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Impact Of Mediterranean Climate and Seasonal Variation on Vitamin D Levels in Children

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BACKGROUND
Vitamin D deficiency causes several health problems. We investigated the frequency of vitamin D deficiency and insufficiency and the impact of seasonal variation on the 25-Hydroxyvitamin D [25(OH) D] levels of healthy children living in Cyprus.

METHODS
A total of 565 healthy children (aged, 0-18 y) under routine pediatric consultation who were followed in our Department of Pediatrics between February 2013 and September 2016 and who were screened for 25(OH) D level were included.

RESULTS
This analysis demonstrated a frequency of 22.5% vitamin D deficiency and 29% insufficiency. 25(OH) D results had a positive correlation with temperature (r=0.25, p=0.00) and a negative correlation with age (r=-0.43, p=0.00). 25(OH) D deficiency was more frequent in females than in males (p=0.04). Deficiency was the most frequent during winter and spring and the least frequent during summer (p=0.00). Deficiency was the most frequent in December and April and the least frequent in June and July (p=0.00), and it was the least frequent in children in the age group of 0-12 month sand the most frequent in those in the age group of 169–216 months (p=0.00). Within this group, 85 of children were evaluated for Ca, P, and alkaline phosphatase (ALP). 25(OH) D results did not have a correlation with Ca, P, and ALP values. When the vitamin D deficient and sufficiency groups were compared, Ca (p=0.01), P (p=0.03), and temperature (p=0.04) values were lower in the deficient group.

CONCLUSION
Vitamin D deficiency is an important health problem even in our country, which has sufficient sun exposure. Therefore, children should spend more time outdoors to adequately benefit from vitamin D synthesis from sunshine.

Keywords: Climate, vitamin D, children

INTRODUCTION

Vitamin D obtained from sun exposure, food, and supplements is important for the growth and remodeling of bones, modulation of cell growth, neuromuscular and immune functions, and control of inflammation. The health effects due to vitamin D deficiency and insufficiency have been studied in the last decades and demonstrated to be related with an increase in infections, allergy, autoimmune diseases, diabetes, and malignancies. Therefore, investigators are currently focusing on the global causes of vitamin D deficiency that depend on seasonal variation, sun exposure, and geographical location. The 25-hydroxyvitamin D [25(OH)D] level is the best and the most accurate measure of the vitamin D status of individuals. 25(OH)D concentrations <20 ng/mL suggest vitamin D deficiency, concentrations between 20 and 30 ng/mL suggest vitamin D insufficiency, and concentrations >30 ng/mL suggest sufficiency (1-3). Cyprus has Mediterranean climate in the North Hemisphere; therefore, June, July, and August are summer months, whereas December, January, and February are winter months. In this study, we aimed to investigate the frequency of vitamin D deficiency and insufficiency and the impact of seasonal variation on the 25(OH) D levels of healthy children living in Cyprus, which is an island situated in the center of the Mediterranean Sea.

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MATERIALS and METHODS

Healthy children (aged 0–18 y) under routine pediatric consultation who were followed in our Department of Pediatrics between February 2013 and September 2016 and who were screened for 25(OH) D levels were included. Data on age, sex, 25(OH)D levels, date of admission, and, if available, Ca, P, andalkaline phosphatase (ALP) levels were retrospectively collected from the hospital database program. The average values of temperature (in C) of each month were obtained from the Central Meteorology Office. 25(OH)D levels were measured via the chemiluminescent micro particle immunoassay method in the Clinical Biochemistry Laboratory of our hospital using Abbott commercial kits on Architect Ci8200 instrument (Abbott Laboratories, Abbott Park, Illinois, USA) (4). Ethical approval was provided by the institutional review board. Because this was a retrospective study, informed consent could not be obtained from the parents of children. The correlation of 25(OH)D with age, sex, and each seasonal and 12 months' average temperature was analyzed.

Statistical Analysis

We used descriptive statistics, one-way ANOVA, Pearson correlation analysis, Pearson chi-square test, and Tukey's test for the statistical analysis, and $p<0.05$ were considered significant.

RESULTS

A total of 565 healthy children (282 females and 283 males) who were screened for 25(OH)D level were enrolled. The mean age was 96.4±60.6 months (range, 2-215 months). The mean 25(OH) D level of all children was 31.07±14.1 ng/mL (range, 3.5–108.1 ng/mL), demonstrating a frequency of 22.5% (n=127) of 25(OH)D deficiency, 29% (n=164) insufficiency, and 48.5% of 25(OH)D levels were sufficient (n=274). The mean temperature of the total months was 19.2°C±6.1°C, with the minimum temperature being 10.6°C in January and the maximum being 29°C in August. The mean temperature of the total months was 16.7°C±5.5°C in the deficiency group, 18.5°C±6.0°C in the insufficiency group, and 20.8°C±5.9°C in the sufficient 25(OH)D levels group, with the difference being significantly different (p=0.00).

The 25(OH) D values of children stratified according to sex, seasons, months, and age groups are presented in Figure I. 25(OH) D results had a positive correlation with temperature (r=0.25, p=0.00) and a negative correlation with age (r=-0.43, p=0.00). The evaluation of 25(OH)D results according to sex revealed that 25(OH)D deficiency and insufficiency were more frequent in females than in males (p=0.04) (Figure I). When the 25(OH)D results in the four seasons were compared, the difference was statistically significant. 25(OH)D deficiency and insufficiency were the most frequent during winter and spring and the least frequent during summer (p=0.00) (Figure 2).

When the 25(OH)D results between months were analyzed, the difference was found to be statistically significant (p=0.00). 25(OH) D deficiency was the most frequent in December and April and the least frequent in June and July. 25(OH)D insufficiency was the most frequent in April and November and the least frequent in June. 25(OH)D values were sufficient mostly in June and July (Figure 3).

25(OH)D deficiency was the least frequent in the age group of 0-12 months and the most frequent in that of 169-216 months. 25(OH)D insufficiency was also the least frequent in the age group of 0-12 months and the most frequent in that of 97-168 and 169-216 months. These results were also statistically significant (p=0.00) (Figure 4).

Within this group, 85 of children were evaluated for calcium (Ca), phosphorus (P), and ALP. 25(OH)D results did not have a

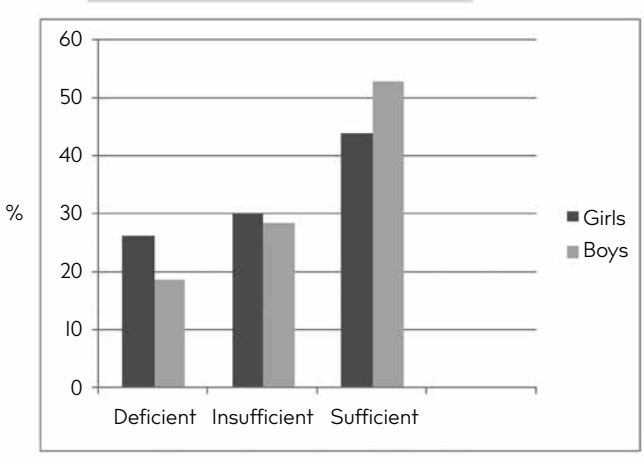

FIGURE I. Distribution of 25(OH)D deficiency, insufficiency and sufficiency based on gender (statistically significant between gender, p<0.04).

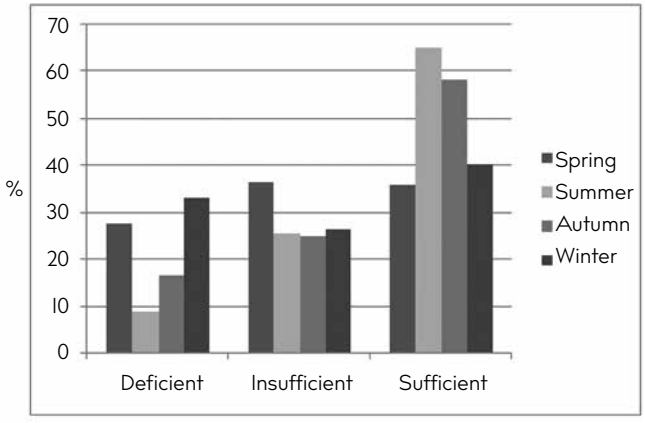

FIGURE 2. Distribution of 25(OH)D deficiency, insufficiency and sufficiency based on seasons (statistically significant between seasons, p=0.00).

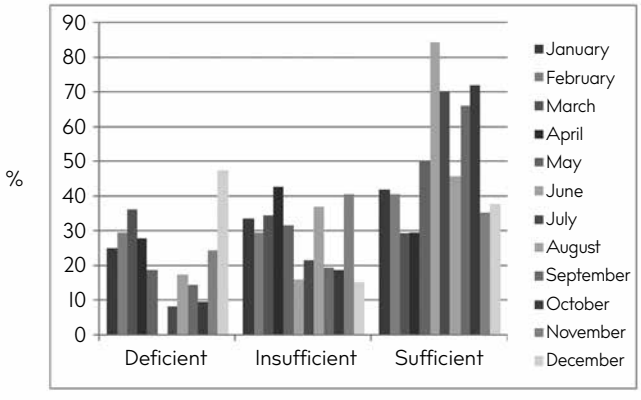

FIGURE 3. Distribution of 25(OH)D deficiency, insufficiency and sufficiency based on months (statistically significant between months, p=0.00).

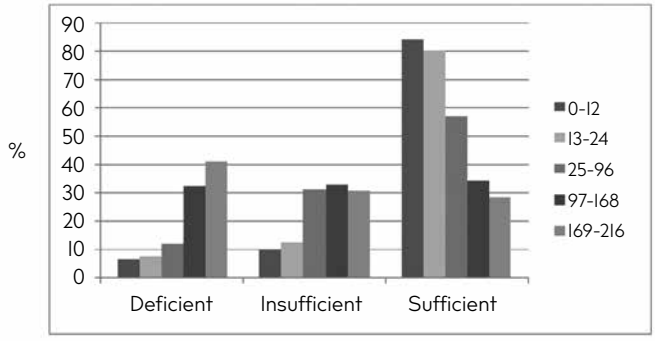

FIGURE 4. Distribution of 25(OH)D deficiency, insufficiency and sufficiency based on age groups (months) (statistically significant between age groups, p=0.00).

TABLE I. Association of 25(OH)D with mean Ca, P, ALP and temperature

	Deficient	Insufficient	Sufficient
Ca (mg/dL) p= 0.01	9.7±0.4	9.9±1.0	10.1±0.5
P (mg/dL) p=0.03	4.7±0.9	4.8±1.2	5.0±0.6
ALP (IU/mL) p=0.45	187.6±119.7	198.7±119.4	314±778.4
Temperature (° C) p=0.04	15.7±6.8	17.3±5.8	19.9±6.0

Ca: calcium; P: phosphorus, ALP; alkalene phosphatase; 25(OH)D; 25- hydroxyvitamin D

correlation with Ca, P, and ALP values. When the vitamin D deficiency and sufficiency groups were compared, Ca (p=0.01), P (p=0.03), and temperature (p=0.04) values were lower in the deficiency group than in the sufficiency group, and the differences were statistically significant. ALP results were also higher in the normal group than in the deficient and insufficient groups, but the difference was not statistically significant (p=0.45) (Table I).

DISCUSSION

Vitamin D synthesis is affected by sunlight exposure, and the measured serum 25(OH)D levels have seasonal variations. In our study, there was a significant seasonal variation in the vitamin D levels of children. A total of 283 children were investigated in a study from Spain, and 25(OH)D level was found to be the lowest during winter (5). Similarly, a longitudinal observational study in Denmark showed that 25(OH)D levels were low during two consecutive winters in healthy adolescent girls and increased during summer (6). Spain and Cyprus are geographical regions that similarly benefit from sunlight. Fluctuations in the vitamin D levels of children between summer and winter may be attributed to the increased indoor lifestyle of children during winter seasons. Actually, in these areas of the world, winter sunlight also has a potential for the maintenance of vitamin D synthesis.

Age is an important determinant of 25(OH)D deficiency that is the most common in adolescents and the least common in infants. A prospective study showed that infants had sufficient vitamin D levels, which wassimilar our result. This shows that infants aged up to 1 year receive sufficient vitamin D majorly via supplements (7). However, the total vitamin D levels in infants were insufficient to compare them among different seasons. Adolescents are assumed to require higher amounts of vitamin D for maintaining an adequate 25(OH)D status; however, they have been reported to have lower 25(OH)D levels (8). With increasing age, vitamin D becomes deficient or insufficient, which shows that vitamin D efficiency decreases. Clothing style or increased indoor activities of adolescents may be responsible for this result.

Sex was related with vitamin D levels in the present study, being lower in females than in males. Some other studies have also reported that females have lower vitamin D levels, which l associated with adiposity. The hypothesis was that as adiposity increases, 25(OH)D is sequestered in adipose tissue and outdoor activities are less common in girls (8). However, another study on 962 children has shown that sex is not related to vitamin D levels (9).

One of the previous studies on vitamin D status in Cyprus has revealed that among 671 adolescents, 90% had vitamin D deficiency or insufficiency, but only10% had normal levels. Vitamin D deficiency was more frequent during winter and spring. During winter, as the sun exposure time decreased, vitamin D levels also decreased. In addition, vitamin D levels were lower in females (10).

Another study from Cyprus conducted 30 years ago has demonstrated that urine Ca levels indicate the vitamin D status of children tested in June and September. Infants born or who had been living in Cyprus for the last year had higher levels of calciuria and serum calcitriol than those who had just immigrated to the island from North Anatolia. Therefore, vitamin D synthesis was thought to be increased by sunlight, and this did not cause hypervitaminosis or hypercalciuria (11).

There are some limitations to this study, one of which is that parathyroid hormone levels were not measured. Further, confounding factors such as skin color, activity levels, duration of sun exposure, clothing styles, and dietary supplements that can affect vitamin D levels were not analyzed.

Although being in a region with a typical Mediterranean climate and not having a closed clothing tradition, vitamin D deficiency is an important health issue in our country. Children and adolescents should be encouraged to have more outdoor activities to adequately benefit from the power of vitamin D synthesis with sunshine that is a wealth for the country.

Ethics Committee Approval: Ethics committee approval was received for this study from the Institutional Review Board of Near East University School of Medicine (Approval Date: 17.11.2016, Approval Number: 345)

Informed Consent: Since this was a retrospective study, informed consent could not be taken from parents of the patients.

Peer-review: Externally peer-reviewed.

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