HK J Paediatr (new series) 2015;**20**:3-9

Original Articles

25-hydroxy Vitamin D Status in Healthy Korean School Children and Adolescents: Striking Difference in Prevalence of Vitamin D Deficiency with School Grade and Season

MS ***Kim***, YH ***Kong***, DY ***Lee***

Abstract ***Purpose:*** The aim of this study was to investigate the prevalence of vitamin D deficiency according to school grade and season in healthy Korean children and adolescents. ***Method:*** We screened for vitamin D deficiency using serum 25-hydroxyvitamin D (25-OHD) combined with anthropometric and laboratory findings. ***Findings:*** Vitamin D deficiency was present in 72.3% of study subjects and prevalence of vitamin D deficiency was higher in girls than in boys (76.6 vs 66.9%). During spring and winter, serum 25-OHD levels were found to be lower compared with other seasons. The prevalence of vitamin D deficiency was highest (87.4%) in high school students and followed by middle school (78.8%) and elementary school students (70.5%). The predictors for vitamin D deficiency were female, winter/spring seasons and high school students. ***Conclusion:*** Adequate outdoor activities and/or oral vitamin D supplements during winter and spring seasons should be necessary in female adolescents.

Key words Adolescents; Korean children; School grade; Season; Vitamin D deficiency

Introduction

Vitamin D is an important fat-soluble vitamin that functions as a pro-hormone and affects bone mineralisation and calcium homeostasis. In addition, vitamin D deficiency has recently been proposed as a risk factor for common chronic diseases, such as cancer, cardiovascular disease, autoimmune diseases, and allergy.[1-4] Recent studies suggest that vitamin D deficiency is important in children and adolescents, not just in older people.[5-7] The majority of the body's vitamin D requirement must be covered by sunlight UVB-induced conversion of 7-dehydrocholesterol to vitamin D_3 in skin.[8] However, this route of supply is limited by the reduced exposure to sunlight due to indoor living, clothing, and the use of sunscreen, as well as by the geographical and seasonal variation in UVB irradiance. Many studies have reported low levels of 25-hydroxy vitamin D (25-OHD) in different paediatric and adolescent population.[5-7,9-11] Recently, Shin et al[12] reported the high prevalence of vitamin D deficiency in Korean young adults. However, comprehensive data are not available in Korean school children and adolescents considering school grade including elementary school and season.

The aim of this study was to investigate the vitamin D status and the prevalence of vitamin D deficiency according to school grade and season in healthy Korean school children and adolescents.

Department of Pediatrics, Chonbuk National University Medical School, Jeonju 561-712, Korea

MS Kim (金旻宣) *MD*
YH Kong (孔晉和) *MD*
DY Lee (李大烈) *MD*

Department of Pediatrics, Research Institute of Clinical Medicine of Chonbuk National University-Biomedical Institute of Chonbuk National University Hospital, Jeonju 561-712, Korea

MS Kim (金旻宣) *MD*
DY Lee (李大烈) *MD*

Correspondence to: Dr DY Lee

Received March 5, 2014

Materials and Methods

Subjects

A total of 817 healthy Korean students aged 7 to 18 years old were enrolled in this study between March 2011 and February 2012. All subjects visited a Pediatric Department Outpatient Clinic, Jeonbuk National University Hospital for health evaluation. Students were excluded if they had acute or chronic illness, including obesity (body mass index, BMI above 95th percentile), precocious puberty, endocrine disorders or any rickets-like signs and symptoms or took any form of calcium or vitamin D supplements. To determine differences based on the clinical characteristics and 25-OHD level, the subjects were subdivided according to gender (boys, n=320; girls, n=497), school grade (elementary school aged 7 to 12 years, n=659; middle school aged 13 to 15 years, n=94; high school aged 16 to 18 years, n=64) and season (spring, March to May, n=267; summer, June to August, n=217; fall, September to November, n=139; winter, December to February, n=194). The clinical and laboratory characteristics of the subjects were obtained by reviewing the medical records.

The study was approved by the Institutional Review Board of the Clinical Research Institute of Jeonbuk National University Hospital, and informed consent was obtained from students and their parents.

Anthropometric and Laboratory Measurements

Anthropometric measurements were performed by the same physician according to a standardised procedure. Body weights were measured to the nearest 0.01 kg using calibrated balances or electronic scales, and heights were measured to the nearest 0.1 cm. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of height in meters. Blood samples were taken in the morning after 12 hours of fasting, and following laboratory data were included: plasma glucose, serum calcium, phosphorus, alkaline phosphatase, triglycerides, total cholesterol and low-density lipoprotein (LDL) cholesterol. Serum 25-OHD levels were measured by a chemiluminescence immunoassay (Roche, Indianapolis, IN, USA).

Definition of Vitamin D Deficiency

Serum 25-OHD levels were categorised as adequate, insufficient, or deficient based on the literature.[13] Vitamin D deficiency was defined as <20 ng/mL, severe deficiency as <10 ng/mL, insufficiency as 20-<30 ng/mL, and sufficiency as ≥30 ng/mL.

Statistical Analyses

All variables are expressed as the means ± standard deviation (SD). All analyses were conducted using the SPSS 17.0 (SPSS Inc., Chicago, IL, USA). Differences in clinical and biochemical parameters between groups were assessed by Student *t*-test and one-way ANOVA. Chi-square test was used to compare frequencies of vitamin D deficiency status. Pearson's correlation analysis was performed to demonstrate the relationship between students' vitamin D level and other parameters. And in order to identify independent risk factors of vitamin D deficiency, we used a logistic multivariate regression model.

Results

Clinical Characteristics and Serum 25-OHD Levels in Studied Subjects

The clinical characteristics and serum 25-OHD levels of subjects are shown in Table 1. The mean age and BMI was 10.2±2.7 years and 18.4±4.2 kg per m^2, respectively. Mean serum 25-OHD level was 16.78±6.09 ng/mL, which was significantly higher in boys than in girls (17.75±6.54 vs 16.12±5.71 ng/mL, p<0.005). The whole prevalence of vitamin D deficiency was 72.3%, and the prevalence of

Table 1 Clinical and laboratory characteristics of 817 healthy school children and adolescents

	Total (n=817, 100.0%)	Boys (n=320, 39.2%)	Girls (n=497, 60.8%)	P value
Age (years)	10.2±2.7	11.4±2.8	9.4±2.3	0.000
BMI (kg/m^2)	18.4±4.2	19.0±4.1	18.1±4.2	0.008
Schcool grade (%)				0.000
Elementary school	659 (80.7)	215 (32.6)	444 (67.4)	
Middle school	94 (11.5)	66 (70.2)	28 (29.8)	
High school	64 (7.8)	39 (60.9)	25 (39.1)	
Season (%)				0.082
Spring	267 (32.7)	86 (32.2)	181 (67.8)	
Summer	217 (26.6)	95 (43.8)	122 (56.2)	
Fall	139 (17.0)	62 (44.6)	77 (55.4)	
Winter	194 (23.7)	77 (39.7)	117 (60.3)	
25-OHD (ng/mL)	16.78±6.09	17.78±6.54	16.12±5.71	0.000
<20 ng/mL (%)	591 (72.3)	211 (65.9)	380 (76.6)	0.001

Data are means ± SDs or number of students.
BMI: body mass index; ALP: alkaline phosphatase; LDL-cholesterol, low-density lipoprotein cholesterol; 25-OHD: 25-hydroxy vitamin D.

vitamin D deficiency was higher in girls than in boys (76.6% vs 66.9%, p<0.001). In contrast, only 2.2% of students (boys, 3.8%; girls, 1.1%) had a serum 25-OHD level of greater than 30 ng/mL (Table 2).

Differences in Serum 25-OHD Level by Season

Mean serum 25-OHD level was significantly different according to month and season (Figure 1). From March to August, serum 25-OHD level gradually increased, reaching its highest level in August (22.4±6.3 ng/mL), then decreased, reaching its lowest level in February (11.9±4.2 ng/mL, Figure 1a). Even though there was a difference only in age between different seasons, serum 25-OHD levels in summer and fall were significantly higher than those in spring and winter (20.4±5.8, 19.1±6.1 vs 15.5±5.2, 12.9±4.4 ng/mL, p<0.001, Figure 1b). As expected, the prevalence of vitamin D deficiency in winter and spring were significantly higher than those of summer or fall (93.8, 80.9 vs 53.9, 54.7%, p<0.005, Figure 2 & Table 2). Furthermore, prevalence of severe vitamin D deficiency was significantly higher in winter and spring than those of summer and fall (15.0, 26.3 vs 1.8, 5.8%, p<0.005).

Differences in Serum 25-OHD Level by School Grade

The mean serum 25-OHD level was gradually decreased from elementary school to high school (17.1±6.0 vs 13.8±6.2 ng/mL, p<0.005, Figure 3). There was a significant difference in the prevalence of vitamin D deficiency among students of different school grade (p<0.001, Table 2 & Figure 4a). As shown in Figure 4a and Table 2, prevalence

Table 2 Clinical and laboratory characteristics according to serum 25-OHD levels

25-OHD (ng/mL)	<10	10 to <20	20 to <30	≥30	P value
Number of patient (%)	103 (12.6)	488 (59.7)	208 (25.5)	18 (2.2)	
25-OHD (ng/mL)	8.2±1.4	15.0±2.8	23.8±2.7	33.9±3.9	0.000
Age (years)	11.2±3.1*	10.2±3.6†	9.6±2.4†	10.1±2.7†	0.000
BMI (kg/m²)	18.8±6.9	18.5±3.9	18.2±2.9	18.7±2.9	0.663
ALP (IU/L)	245.8±105.5	266.2±86.3	257.1±77.3	244.5±93.3	0.127
Calcium (mg/dL)	9.8±0.4	10.1±4.2	9.9±0.4	9.7±0.6	0.754
Phosphorus (mg/dL)	4.8±0.7	5.1±3.9	5.0±0.5	4.9±0.5	0.805
Cholesterol (mg/dL)	163.6±28.1	163.6±27.3	160.2±25.4	152.±29.5	0.238
Triglyceride (mg/dL)	97.4±64.2	92.0±56.8	88.9±53.0	75.8±28.9	0.465
LDL-cholesterol (mg/dL)	92.6±21.9	91.4±25.1	92.3±26.1	76.7±3.5	0.749
Gender					0.000
Boys	33 (10.3)	178 (56.6)	97 (30.3)	12 (3.8)	
Girls	70 (14.1)	310 (62.5)	111 (22.3)	6 (1.1)	
Ratio	0.47	0.57	0.87	2.0	
Season					0.001
Spring (%)	40 (15.0)	176 (65.9)	51 (19.1)	0 (0.0)	
Summer (%)	4 (1.8)	113 (52.1)	88 (40.6)	12 (5.5)	
Fall (%)	8 (5.8)	68 (48.9)	58 (41.7)	5 (3.6)	
Winter (%)	51 (26.3)	131 (67.5)	11 (5.7)	1 (0.5)	
School grade					0.000
Elementary (%)	72 (10.9)	392 (59.6)	180 (27.3)	15 (2.2)	
Middle (%)	18 (19.2)	56 (59.6)	18 (19.1)	2 (2.1)	
High (%)	17 (26.5)	39 (60.9)	7 (10.9)	1 (1.6)	

Data are means ± SDs or number of students.

*, †Statistical significances were tested by one way analysis of variances among groups. The same markers indicate non-significant difference among groups based on Duncan multiple comparison test.

BMI: body mass index; ALP: alkaline phosphatase; LDL-cholesterol: low-density lipoprotein cholesterol; HDL-cholesterol: high-density lipoprotein cholesterol; 25-OHD: 25-hydroxy vitamin D.

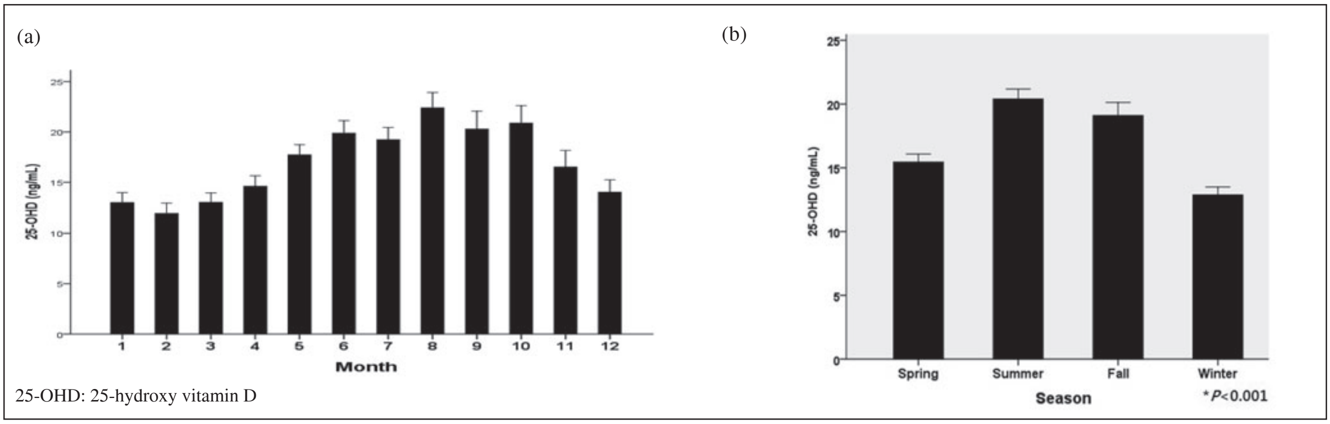

Figure 1 The changes of serum 25-OHD levels according to (a) month (January-December) and (b) season (spring-winter). Bars mean the 95th confidence intervals. Statistical significances were tested by one-way analysis.

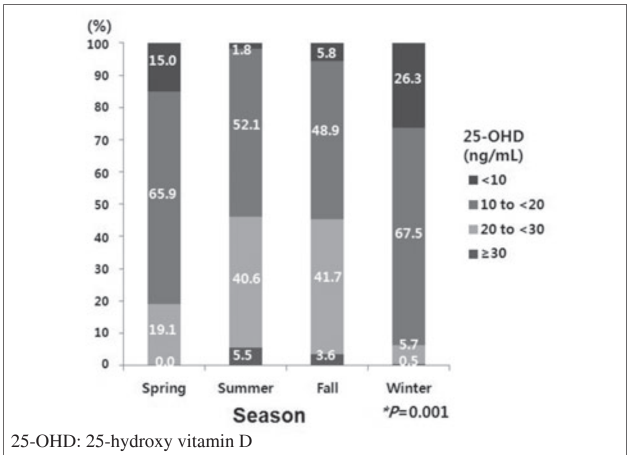

Figure 2 Prevalence of serum 25-OHD levels >10, 10 to <20, 20 to <30 and ≥30 ng/mL according to season. P=0.001 was calculated by chi-squared test.

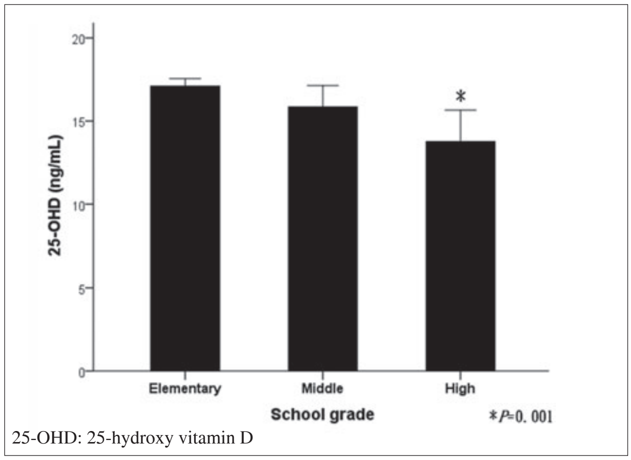

Figure 3 The serum 25-OHD levels in elementary, middle and high school students. Bars mean the 95th confidence intervals. Statistical significances were tested by one-way analysis.

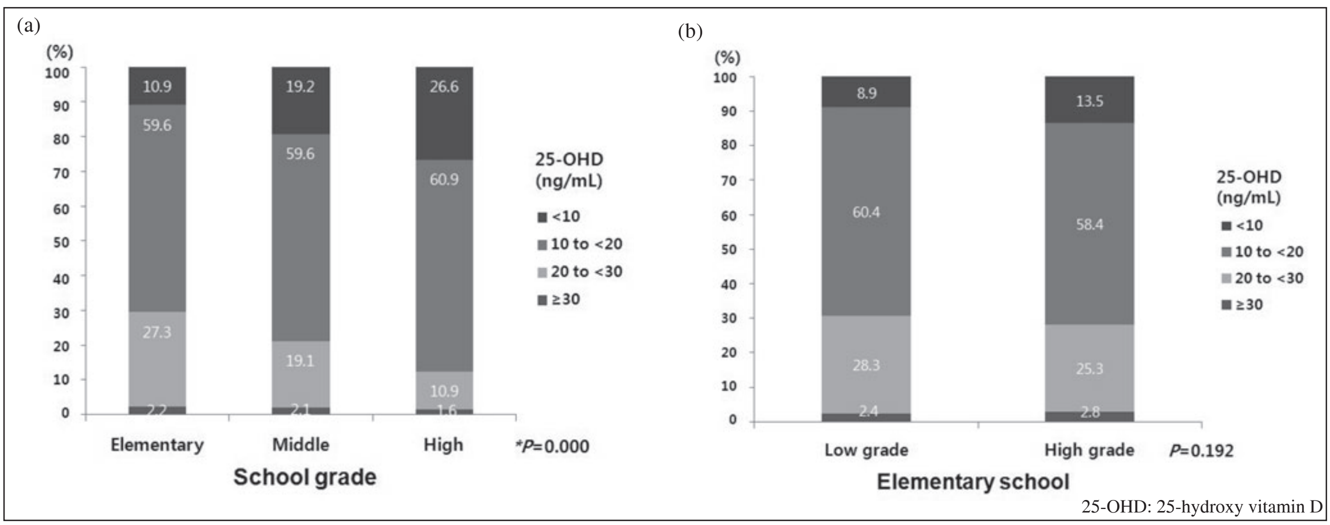

Figure 4 Prevalence of serum 25-OHD levels >10, 10 to <20, 20 to <30 and ≥30 ng/mL according to (a) school grade, and (b) low grade (7 to 9 years) and high grade (10 to 12 years) elementary school students. P values were calculated by chi-squared test.

of vitamin D deficiency was found to be highest in high school students (87.4%), then, followed by middle school students (78.7%) and elementary school students (70.5%). Furthermore, prevalence of severe vitamin D deficiency was significantly higher in middle and high school students than those of elementary school (19.2, 26.5 vs 10.9%, p<0.001). However, there was no difference in prevalence of vitamin D deficiency between the low grade (7 to 9 years) and high grade (10 to 12 years) elementary school students (69.3 vs 71.9%, p>0.05, Figure 4b).

Clinical Characteristics According to 25-OHD Status and Risk Factors for Vitamin D Deficiency

Anthropometric and laboratory results of subject groups assigned as severe deficient, deficient, insufficient, and adequate vitamin D level were shown in Table 2. No significant difference was found between these four groups in terms of BMI, serum alkaline phosphatase, calcium, phosphorus and cholesterols. Whereas mean age, gender, school grade and season were significantly different in severe vitamin D deficient group compared with those of vitamin D insufficient or adequate group (p<0.005, Table 2). Pearson's correlation results are listed in Table 3. Serum 25-OHD level was only significantly inversely correlated with only age. In multivariate logistic regression analysis, predictors for vitamin D deficiency were female (odds ratio [OR]; 1.678), winter/spring seasons (OR; 12.963/3.620) and high school students (OR; 2.644, Table 4).

Discussion

It is clear that low vitamin D levels in children and adults are sufficiently common to be considered a significant public health issue in many parts of the world.[13] Variations in prevalence of vitamin D deficiency across different countries are explained by factors including latitude, skin color, clothing, and diet. Korean adolescents theoretically are at increased risk for vitamin D deficiency because of the high latitude (34-38°N), increased use of sunscreen, reduced outdoor activity and lack of vitamin D-fortified foods.

In this cross-sectional study, we found that vitamin D deficiency and insufficiency are common in healthy school children and adolescents. About 72.3% exhibited a serum 25-OHD level less than that considered to represent deficiency (<20 ng/mL), 25.5% showing levels considered insufficient (20-<30 ng/mL) and with only 2.2% showing levels of sufficiency (≥30 ng/mL). These findings are in line with previous studies, which showed high prevalence of vitamin D deficiency in young adults.[5-7] Recently, a population-based survey performed by Kim et al[14] in Korea reported that 68.1% of participants aged 10 to 18 years had serum 25-OHD levels <20 ng/mL. Our study also demonstrated that girls had a higher prevalence of vitamin D deficiency than boys. Some studies have supported a higher prevalence of vitamin D deficiency in girls than

Table 3 Correlation between 25-OHD levels and clinical and laboratory parameters

	P	γ
Age	0.000	-0.155
BMI	0.120	-0.057
ALP	0.880	-0.005
Cholesterol	0.052	-0.072
Triglyceride	0.051	-0.086
LDL-cholesterol	0.570	-0.030
Calcium	0.738	-0.012
Phosphorus	0.613	-0.018

Coefficients(γ) and p value were calculated using Pearson's correlation analysis.
BMI: body mass index; ALP: alkaline phosphatase; TG: triacylglyceride; LDL-cholesterol: low-density lipoprotein cholesterol; 25-OHD: 25-hydroxy vitamin D.

Table 4 Factors independently associated with deficiency of serum 25-OHD levels

	OR	95% CI	P value
Sex			
Male	–	–	–
Female	1.678	1.230, 2.289	0.001
Season*			
Spring	3.620	2.413, 5.430	0.000
Summer	–	–	–
Fall	1.031	0.672, 1.5810	0.913
Winter	12.963	6.820, 24.639	0.000
School grade†			
Elementary	–	–	–
Middle	1.545	0.918, 2.601	0.061
High	2.644	1.101, 6.354	0.015

*Seasons were grouped as spring (March to May), summer (June to August), fall (September to November) and winter (December to February).
†All students were divided as elementary school (7-12 years old), middle school (13-15 years old) and high school (16-18 years old) according to age.
25-OHD: 25-hydroxy vitamin D; OR: odds ratio; CI: confidence interval.

boys,[15,16] while other studies have not found any gender differences.[11,17] It may be due to less physical activity and low dietary calcium and vitamin D intake in girls.[14,18]

Previous studies have demonstrated that aging, obesity, and winter season were associated with lower serum 25-OHD levels.[19-21] In the present study, serum 25-OHD levels showed strong seasonal variation with the lowest serum 25-OHD levels in winter and spring. This result was similar to that reported previously for population of temperate regions including Korea.[9,21-23] Seasonal variation of serum 25-OHD is caused by the strong dependence on the exposure to sunlight. Brot et al[24] reported that seasonal fluctuation is associated with duration and frequency of sun exposure. With regard to 25-OHD_3 half-life of 2 months, the highest annual vitamin D levels in northern hemisphere are expected in August/September and the lowest in February/March.[25] In the present study, we observed maximum serum 25-OHD levels in August and minimum levels in February. Therefore, spring and winter season is one of the most potent predictor of low vitamin D status in temperate regions including Korea. It needs to be appreciated that unprotected sun exposure is the major source of vitamin D for both children and adults, and in the absence of sun exposure it is difficult to obtain an adequate amount of vitamin D from dietary sources without supplementation to satisfy the body's requirement.

The higher prevalence of vitamin D insufficiency in younger age groups was noted in the National Diet and Nutrition Survey (NDNS) 1992-2001 of the United Kingdom and NHANES 2001-2004 of the United States.[6,25] The study by Choi et al[9] based on the Fourth Korea National Health and Nutritional Examination Surveys (KNHANES IV) conducted in 2008 found that about 60% of study subjects aged 10 to 19 years had a serum 25-OHD level of less than 20 ng/mL. In the present study, prevalence of vitamin D deficiency in students increased from elementary school students, reaching the highest in high school students (70.5% vs 87.4%). However, there was no difference in the prevalence of vitamin D deficiency between low grade aged 7-9 years and high grade aged 10-12 years elementary school students. These results suggest that the different prevalence of vitamin D deficiency in students were not just related to age, but rather related to school grade. The main factor that explains the association between school grade and/or age and vitamin D status seems not to be related to the duration of outdoor activities, which presumably reflects each subject's amount of sunlight exposure.[6] It has been assumed that school children and adolescents, especially Korean middle and high school students spend much of the daytime indoor for study and the proportion of physical exercise in the curriculum is reduced compared to the past.[6,26] Moreover, most physical training programs for middle and high school students are carried out in a gymnasium. Even if we did not obtain information on each subject's amount of sunlight exposure, we speculate that this pattern of school life is most likely to have affected serum 25-OHD levels in our students. Therefore, we suggest that the changes of curriculum in middle and high school should be considered to increase sunlight exposure at school.

Several studies have suggested that the recommended dietary allowances of the Institute of Medicine may be inadequate, especially for patients who have underlying conditions or are receiving medications that put them at risk for vitamin D deficiency.[27,28] The Endocrine Practice Guidelines Committee required at least 600 IU of vitamin D for children aged 1-18 years.[29] The Korean Nutritional Society recommended a daily intake of 200 IU vitamin D for young Korean adults.[30] Based on our results, however, we suggest that school children and adolescents are now at greater risk for vitamin D deficiency, and may need vitamin D supplementation as much as or even more dosage than that for elderly.

There are some limitations in this study: 1) the proportions of middle and high school students were too small compared with elementary school; 2) we did not obtain data regarding individual's vitamin D intake through diet, which might have affected the individual's vitamin D status, and duration of outdoor activities, which reflect the amount of sunlight exposure; 3) This study was a single-center observational and cross-sectional study, with different subjects studied in different seasons.

In conclusion, vitamin D deficiency was a common problem in healthy Korean school children and adolescents and the prevalence of vitamin D deficiency was very high in middle and high school adolescent during winter and spring seasons. As our results suggest, middle and high school students are at greater risk of vitamin D deficiency, especially in spring and winter seasons. Based on these results, we suggest that curriculum in school, especially middle and high school should be changed for encouraging outdoor activity to exposure of sunlight.

Acknowledgment

This paper was supported by research funds of Chonbuk National University in 2012.

Declaration of Interest

We declare that we have no conflict of interests.

References

1. Chang ET, Smedby KE, Hjalgrim H, et al. Family history of hematopoietic malignancy and risk of lymphoma. J Natl Cancer Inst 2005;97:1466-74.
2. Wang TJ, Pencina MJ, Booth SL, et al. Vitamin D deficiency and risk of cardiovascular disease. Circulation 2008;117:503-11.
3. Arnson Y, Amital H, Shoenfeld Y. Vitamin D and autoimmunity: new aetiological and therapeutic considerations. Ann Rheum Dis 2007;66:1137-42.
4. Freishtat RJ, Iqbal SF, Pillai DK, et al. High prevalence of vitamin D deficiency among inner-city African American youth with asthma in Washington, DC. J Pediatr 2010;156:948-52.
5. Absoud M, Cummins C, Lim MJ, Wassmer E, Shaw N. Prevalence and predictors of vitamin D insufficiency inn children: a Great Britain population based study. PLoS One 2011;6:e22179.
6. Ginde AA, Liu MC, Camargo CA Jr. Demographic differences and trends of vitamin D insufficiency in the US population, 1988-2004. Arch Intern Med 2009;169:626-32.
7. Gordon CM, DePeter KC, Feldman HA, Grace E, Emans SJ. Prevalence of vitamin D deficiency among healthy adolescents. Arch Pediatr Adolesc Med 2004;158:531-7.
8. Holick MF. Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease. Am J Clin Nutr 2004;80(6 suppl):1678S-88S.
9. Choi HS, Oh HJ, Choi H, et al. Vitamin D insufficiency in Korea – a greater threat to younger generation: the Korea National Health and Nutritional Examination Survey (KNHANES) 2008. J Clin Endocrinol Metab 2011;96:643-51.
10. Nesby-O'Dell S, Scanlon KS, Cogswell ME, et al. Hypovitaminosis D prevalence and determinants among African American and white women of reproductive age: Third National Health and Nutrition Examination Survey, 1988-1994. Am J Clin Nutr 2002;76:187-92.
11. Marwaha RK, Tandon N, Reddy DR, et al. Vitamin D and bone mineral density status of healthy school children in northern India. Am J Clin Nutr 2005;82:477-82.
12. Shin YH, Kim KE, Lee C, et al. High prevalence of vitamin D insufficiency or deficiency in young adolescents in Korea. Eur J Pediatr 2012;171:1475-80.
13. Holick MF, Chen TC. Vitamin D deficiency: a worldwide problem with health consequences. Am J Clin Nutr 2008;87:1080S-6S.
14. 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;17:122-30.
15. Kumar J, Muntner P, Kaskel FJ, Hailpern SM, Melamed ML. Prevalence and associations of 25-hydroxyvitamin D deficiency: NHANES 2001-2004. Pediatrics 2005;124:362-70.
16. El-Hajj Fuleihan G, Nabulsi M, Choucair M, et al. Hypovitaminosis D in healthy schoolchildren. Pediatrics 2001;107:E53.
17. Weng FL, Shults J, Leonard MB, Stallings VA, Zemel BS. Risk factors for low serum 25-hydroxyvitamin D concentrations in other-wise healthy children and adolescents. Am J Clin Nutr 2007;86:150-8.
18. Moore C, Murphy MM, Keast DR, Holick MF. Vitamin D intake in the United States. J Am Diet Assoc 2004;104:980-3.
19. Holick MF. Vitamin D status: measurement, interpretation and clinical application. Am Epidemiol 2009;19:73-8.
20. DeLuca HF. Overview of general physiologic features and function of vitamin D. Am J Clin Nutr 2004;87:1689S-96S.
21. Webb AR, Pilbeam C, Hanafin N, Holick MF. An evaluation of the relative contribution of 25-hydroxyvitamin D in an elderly nursing home population in Boston. Am J Clin Nutr 1990;51:1075-81.
22. Rockell JE, Green TJ, Skeaff CM, et al. Season and ethnicity are determinants of serum 25-hydroxyvitamin D concentrations in New Zealand children aged 5-14 y. J Nutr 2005;135:2602-8.
23. Prentice A. Vitamin D deficiency: global perspective. Nutr Rev 2008;66:S153-64.
24. Brot C, Vestergaard P, Kolthoff N, Gram J, Hermann AP, Sørensen OH. Vitamin D status and its adequacy in healthy Danish perimenopausal women: relationships to dietary intake, sun exposure and serum parathyroid hormone. Br J Nutr 2001;86:S97-103.
25. Vieth R. The Pharmacology of Vitamin D, including fortification strategies.In: Feldman D, Pike JW, Glorieux FH, eds. Vitamin D. 2nd ed. Elsevier Academic Press; 2005.
26. Lee M, Larson R. The Korean "examination hell": long hours of studying, distress, and depression. J Youth Adolescence 2000;29:249-71.
27. Yetley EA, Brulé D, Cheney MC, et al. Dietary reference intakes for vitamin D:justification for a review of the 1997 value. Am J Clin Nutr 2009;89:719-27.
28. Bischoff-Ferrari HA, Giovannucci E, Willett WC, Dietrich T, Dawson-Hughes B. Estimation of optimal serum concentration of 25-hydroxyvitamin D for multiple health outcomes. Am J Clin Nutr 2006;84:18-28.
29. Holick MF, Binkley NC, Bischoff-Ferrari HA, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society Clinical Practice Guideline. J Clin Endocrinol Metab 2011;6:1911-30.
30. Paik HY. Dietary reference intake for Koreans (KDRIs). Asia Pac J Clin Nutr 2008;17(Suppl 2):416-9.