the possibility that vitamin D could influence body weight and energy expenditure through calcium regulation. However, result of obesity per se as a predictor did not show significant correlation in this study probably due to small number in the obese group. On the other hand, studies in India found VDD significantly associated with wasting.[37-38] The etiology of wasting is complex and includes the increased secretion of pro-inflammatory cytokines such as tumor necrosis factor-α (TNF-α), interferon-gamma (INF-γ), and interleukins (IL) 1 and 6. Both TNF-α and INF-γ are known to inhibit myosin expression in muscle cells and TNF-α also induces anorexia. A potential explanation of the observed association between vitamin D and wasting may be the known anti-inflammatory role of vitamin D that includes decreasing the levels of TNF- α.[39]

Environmental factors such as air pollution may also have a contributory role in the low vitamin D status of the students. Existing studies have generally shown lower vitamin D reserves among urban population.[23,40-41] All of the participants in this study reside in big cities, 94% being in Metro Manila with 85% living in Quezon City area. A study in Bangkok Thailand (13°45'N) which has almost the same latitude as Quezon City, (14°38'N) found an association between lower vitamin D status and living in the urban where air pollution is high.[23] Quezon City is one of the most polluted areas in the Philippines due to its large population and rapid urbanization. Based on the latest Department of Environment and Natural Resources (DENR)-Environmental Management Bureau (EMB) data, the total suspended particulates (TSP),which is the standard measurement of pollution in Metro Manila is 117 Ug/Ncm, which is above the healthful Philippine standard of 90 Ug/Ncm. Tropospheric ozone is a common urban air pollutant and an efficient absorber of UV radiation.[42] and would therefore interfere with the penetration of UVB radiation into the skin which will affect the cutaneous synthesis of vitamin D leading to inadequate vitamin D levels.

Other factors that could lead to decreased vitamin D synthesis thus hypovitaminosis D are lack of adequate sun exposure, skin pigmentation, sunscreen use and clothing style. Ultraviolet radiation (UVR) exposure to the skin is measured as the minimum erythema dose (MED) or the amount of UVR exposure that will cause minimal skin erythema. The amount of UVR exposure that is equivalent to 1 MED depends on skin pigmentation and duration of exposure. Exposure of 40% of the body to ¼ MED will result in generation of ~1000 IU of vit D per day, the minimum amount of vitamin D synthesis necessary to maintain concentrations in the reference range.[43] In our study, clothing style of the students expose just 25%-30% of the body to the sun, which is estimated to result in release of approximately 625-750 IU of vitamin D which is inadequate to maintain vitamin D concentrations at normal range. Another factor is skin pigmentation which is one of the reasons for VDD in Delhi despite abundant sunlight.[44] More UV-B is necessary to produce MED in darker-skinned people; therefore they require a longer duration (5-10x) of sun exposure than light-skinned people for a similar response.[15,45] Holick et al. have also shown that the time to maximum previtamin D formation is 15-30 minutes in type III skin, during exposure to equatorial amounts of UV energy. In our study, we observed that 85.6% of the students have type IV-VI skin type but only 19.6% have more than 30 minutes of sun exposure, which is inadequate for optimal vitamin D synthesis. In relation to this, increased time spent indoors at home or in school may lead to less sun exposure thus decrease vitamin D synthesis, even in light-skinned individuals as shade reduces the amount of solar radiation by 60%, and windowpane glass blocks UVR.[42] Added to this is the use of sunscreen. Sunscreen absorbs UV-B and some UV-A light and prevents it from penetrating the skin. A sunscreen with a sun protection factor (SPF) of 8 can decrease vitamin D_3 synthetic capacity by 95% and SPF 15 can decrease it by 98%.[46] Nonetheless, in our study, the association of the duration of sun exposure, sunscreen use, clothing style, and skin color with 25-(OH)D levels did not reach statistical significance. This is in agreement with previous studies done wherein no relationship was found between 25 (OH)D concentrations and skin color, sunscreen use, duration of sun exposure and kind of clothing.[47-49]

The association between hypovitaminosis D and poor vitamin D intake, BMI outside the normal range and upper socioeconomic status suggests that attention should be paid to optimize the adolescents' vitamin D intake. Given the dietary practices of many adolescents especially those belonging to the USES, a dietary intake of 400 IU of vitamin D is difficult to achieve therefore, vitamin D stores would depend on sunlight exposure and vitamin D fortification of food or vitamin D supplementation. In view of current guidelines of many pediatric organizations including the AAP of decreasing sunlight exposure due to the risks of various skin cancer, in addition to the concern of photo-aging, higher sunlight exposure may be resisted in this population. The timing of optimal sun exposure (between 10 AM and 3PM) would also pose a problem to school-going adolescents because it is during these times that classes are held. Nonetheless, awareness needs to be generated about the benefits derived from direct sunlight exposure. Nutritional education should be encouraged in schools focusing on the importance of increased intake of vitamin D-rich foods. The help of nutritionists and health professionals who can advise students on how to increase dietary intake of vitamin D-rich foods may be sought. Because of the lower dietary intake in this age group there may also be a public health need to fortify Filipino foods with vitamin D, however this would entail a huge cost. A daily multivitamin with vitamin D content or vitamin-D only preparation would also be necessary since it is easy and inexpensive.

We acknowledge some limitations in this study. First, the study is cross-sectional, and therefore, causality cannot be inferred. Only a longitudinal study will be able to give greater validity to correlations observed in this study. Second, the many randomly chosen subjects who refused to participate may lead to non-response bias which may have an effect on representativeness of the sample and results, though it may have affected the results only marginally. Third, the limited number of subjects may have resulted in low variability in the different variables studied. However, this research will serve as a baseline for future studies on Vitamin D in Filipino adolescents. Lastly, as the original objective of the study is to determine the vitamin D status of adolescents, bone turnover markers were not measured due to high cost. These should be included in future studies to determine changes of bone metabolism and its relation with vitamin D. Because of the various consequences of VDD, long term skeletal and other consequences of these findings deserve further study.

CONCLUSION

This study has shown that hypovitaminosis D is highly prevalent among apparently healthy Filipino high school students despite the abundance of sunlight. Cases may be missed due to lack of symptoms. Poor vitamin D intake, BMI scores outside the normal range of 0 to <1SD and high socioeconomic status emerged as significant predictors of vitamin D deficiency/insufficiency. Gender, skin color, duration of sun exposure, clothing style, sunscreen use, waist measurement/WHR, obesity,and intake of milk and fish were not found to be significantly associated with serum 25(OH)D levels.

It is recommended that interventional studies to evaluate the role of nutrition in improving vitamin D status be done in future studies. Additional studies are also needed to evaluate what the optimal dose of vitamin D supplement should be to achieve the optimal vitamin D status for adolescents.

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