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Weight and Body Mass Index in Relation to Vitamin D Status in Healthy 4–13 Years Old Children in Saudi Arabia

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Research Article

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Abbrevations: WHO: World Health Organization; BMI: Body Mass Index; 25(OH)D: 25-Hydroxyvitamin D

ABSTRACT

Background: According to the World Health Organization (WHO), obesity became an epidemiological problem and one of the leading causes of death in developed countries. Obese children seem to be more at risk of developing vitamin D deficiency because of limitation in their physical activity, which results in limited sun exposure and vitamin D deficiency. This study aimed to identify a relationship between body mass index (BMI) and serum 25-hydroxyvitamin D [25(OH)D] levels.

Methods: This retrospective cross-sectional study involved 458 children (47.8% females, and 52.2% males) aged 4-13 years. A questionnaire-based study design was used, followed by height, weight, and vitamin D measurement at an ambulatory pediatric clinic. BMI percentile was determined for each subject according to the WHO and serum vitamin D concentration was classified as deficient, insufficient, or sufficient. Children with chronic serious diseases and those receiving calcium or vitamin D supplementation were excluded.

Results: We found 418 (91.3%) children with low vitamin D levels and 37 (8.1%) children with normal vitamin D levels; in 3 (0.6%) children, the vitamin D levels were not available. Significant difference in weight was found among the children with different levels of vitamin D. The mean of log weight in the group with low vitamin D levels was 1.45, while in children with normal vitamin D levels, it was 1.3 (p-value=0.0001). Moreover, BMI showed a similar relationship with serum levels of vitamin D. The mean of log BMI in children with low vitamin D levels was 1.23, and the mean of log BMI in the group with normal vitamin D levels was 1.1 (p-value=0.001).

Conclusion: Children with high BMI showed lower levels of vitamin D. Healthy diet, physical activities, early diagnosis of vitamin D deficiency, and definitive management can prevent many complications that could affect child health and cause burden on the community.

INTRODUCTION

In recent decades, obesity has become an epidemiological problem according to the World Health Organization's (WHO) reports [1,2]. Obesity is one of the leading causes of death in developed countries because obese children face many health problems later in life, such as cardiovascular and pulmonary disorders, metabolic syndrome, musculoskeletal and mental difficulties [1,3,4].

Obese children seem to be more at risk of developing vitamin D deficiency. This is a worldwide issue due to vitamin D sequestration in adipose tissue [5,6]. Additionally, the physical activity of obese children is limited, which consequently causes limited sun exposure and increases the risk of developing vitamin D deficiency [7]. Generally, children are screened for obesity using body mass index (BMI) (calculated as weight in kg divided by the square of height in meters) and for vitamin D deficiency using serum 25-hydroxyvitamin D [25(OH)D] levels [3,4]. The aim of this study was to identify the relationship between BMI and serum 25(OH)D levels [2].

METHODS

This retrospective cross-sectional study was conducted in Jeddah in 2015 among children and adolescents aged 4–13

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years. Males and females were selected randomly to represent different economic status, parental educational level, and family structure of the Jeddah population in the sample. A total of 458 children (219 [47.8%] females, 239 [52.2%] males) had complete data for the analysis.

A questionnaire-based study design was used. The children and their family were interviewed, and height, weight, and vitamin D levels were measured at an ambulatory pediatric clinic in King Abdulaziz University Hospital in Jeddah, Saudi Arabia. Written consent was obtained from the children and their parents prior to filling the questionnaire. Consent was obtained from children before measuring their weight, height, and BMI. Data were collected between March 2015 and September 2015.

The research and ethics committee at King Abdulaziz University Hospital in Jeddah approved the study.

The Questionnaire

Each participant in the sample received a questionnaire that needed to be answered by the parents or guardians and completed by a trained health care provider.

A set of standardized data collection sheets entailing a series of questions with multiple answer choices were included to collect the following information: demographic data (age, gender, ethnicity), monthly income, birth order, duration of sun exposure, nutritional status, medical history of the child, general information on the symptoms of vitamin D deficiency, and specific questions about child physical activity levels in number of hours per week.

Inclusion criteria

Children and adolescents aged 4-13 years. Males and females were selected randomly to represent different economic status, parental educational level, and family structure of the Jeddah population.

Exclusion criteria

The exclusion criteria were age less than 4 years, chronic serious intercurrent illness (liver and biliary disease, renal disease, rickets, calcium and phosphate disease, malabsorption), medication use, calcium or vitamin D supplementation use and insufficient data.

BMI Measurements

Height was measured using a wall-mounted stadiometer. The children did not wear shoes, their shoulders were in a relaxed position, and their arms were hanging freely to their side. Weight was measured with a beam balance scale, which was re-calibrated for every new subject. Subjects were weighed barefoot and wearing minimal clothing. Obesity and overweight were defined using the growth chart standards. BMI was calculated as weight in kilograms divided by the square of height in meters. BMI percentile was determined for each subject according to the WHO and defined as follows: normal, BMI between the 5^{th} and 85^{th} percentiles; overweight, BMI between the 85^{th} and 95^{th} percentiles; obesity, BMI above the 95^{th} percentile; and severe obesity, BMI above the 99^{th} percentile.

Vitamin D Status Definitions

Serum vitamin D concentration was classified as follows: deficient when 25(OH)D<50 nmol/L; insufficient when 25(OH)D>50 nmol/L, but <75 nmol/L; and sufficient when 25(OH)D>75 nmol/L.

Statistical Analysis

The SPSS 16.0 statistical analysis software (IBM corp., Chicago, USA) was used for data processing. After checking all assumptions and logarithmic transformation of weight (kg) and BMI (kg/m^2) to achieve a normal distribution, the independent sample t-test was used to assess the difference in BMI and weight among children low and normal vitamin D levels **(Figures 1 and 2).** Percentages and frequencies of dietary factors were calculated as descriptive statistics. The p value<0.05 was considered statistically significant.

RESULTS

The study was conducted in 458 children with a mean age of 9.5 ± 3.72 years; 219 (47.8%) were female and 239 (52.2%) were male. We found 418 (91.3%) children with low vitamin D levels and 37 (8.1%) children with normal vitamin D levels; in 3 (0.6%) children, the vitamin D levels were not available. The characteristics of the participants are shown in **Table 1.**

Significant difference in weight was found among children with different levels of vitamin D **(Figure 3).** The actual mean weight in the sample with low vitamin D levels was 30.98 kg, while the mean weight in the group with normal vitamin D levels was 21.4 kg. We found the same results after logarithmic transformation of weight: the mean of log weight in the group with low vitamin D levels was 1.45, while in children with normal vitamin D levels, it was 1.3 (p-value=0.0001).

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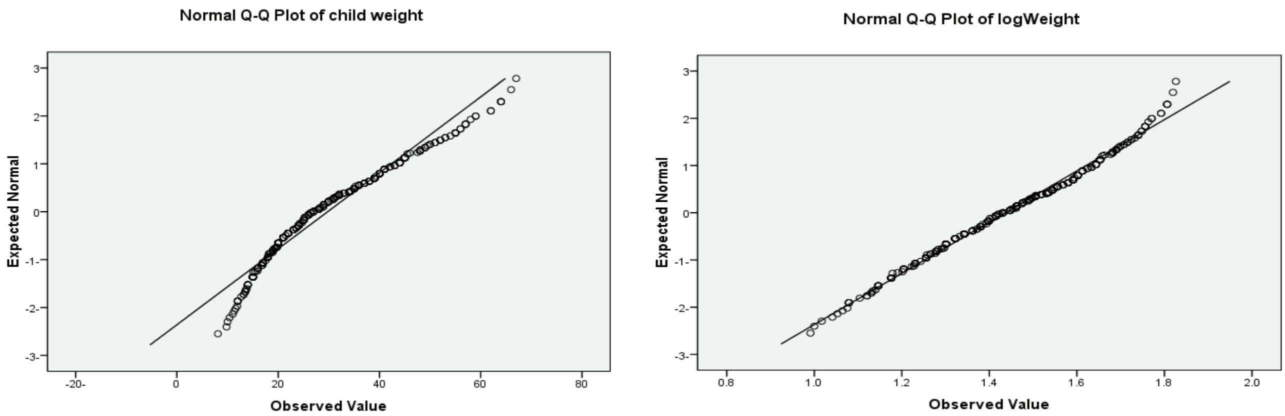

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Figure 1. A: The distribution of weight values (kg) before the logarithmic transformation. **B:** The distribution of logarithmically transformed values of weight (kg).

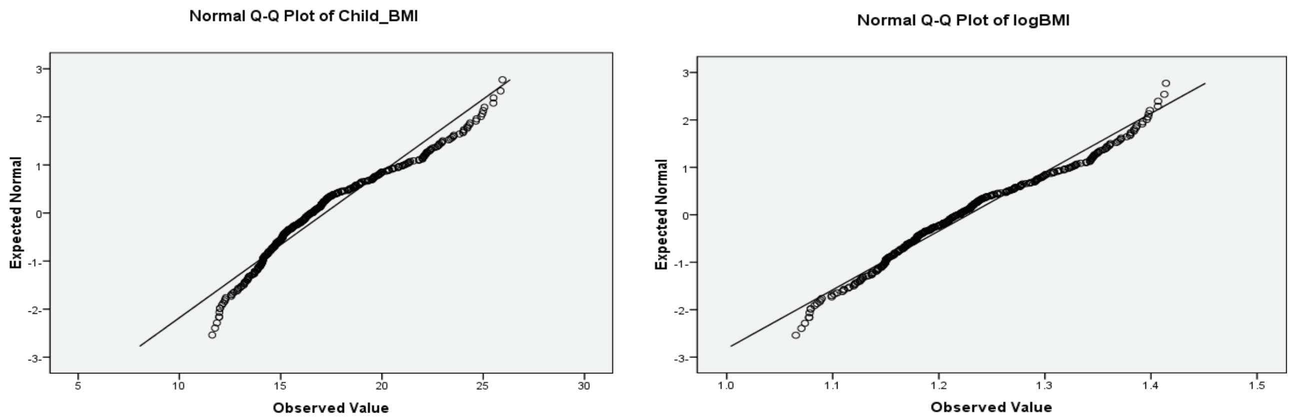

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Figure 2. A: The distribution of BMI values (kg/m^2) before the logarithmic transformation. **B:** The distribution of logarithmically transformed values of BMI (kg/m^2).

Table 1. General characteristics of the study participants.

	Mean ± SD
Serum level of vitamin D, nmol/l	31.1475 ± 14.50908
Age, years	9.4765 ± 3.71512
Height, cm	128.9 ± 18.80599
Weight, kg	29.9827 ± 12.93626
BMI, kg/m^2	17.1852 ± 3.29792
Log weight	1.4388 ± .18637
Log BMI	1.2275 ± .08068

BMI: Body Mass Index; SD: Standard Deviation

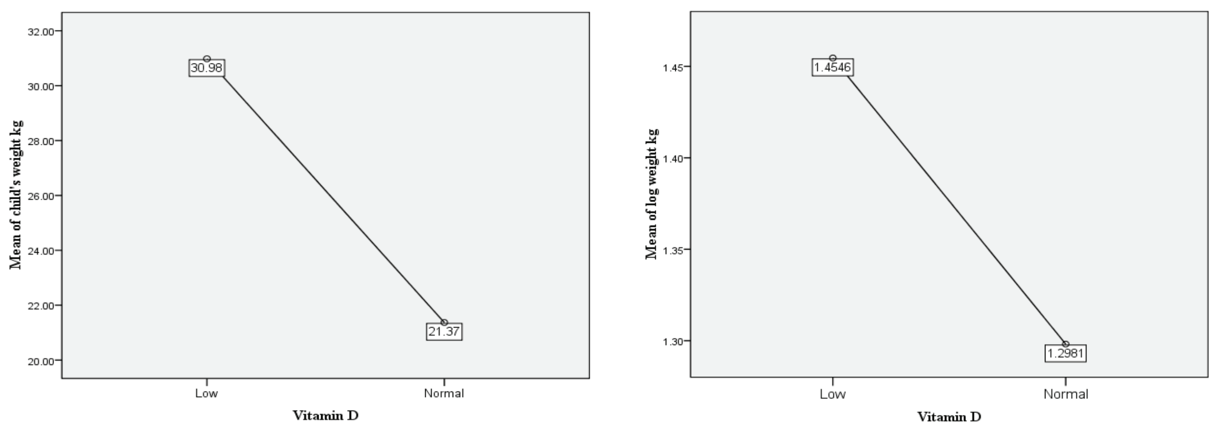

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Figure 3. A: The correlation between the mean of weight and the vitamin D level before the logarithmic transformation. **B:** The correlation between the logarithmically transformed mean of weight and the vitamin D level.

BMI showed similar relationship with serum levels of vitamin D **(Figure 4).** The mean of log BMI in children with low vitamin D levels was 1.23, and the mean of log BMI in the group with normal vitamin D levels was 1.1 **(Table 2).** In addition, the mean actual BMI in the sample with low vitamin D levels was 17.4 kg/m^2, while the mean BMI in children with normal vitamin D levels was 15.7 kg/m^2. This difference was found to be statistically significant (p-value=0.001).

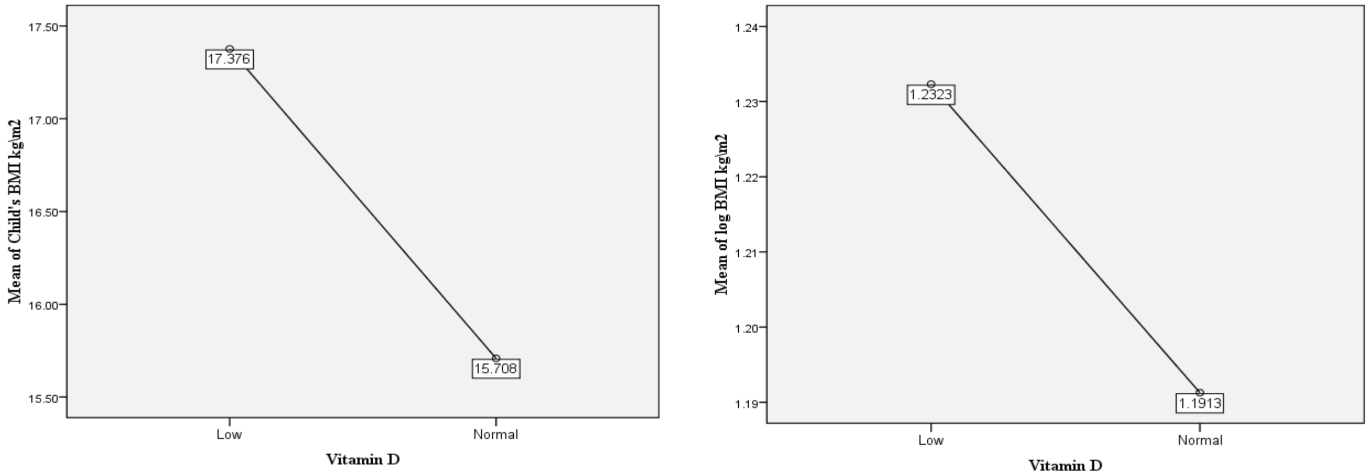

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Figure 4. A: The correlation between the mean of BMI and the vitamin D level before the logarithmic transformation. **B:** The correlation between the logarithmically transformed mean of BMI and the vitamin D level.

Table 2. Mean of body measurements in relation to Vitamin D levels.

Body Measurements	Low vitamin D	Normal vitamin D	p-value
Log weight	1.45 ± 0.2	1.3 ± 0.2	0.0001 0.001
Log BMI	1.23 ± 0.1	1.19 ± 0.1	

BMI: Body mass index

DISCUSSION

Many children living in Saudi Arabia have vitamin D deficiency [8]. Limited sun exposure and inadequate dietary intake contribute to this deficiency [9]. Previous studies reported that vitamin D deficiency is more prevalent in obese children. Excess adiposity is associated with poor vitamin D status. The reason for this association is not known, but is considered to be related the sequestration of the fat-soluble vitamin within the adipose tissue or the effect of volume dilution due to the larger body size of obese individuals [10]. The effects of this deficiency in obese children appear to have several health implications, including compromised bone growth and mineralization [11].

There is a lot of controversy whether the vitamin D deficiency is a consequence or a factor predisposing to obesity [6]. The underlying causal explanation is unclear. Does obesity cause vitamin D deficiency, does vitamin D deficiency cause obesity, or do both of them influence each other? In a study performed to assess whether obesity alters the cutaneous production of vitamin D_3 or the intestinal absorption of vitamin D_2, obesity-associated vitamin D insufficiency was found to be likely due to the decreased bioavailability of vitamin D_3 from cutaneous and dietary sources, because of its deposition in body fat compartments [12]. Another study that assessed the effect of vitamin D_3 supplementation on body fat mass in healthy overweight and obese women found that increasing 25(OH)D concentrations by vitamin D_3 supplementation led to body fat mass reduction [13].

Our study examined the relationship between serum vitamin D levels, and weight and BMI in a retrospective cross-sectional study of children from Jeddah, Saudi Arabia.

BMI showed a significant relationship with vitamin D level. Children with vitamin D deficiency had a higher BMI than those with normal vitamin D level (p=0.001).

A previous study was performed on 479 children aged 5–12 years in Bogota, Colombia, to investigate the association between the serum vitamin D level and change in BMI, skin fold thickness ratio, waist circumference, and height. The results showed that vitamin D deficiency was related to slower linear growth in girls (20.6 cm/year, p=0.04), but not in boys (0.3 cm/year, p=0.34). However, an interaction with sex was not statistically significant. Additionally, low vitamin D levels were inversely proportional to the development of adiposity in school-age children [4].

Another significant result was the relationship between child weight and vitamin D level. Our study shows that weight of children with low vitamin D levels was higher than the weight of children with normal vitamin D levels (p-value=0.0001).

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CONCLUSION

On the contrary, a cross sectional observational study performed in Iran on 215 children aged 2 to 7 years to determine the association between BMI and serum level of vitamin-D in children, found no correlation between BMI and vitamin-D deficiency [2]. According to other studies on the association between obesity and BMI on vitamin D status among children in Spain (102 children aged 9-13 years) and Poland (100 children aged 1-5 years), BMI and abdominal obesity can lead to vitamin D insufficiency in children, particularly in the autumn-winter season [6,14].

Future studies should investigate whether vitamin D deficiency is a risk factor for developing obesity in children or whether obesity is a risk factor for vitamin D deficiency.

In conclusion, early diagnosis of vitamin D deficiency and definitive management can prevent many complications that could affect child health and cause burden on the community. It remains unknown whether vitamin D deficiency is a risk factor for the development of obesity in children. However, children with high BMI showed lower levels of vitamin D. We recommend promoting healthy diet and physical activities for children to prevent obesity and vitamin D deficiency.

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