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Factors Associated with Vitamin D Status Among Korean Female Adolescents☆

Ji-Soo Kim, Ph D, RN

College of Nursing, Gachon University, Incheon, Republic of Korea

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ABSTRACT

Purpose: The prevalence of vitamin D deficiency among female adolescents in South Korea is the highest in East Asia. Therefore, this study aims to identify factors associated with vitamin D status among female adolescents in South Korea.

Design and Methods: This cross-sectional descriptive study was conducted using a data set from the fifth Korean National Health and Nutrition Examination Survey (2010—2012). Participants comprised 734 female adolescents aged 12–18 years. A general linear model using a complex samples design was employed.

Results: The mean vitamin D level of the participants was 14.90 ng/mL. Among these participants, 87.6% had a vitamin D deficiency. As their age increased by one year, their vitamin D level decreased by 0.47 ng/mL. Female adolescents with a low household income had vitamin D levels lower by 1.88 ng/mL than those with a high household income. Vitamin D levels in female adolescents who skipped lunch was lower by 3.41 ng/mL than those who had lunch.

Conclusion: The prevalence of vitamin D deficiency among female adolescents in South Korea is considerable. The findings suggest that age, socioeconomic status, and skipping a meal were associated with vitamin D status in female adolescents, but physical activity was not.

Practice Implications.

As the findings of this study indicate, older female adolescents and those from lower household incomes may be at higher risk for lower levels of Vitamin D. Counseling female adolescents as to dietary measures to avoid vitamin D deficiency is advised. Preventive health for at risk female adolescents includes provision of health education and counseling.

Introduction

Vitamin D is important for the absorption of calcium, one of the primary components of bones, and therefore affects bone growth and maintenance. In addition, evidence has shown that vitamin D deficiency increases the risk of immune disease, cardiovascular disease, and diabetes mellitus among adolescents (Bozzetto, Carraro, Giordano, Boner, & Baraldi, 2012; Gul et al., 2017). The optimal level of vitamin D reported in the literature is not consistent; however, a serum concentration < 20 ng/mL of 25-hydroxyvitamin D (25 [OH] D) is currently defined as vitamin D deficiency based on the recommendation of the Institute of Medicine (IOM; Institute of Medicine Food and Nutrition Board, 2011; Manios et al., 2018; Kim, Hwang, & Song, 2018).

Given the impact of vitamin D on metabolism and health, it is essential for adolescents in a transitional stage of physical development (Smith, Lanham-New, & Hart, 2017). Nevertheless, previous studies have reported that many adolescents are deficient in vitamin D. According to González-Gross et al. (2012), about 80.0% of adolescents in Europe had a vitamin D deficiency. Furthermore, 82.2% of Italian adolescents were also vitamin D deficient (Vierucci, Del Pistoia, Fanos, Erba, & Saggese, 2014). Other studies have found the same pattern in Asia. In Hu et al.'s (2017) study, 53.2% of Chinese children and adolescents were vitamin D deficient. In South Korea, the prevalence of vitamin D deficiency among adolescents was 82.9% (Min & Min, 2018). Some studies also found that vitamin D deficiency was higher in female than in male adolescents (Kim et al., 2018; Lee et al., 2016; Öberg, Jorde, Almås, Emaus, & Grimnes, 2014).

The main sources of vitamin D are synthesis via skin exposure to sunlight and meat consumption. Further, it has been reported that several factors, such as demographics, weight, physical activity, and dietary intake play a role in vitamin D deficiency (Manios et al., 2018). Aging has been reported as a major factor in the lowering of vitamin D status in the blood (Absoud, Cummins, Lim, Wassmer, & Shaw, 2011). Additionally, urban living, associated with less sunlight exposure has been linked with increased rates of vitamin D deficiency (Checkley et al., 2015). Some studies have found that adiposity status was associated with vitamin D status (Absoud et al., 2011; Vierucci et al., 2014).

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E-mail address: kimjisoo@gachon.ac.kr.

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Other studies have also shown that the lack of physical activity can lead to an increased deficiency of vitamin D (Kim, Choi, & Yi, 2017; Wanner, Richard, Martin, Linseisen, & Rohrmann, 2015).

In recent years, an association between habitual dietary intake and vitamin D deficiency has been reported (Manios et al., 2018). Koreans have a high percentage of carbohydrate intake (62.2%) and their main sources of vitamin D are fish and eggs. However, their consumption of dairy products, which are main dietary sources of vitamin D, is low; this makes it difficult for them to maintain a sufficient levels of vitamin D (Kim, Kim, & Ly, 2016; Korean Statistical Information Service, 2018). A previous study (Oh, Kim, & Kim, 2013) revealed that 24.1% of Korean female adolescents displayed eating behaviors aimed at weight loss, such as eating less and skipping meals. Furthermore, adolescents who do not eat breakfast are at greater risk of vitamin D deficiency than those who eat breakfast (Mielgo-Ayuso et al., 2017; Min & Min, 2018).

In previous studies that investigated factors affecting vitamin D deficiency, differences according to sex, age, and country were found (Byun, Heo, Cho, Lee, & Kim, 2017; Manios et al., 2018; Mielgo-Ayuso et al., 2017; Wanner et al., 2015). The prevalence of vitamin D deficiency among women in South Korea is the highest in East Asia (Lim, Kung, Sompongse, Soontrapa, & Tsai, 2008), with female adolescents having the highest prevalence among this group (Lee et al., 2016). Nevertheless, little is known about the factors associated with vitamin D status among female adolescents. One study (Min & Min, 2018) examined factors, including gender associated with adolescent vitamin D deficiency. However, the study did not include physical activity as a potential variable associated with vitamin D deficiency; other previous studies have suggested that the association between vitamin D status and physical activity could be due to the sunlight exposure that accompanies physical activity (Al-Othman et al., 2012; Vierucci et al., 2014; Wanner et al., 2015).

To promote good health during adolescence, an enhanced understanding of the factors associated with vitamin D status, particularly among girls, is needed. Therefore, the purpose of this study was to identify factors associated with vitamin D status among female adolescents, including potential factors such as demographics, adiposity status, physical activity level, and habitual dietary intake.

Methods

Study Design

This was a cross-sectional descriptive study conducted to identify the factors associated with vitamin D status among female adolescents in South Korea.

Sampling Procedure and Participants

This study used a nationally representative sample from the fifth Korea National Health and Nutrition Examination Survey (KNHANES), 2010–2012. This national survey has been conducted annually since 2007 by the Ministry of Health and Welfare and the Korea Centers for Disease Control and Prevention (KCDC). The KNHANES comprised health questionnaires, examinations, and nutritional surveys. The serum 25-hydroxyvitamin D level was recorded from 2008 to 2012 for all survey participants over 10 years of age. However, recent data from 2013 to 2014 includes records of only 2400 people over 10 years of age. For the purpose of this study, the data set from the 2010–2012 KNHANES was used.

The sampling unit of households for the KNHANES was obtained using a stratified, multistage, cluster probability sampling method. All family members (excluding those less than one year old) in the randomly selected households participated in the survey. There were 25,533 KNHANES participants from 2010 to 2012 (KCDC, 2014).

The inclusion criteria for the present study were (1) being a female adolescent aged 12–18 years and (2) having a serum level of 25(OH) D. There were 1007 female adolescents aged 12–18 years in the KNHANES; however, after excluding 273 owing to missing data, 734 individuals were included in the final study sample.

The KNHANES was approved by the KCDC institutional review board (Approval No. 2010-02CON-21-C, 2011-02CON-06-C, 201201EXP-01-2C). After acquiring permission from the KCDC, the data set was downloaded directly from the KCDC website (http://knhanes.cdc.go.kr/).

Measures

The KNHANES survey items analyzed for the purpose of this study were demographic data (i.e. age, living in urban/rural region, level of household income), BMI, levels of physical activity, habitual dietary intake, and serum levels of Vitamin D. Household income was classified as low, middle-low, middle-high, and high based on the income quintile in Korea. Body mass index (BMI) was calculated after measuring height and weight using a formula of weight in kilograms divided by height in meters squared (kg/m^2).

Physical Activity

Data of vigorous and moderate physical activity levels were included in the study. Vigorous physical activity was assessed from responses to the following question: “During the last week, did you engage in physical activity to the point of feeling exhausted or out of breath, more than three days for over 20 minutes at a time (for example, jogging or cycling)?” Similarly, moderate physical activity was assessed based on responses to the question: “During the last week, did you engage in physical activity, to the point of feeling a little exhausted or a little out of breath, more than five days for over 30 minutes at a time (for example, playing ping-pong or badminton)?” The responses were recorded as “yes” or “no.”

Habitual Dietary Intake

The habits of meal intake and eating less for weight control were included in the study. Meal intake was assessed with the question, “Did you have meals in the last two days?” The responses were divided into “yes” or “no” for breakfast, lunch, and dinner. Those who reported not having the same meal for two consecutive days were categorized as not having that meal.

Habits of eating less for weight control were measured based on responses to the question: “Have you been trying to control your body weight for the last year? If yes, what methods did you use for weight control?” Those who reported trying to control body weight by eating less were categorized as having dietary habits corresponding to eating less.

Vitamin D Status

Vitamin D was assessed using levels of serum 25(OH) D. Vitamin D deficiency was defined as <20 ng/mL of serum 25(OH) D according to the recommendation of the IOM (Institute of Medicine Food and Nutrition Board, 2011).

Data Analysis

The data were analyzed using the statistical software IBM SPSS Statistics 21.0 (IBM, Armonk, NY). All study variables were assessed for outliers, missing data, and suspected errors. The KNHANES data were weighted to generate appropriate population estimates. Therefore, we took the complex sampling design of the KNHANES into consideration. The weighted percentage, mean, and standard error of study variables were used to describe the study results. To estimate the group means (vitamin D deficiency and no deficiency) and identify the factors associated with vitamin D status among female adolescents, a general linear model using a complex samples design was employed (significance level = 0.05).

Results

Participant Demographics and Characteristics

The mean age of the participants was 15.15 years and 80.4% (n = 615) were living in urban areas. Of the participants, 31.8% (n = 190) were classified as having middle-low economic status. The mean BMI was 20.89 kg/m^2. Regarding physical activity, 23.7% (n = 47) reported engagement in vigorous physical activity during the last week, while 6.3% (n = 13) reported moderate physical activity. In terms of diet, 21.4% (n = 133) did not have breakfast, 2.6% (n = 14) did not have lunch, and 2.3% (n = 14) did not have dinner. To control their weight, 45.8% (n = 312) of the participants reported eating less (Table 1). The mean vitamin D level of the participants was 14.90 ng/mL. Fig. 1 shows the proportions of vitamin D deficiency among female adolescents aged 12–18 years based on the recommendation of the IOM (Institute of Medicine Food and Nutrition Board, 2011). Of all the participants, 87.6% (n = 643) were found to be vitamin D deficient with a mean vitamin D level of 13.73 ng/mL.

Factors Associated with Vitamin D Status Among Female Adolescents

Table 2 shows the associations of demographics, BMI, physical activity, and habitual dietary intake with vitamin D level. When adjusted for all study variables, age, household income, and skipping lunch were associated with vitamin D status among female adolescents. As their ages increased by one year, their vitamin D levels decreased by 0.47 ng/mL (p = .005). Female adolescents with low household income had a vitamin D level lower by 1.88 ng/mL than those with high household income (p = .038). In addition, vitamin D level in female adolescents who did not eat lunch was lower by 3.41 ng/mL than those who did eat lunch (p = .010).

Discussion

Previous studies have shown that female adolescents have a higher prevalence of low average serum vitamin D levels relative to male adolescents or older women (Hu et al., 2017; Lee et al., 2016; Öberg et al., 2014). In the present study, however, the mean vitamin D levels of Korean female adolescents were much lower than that of adolescents in previous studies (Giudici, Fisberg, Marchioni, & Martini, 2017; Hu et al., 2017). Additionally, the mean vitamin D levels found in the current study were lower than found in a previous study on Korean adolescents (Lee et al., 2016). Further, the prevalence of vitamin D deficiency among female adolescents was high, which is similar to a recent study that investigated vitamin D deficiency among 12- to 18-year-old Korean adolescents (Min & Min, 2018). As the findings demonstrated, vitamin D status in female adolescents in Korea is considerably lower as compared to other countries, and is gradually getting worse.

Previous studies also have examined the predictors for lower vitamin D status among adolescents, which include physical activity levels and eating behaviors (Hu et al., 2017; Martini, Verly, Marchioni, & Fisberg, 2013; Vierucci et al., 2013). Moreover, despite differing levels of physical activity and behavior patterns between female and male adolescents, studies have not identified the factors associated with vitamin D status among female adolescents (Min & Min, 2018).

The present study found that as age increased among female adolescents, their levels of vitamin D decreased. This finding is consistent with a previous study reporting that the level of serum vitamin D was lower, and the risk of vitamin D deficiency was higher in adolescents in high school than in middle school (Lee et al., 2016). In another study (Sisson et al., 2009), higher grade level was found to be associated with a decrease in adolescents' outdoor activities and increased screen time such as watching TV and using a computer. It is assumed that adolescents' lifestyle changes may lead to less sunlight exposure, possibly resulting in a lower levels of vitamin D. In addition, since female adolescents are less active in sports and engage in less physical activity than male adolescents (Sathya, Raji, & Ramesh, 2017), health professionals need to be aware that female adolescents are at risk for lower levels of vitamin D.

In addition, this study revealed that household income was associated with vitamin D status among female adolescents. Similarly, a previous study with adults associated low socioeconomic status with vitamin D deficiency (Léger-Guist'hau et al., 2017); those at a low-income level are likely to have fewer outdoor leisure activities, which can reduce opportunities for exposure to sunlight. Additionally, people with low socioeconomic status may have a diet characterized by poor nutritional quality due to its cost, which could contribute to nutrition deficiency, including vitamin D (Léger-Guist'hau et al., 2017). Considering this previous study (Léger-Guist'hau et al., 2017) together with present findings, socioeconomic status may in part be responsible for vitamin D vulnerability in adolescents. Therefore, it should be considered that low

Table 1
Participants' characteristics (N = 734).

Variables		n (%)[a]	
Age (year)	M[a] ± SE[a] (range)	15.15 ± 0.09	(12–18)
Sex	Female	734 (100.0)	
Region of residence	Rural	119 (19.6)	
	Urban	615 (80.4)	
Household income	High	223 (23.9)	
	Middle-high	227 (28.9)	
	Middle-low	190 (31.8)	
	Low	90 (15.5)	
Body mass index (kg/m^2)	M[a] ± SE[a] (range)	20.89 ± 0.16	(13.0–36.0)
Vigorous physical activity	Yes	47 (23.7)	
	No	169 (76.3)	
Moderate physical activity	Yes	13 (6.3)	
	No	203 (93.7)	
Breakfast (2 days)	Had	601 (78.6)	
	Not	133 (21.4)	
Lunch (2 days)	Had	720 (97.4)	
	Not	14 (2.6)	
Dinner (2 days)	Had	720 (97.7)	
	Not	14 (2.3)	
Eating less for weight control	Yes	312 (45.8)	
	No	416 (54.2)	
Vitamin D (serum 25-hydroxyvitamin D ng/mL)	M[a] ± SE[a] (range)	14.90 ± 0.25	(5.56–33.63)

M ± SE, Mean ± standard error.
[a] Unweighted n, weighted percentage, weighted mean, and standard error.

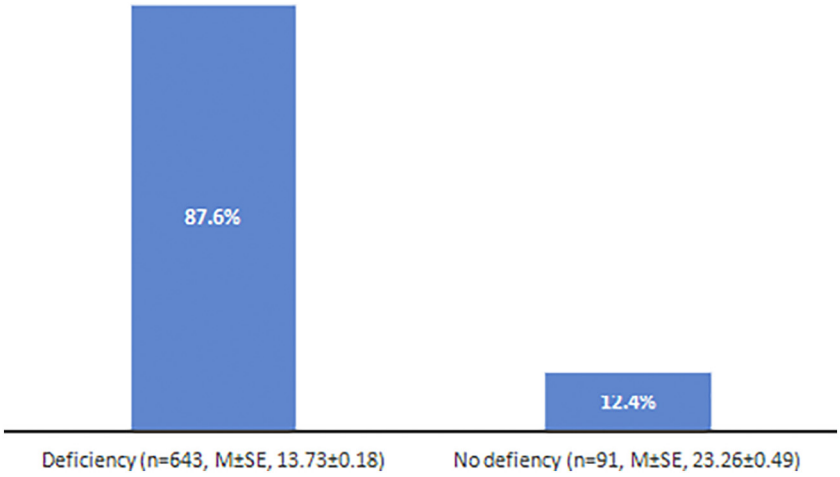

Fig. 1. Prevalence of vitamin D deficiency and mean vitamin D level among female adolescents (Unweighted n and weighted percentage, mean ± standard error).

economic status may be a potential factor influencing low vitamin D status among female adolescents in future studies.

Physical activity was not associated with vitamin D status in the present study, although previous studies have reported an association between physical activity levels and vitamin D deficiency among adolescents (Al-Othman et al., 2012; Vierucci et al., 2014; Wanner et al., 2015). Recent studies of vitamin D status in adolescents, however, showed that it was not associated with sunlight exposure or physical activity levels (Giudici et al., 2017; Kim et al., 2017), which was consistent with the results of the present study. In another study of vitamin D status in adolescents, the associations between physical activity and vitamin D status were significant only for boys (da Silva et al., 2018). According to researchers, female adolescents were less likely to engage in regular exercise or physical activity than male adolescents. Furthermore, they were more likely to use sunscreen than male adolescents, which may have contributed to vitamin D deficiency (Giudici et al., 2017; Sathya et al., 2017). The methods for measuring physical activity differed among the studies and it seems that the effect of physical activity on vitamin D status has shown conflicting results. Further study is needed to identify the associations between physical activity and vitamin D status.

Finally, regularly skipping lunch was associated with low vitamin D status among female adolescents in this study. It is well-known that adequate exposure to ultraviolet light and dietary intake of vitamin D from food are the primary ways to maintain a healthy level of serum vitamin D. However, the present results indicate that dietary intake is associated with vitamin D status in female adolescents, but physical activity is not. It has been suggested that breakfast intake is related to vitamin D status in adolescents (Mielgo-Ayuso et al., 2017; Min & Min, 2018). Dietary intake of vitamin D was also found to increase serum vitamin D concentration in young adults (Kim et al., 2016); regular eating behaviors might help to improve vitamin D status in female adolescents. Therefore, health professionals should assess dietary intake habits when aiming to improve vitamin D status in this population. Moreover, one study reported that Korean female adolescents tend to skip meals for weight control (Hong, Bae, Kim, & Park, 2014). It is therefore recommended that future studies further examine the relationships among skipping meals, weight loss diet, and vitamin D status in female adolescents.

Table 2
Regression coefficient (95% CI) for association between vitamin D status and study variables.

Variables		B	SE	95% CI		p
				Lower	Upper	
Age (year)		−0.47	0.16	−0.79	−0.14	0.005
Region of residence	Urban	−0.88	1.03	−2.92	1.16	0.394
	Rural	Reference[a]				
Household income	Low	−1.88	0.89	−3.64	−0.11	0.038
	Middle-low	−2.12	1.09	−4.27	0.03	0.053
	Middle-high	−1.10	1.01	−3.07	0.88	0.274
	High	Reference[a]				
Body mass index (kg/m^2)		−0.01	0.12	−0.21	0.21	0.978
Vigorous physical activity	No	0.62	0.78	−0.91	2.16	0.424
	Yes	Reference[a]				
Moderate physical activity	No	−0.96	1.16	−3.25	1.33	0.409
	Yes	Reference[a]				
Breakfast (2 days)	Not	0.37	1.32	−1.87	2.61	0.744
	Had	Reference[a]				
Lunch (2 days)	Not	−3.41	1.30	−6.00	−0.83	0.010
	Had	Reference[a]				
Dinner (2 days)	Not	−1.07	1.01	−3.07	0.94	0.295
	Had	Reference[a]				
Eating less for weight control	No	−2.11	1.18	−4.44	0.22	0.075
	Yes	Reference[a]				

SE, standard error; CI, confidence interval.
[a] This parameter is set to zero because it is redundant.

Limitations

As a retrospective study, the present study was unable to include other confounding variables that could affect vitamin D status such as supplement use, quality of dietary intake, and seasonal effect. Moreover, the assessment of dietary intake in previous studies included varied definitions, making comparisons difficult (Mielgo-Ayuso et al., 2017; Min & Min, 2018). In addition, other studies included only breakfast consumption for dietary intake (Mielgo-Ayuso et al., 2017; Min & Min, 2018), while the present study included all three daily meals. Nevertheless, this study's findings should be interpreted with caution because vitamin D intake was not evaluated through precise calculations. It is also important to note that although most female adolescents were having lunch, they were found to have vitamin D deficiency. The eating habits of Koreans, who have diets high in carbohydrates, may not be sufficient to maintain an appropriate vitamin D status (Kim et al., 2016). To improve vitamin D status, vitamin D supplements, in addition to encouraging regular dietary intake, should be recommended for female adolescents (Lee et al., 2016).

Conclusion

The present study, conducted with nationally representative data, found a considerable prevalence of vitamin D deficiency among female adolescents in South Korea. Moreover, the vitamin D deficiency in

female adolescents was associated with a lack of dietary intake. Interestingly, physical activity was not associated with vitamin D status among this population in the present study. However, as the data used in this study were drawn from the 2010–2012 KNHANES, it is recommended that future studies evaluate the factors associated with vitamin D status using the latest data.

The present study's findings highlight the need for special attention toward dietary intake to prevent vitamin D deficiency in female adolescents. To address this issue, health professionals should provide information to these young females about the importance of vitamin D intake. Through health education, nurses especially need to emphasize the importance of sufficient dietary intake for these females to improve their vitamin D levels.

CRediT authorship contribution statement

Ji-Soo Kim: Ph D, RNConceptualization, Methodology, Formal analysis, Investigation, Funding acquisition, Writing - original draft, Visualization, Writing - review & editing.

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