**Study of risk factors affecting vitamin D deficiency in obese children.**

# ABSTRACT

Vitamin D deficiency is a widespread health issue among obese children, contributing to metabolic disturbances despite adequate sunlight exposure in many regions. Understanding its relationship with biochemical markers is crucial for early detection and intervention. This study aimed to evaluate the association between serum vitamin D levels and calcium, magnesium, cholesterol, and triglycerides in morbidly obese children. It sought to identify potential early biomarkers of metabolic dysfunction related to hypovitaminosis D. The study was conducted at the Women’s and Children’s Hospital in Diwaniyah, Iraq, from March to July 2025. Blood samples were collected from 50 children aged 6–16 years diagnosed with morbid obesity, attending various hospitals and outpatient clinics across Diwaniyah. Anthropometric measurements were recorded using standardized equipment. Biochemical analysis included spectrophotometric enzyme assays for calcium, magnesium, cholesterol, and triglycerides, and CLIA for 25(OH)D. Data were analyzed using SPSS v26.0 with Pearson’s correlation and linear regression tests. Results showed that 86% (n = 43) of participants had vitamin D deficiency (< 20 ng/mL), with a mean level of 15.2 ± 3.5 ng/mL. Elevated cholesterol was observed in 64% (n = 32) and high triglyceride levels in 70% (n = 35) of children. Mean calcium was 8.7 ± 0.4 mg/dL and magnesium 1.8 ± 0.2 mg/dL, with low magnesium observed in 36% (n = 18). A moderate negative correlation was found between vitamin D and triglycerides (r = -0.45) and cholesterol (r = -0.41), while positive correlations were observed with magnesium (r = 0.35) and calcium (r = 0.28). The findings indicate that vitamin D deficiency in morbidly obese children is significantly associated with lipid abnormalities and marginal mineral status, suggesting its potential role as a biomarker of early metabolic risk.

**Keywords: Vitamin D Deficiency; Morbid Obesity; Children; Calcium; Magnesium; Triglycerides; Cholesterol; Metabolic Risk; Pediatric Obesity; Iraq.**

# INTRODUCTION

Vitamin D deficiency has emerged as a widespread public health concern, particularly among children and adolescents with obesity. Despite abundant sunshine in regions such as the Middle East, a high prevalence of hypovitaminosis D continues to affect these populations [(Al-Ajlan et al. 2023)](https://paperpile.com/c/XINzeu/cczq). A recent meta-analysis confirmed that obese children and adolescents are 41% more likely to be vitamin D deficient compared to their normal-weight peers [(Fiamenghi and Mello 2021)](https://paperpile.com/c/XINzeu/J5r4). This deficiency contributes to a range of complications including impaired bone development, immune dysfunction, and increased susceptibility to metabolic disorders. Such widespread deficiency carries significant clinical, social, and economic implications.

Treating vitamin D deficiency in obese pediatric populations presents numerous challenges. Obese individuals often demonstrate a blunted response to standard vitamin D supplementation regimens, requiring higher doses for effective correction [(Aguirre Castaneda et al. 2012)](https://paperpile.com/c/XINzeu/13Yg). Moreover, hypovitaminosis D is frequently undiagnosed due to vague or absent clinical symptoms, delaying intervention and increasing long-term health risks [(Vlad, Istrate-Grigore, and Pacurar 2025)](https://paperpile.com/c/XINzeu/wME5). The multifactorial causes of deficiency—ranging from limited sun exposure and sedentary behavior to poor nutritional intake—complicate treatment strategies, especially in developing regions with limited healthcare access and public health infrastructure [(Fiamenghi and Mello 2021)](https://paperpile.com/c/XINzeu/J5r4).

There is growing evidence supporting the hypothesis that vitamin D deficiency may be associated with alterations in serum biochemical markers such as calcium, magnesium, triglycerides, and cholesterol in obese children. While some studies have found a strong association between low vitamin D and elevated triglycerides and LDL levels [(Torun et al. 2013)](https://paperpile.com/c/XINzeu/ROpX) , others have highlighted a significant link with hypomagnesemia [(Al-Ajlan et al. 2023)](https://paperpile.com/c/XINzeu/cczq). These correlations suggest potential underlying mechanisms of metabolic dysregulation that may contribute to the compounded health risks observed in this population.

Vitamin D, calcium, and magnesium share interconnected metabolic pathways. Vitamin D regulates calcium and magnesium absorption in the intestines, while magnesium is a cofactor in the activation of vitamin D into its biologically active form [(Dominguez et al. 2025)](https://paperpile.com/c/XINzeu/9JrA). Simultaneously, dyslipidemia—manifested by elevated cholesterol and triglyceride levels—has been associated with both vitamin D deficiency and obesity-induced insulin resistance [(Li et al. 2025)](https://paperpile.com/c/XINzeu/2HJZ) . Understanding these interlinked pathways may provide insight into early biomarkers for identifying children at higher risk for metabolic complications.

This study aims to investigate the relationships between serum calcium, magnesium, triglycerides, and cholesterol with vitamin D status among morbidly obese children in Diwaniyah, Iraq.

# MATERIALS AND METHODS

## Study Design and Setting

This cross-sectional observational study was conducted at the Women's and Children's Hospital in Diwaniyah Governorate, Iraq. Data were collected over a five-month period, from March to July 2025.

## Study Population

Blood samples were collected from various hospitals in the governorate and from outpatient clinics. Fifty children aged 6 to 16 years were diagnosed with morbid obesity (defined as a body mass index (BMI) ≥ 120% of the 95th percentile for age and sex) at outpatient and consulting clinics [(Fiamenghi and Mello 2021)](https://paperpile.com/c/XINzeu/J5r4). Children with known endocrine disorders, chronic liver or kidney disease, genetic syndromes, or those receiving vitamin D or mineral supplements within the past three months were excluded [(Durá-Travé and Gallinas-Victoriano 2023)](https://paperpile.com/c/XINzeu/ehRS).

## Anthropometric Assessment

Body weight was measured using a calibrated digital scale to the nearest 0.1 kg, and height was measured using a wall-mounted stadiometer to the nearest 0.1 cm. Body mass index (BMI) was calculated by dividing weight (kg) by height squared (m²). BMI percentiles were interpreted according to the World Health Organization's growth reference charts [(Bundak et al. 2006)](https://paperpile.com/c/XINzeu/83fq).

## Biochemical Analysis

Fasting blood samples were collected in the morning after an overnight fast of at least 10 hours. Serum calcium, magnesium, total cholesterol, and triglyceride levels were measured using automated spectrophotometric enzyme assays (Roche Cobas c311 Analyzer, Roche Diagnostics, Switzerland), following protocols used in previous pediatric obesity studies [(Torun et al. 2013)](https://paperpile.com/c/XINzeu/ROpX) . Vitamin D status was assessed by measuring serum 25-hydroxyvitamin D [25(OH)D] using a chemiluminescent immunoassay (CLIA) on the Liaison XL platform (DiaSorin, Italy), which is considered a reliable method in pediatric vitamin D assessment [(Al-Ajlan et al. 2023)](https://paperpile.com/c/XINzeu/cczq). Vitamin D deficiency was defined as serum 25(OH)D less than 20 ng/ml [(Fiamenghi and Mello 2021)](https://paperpile.com/c/XINzeu/J5r4).

## Data Analysis

Descriptive statistics were calculated for all variables. Correlational variables were expressed as mean ± standard deviation (SD), and categorical variables were expressed as frequencies and percentages. The relationship between serum 25(OH)D levels and biochemical parameters (calcium, magnesium, triglycerides, and cholesterol) was assessed using Pearson's correlation coefficient and linear regression analysis, similar to models used in earlier studies [(Xu et al. 2022)](https://paperpile.com/c/XINzeu/VihK). A p-value of < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 26.0 (IBM Corporation, Armonk, NY, USA).

## Ethical Considerations

The study protocol was approved by the Ethics Committee of Iraqi Ministry of Health - Diwaniyah Health Directorate. All procedures were conducted in accordance with the Declaration of Helsinki guidelines for human research.

# Results and Discussion

## Descriptive Statistics of Biochemical Markers

The present study examined the biochemical profiles of 50 morbidly obese children between the ages of 6 and 16 years. The measured parameters included serum levels of vitamin D, calcium, magnesium, total cholesterol, and triglycerides. As shown in Table 1, the mean vitamin D level was 15.2 ± 3.5 ng/mL, with values ranging from 8.0 to 22.5 ng/mL, indicating widespread vitamin D deficiency within the study population. Mean serum calcium was 8.7 ± 0.4 mg/dL, while magnesium averaged 1.8 ± 0.2 mg/dL. Total cholesterol and triglyceride levels were elevated, with mean values of 190 ± 30 mg/dL and 160 ± 40 mg/dL, respectively. Both lipid markers exhibited a wide range across participants, reflecting varying degrees of metabolic dysregulation.

#### Table 1. Descriptive Statistics of Biochemical Markers in Morbidly Obese Children (n = 50)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Biomarker** | **Mean ± SD** | **Min** | **Max** | **Abnormal (%)** |
| Vitamin D (ng/mL) | 15.2 ± 3.5 | 8.0 | 22.5 | 86% (<20) |
| Calcium (mg/dL) | 8.7 ± 0.4 | 7.9 | 9.4 | — |
| Magnesium (mg/dL)\* | 1.8 ± 0.2 | 1.3 | 2.1 | 36% (low) |
| Cholesterol (mg/dL) | 190 ± 30 | 130 | 245 | 64% (high) |
| Triglycerides (mg/dL) | 160 ± 40 | 90 | 240 | 70% (high) |
| \*Note: Magnesium reference range: 1.7–2.2 mg/dL.\* | | | | |

The present study reports a mean serum vitamin D level of 15.2 ± 3.5 ng/mL among morbidly obese children in Diwaniyah, Iraq. This finding falls below the standard deficiency threshold of 20 ng/mL, indicating widespread hypovitaminosis D in the study population. These results are consistent with the findings of [(Fiamenghi and Mello 2021)](https://paperpile.com/c/XINzeu/J5r4), who reported that obese children and adolescents had significantly lower serum 25(OH)D levels compared to their normal-weight counterparts, with a pooled prevalence of deficiency exceeding 40%. Similarly, [(Al-Ajlan et al. 2023)](https://paperpile.com/c/XINzeu/cczq) documented high rates of vitamin D deficiency among adolescents in the Middle East, despite abundant sunlight, attributing this paradox to lifestyle factors such as limited sun exposure, dietary inadequacies, and sedentary behavior. The narrow range of vitamin D values observed in the current study suggests that deficiency is both common and relatively homogeneous within the target population.

In terms of serum calcium and magnesium levels, the current study revealed mean values of 8.7 ± 0.4 mg/dL and 1.8 ± 0.2 mg/dL, respectively. These results fall within the normal laboratory ranges for pediatric populations but reflect the lower bounds of adequacy. [(Al-Ajlan et al. 2023)](https://paperpile.com/c/XINzeu/cczq) previously observed that vitamin D deficiency in obese adolescents was frequently accompanied by suboptimal magnesium levels, a mineral essential for vitamin D activation and calcium homeostasis. Additionally, [(Dominguez et al. 2025)](https://paperpile.com/c/XINzeu/9JrA) explained that magnesium functions as a cofactor in the enzymatic conversion of vitamin D to its active form, suggesting that even moderate hypomagnesemia may compound the functional consequences of low vitamin D. The moderately low calcium levels reported here may also reflect impaired intestinal absorption secondary to vitamin D deficiency, as previously proposed by [(Vlad, Istrate-Grigore, and Pacurar 2025)](https://paperpile.com/c/XINzeu/wME5), who highlighted a combined deficiency of vitamin D and micronutrients among obese children.

Regarding lipid profiles, the present study found elevated mean serum cholesterol (190 ± 30 mg/dL) and triglyceride levels (160 ± 40 mg/dL), with some values exceeding 240 mg/dL. These findings align with those of [(Torun et al. 2013)](https://paperpile.com/c/XINzeu/ROpX), who found that children with low vitamin D concentrations exhibited significantly higher levels of total cholesterol and triglycerides. Similar lipid disturbances were reported by [(Huang et al. 2015)](https://paperpile.com/c/XINzeu/FtWp), who observed that vitamin D deficiency was associated with increased dyslipidemia and markers of insulin resistance in obese adolescents. The wide variation in cholesterol and triglyceride levels seen in this study further suggests individual differences in dietary intake, physical activity, or genetic predisposition. These results support the idea that vitamin D deficiency in obese pediatric populations may contribute not only to skeletal problems but also to broader metabolic dysregulation.

## Correlation Between Vitamin D and Biochemical Markers

The correlation matrix provided in Table 2 describes the linear relationships between serum vitamin D and other biochemical markers. A moderate negative correlation was observed between vitamin D and triglycerides (r = -0.45), indicating that lower vitamin D levels were associated with higher triglyceride concentrations. Similarly, vitamin D was moderately inversely correlated with cholesterol (r = -0.41), suggesting a consistent relationship between vitamin D deficiency and lipid abnormalities. Positive correlations were observed between vitamin D and both magnesium (r = 0.35) and calcium (r = 0.28), indicating that higher vitamin D levels were mildly associated with improved mineral status. These findings reflect the interconnected nature of vitamin D with both lipid and mineral metabolism.

#### Table 2. Correlation Matrix Between Vitamin D and Other Biochemical Markers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Vitamin D** | **Calcium** | **Magnesium** | **Cholesterol** | **Triglycerides** |
| Vitamin D | 1.00 | 0.28\* | 0.35\* | -0.41\* | -0.45\* |
| Calcium | — | 1.00 | 0.32\* | -0.20 | -0.25 |
| Magnesium | — | — | 1.00 | -0.30\* | -0.22 |
| Cholesterol | — | — | — | 1.00 | 0.55\* |
| Triglycerides | — | — | — | — | 1.00 |
| \*Statistical significance (p<0.05). | | | | | |

The correlation analysis revealed several meaningful associations between serum vitamin D levels and biochemical markers among morbidly obese children. Most notably, vitamin D levels demonstrated a moderate negative correlation with triglycerides (r = -0.45) and cholesterol (r = -0.41), indicating that lower vitamin D concentrations were associated with higher lipid levels. These findings are consistent with earlier observations by [(Torun et al. 2013)](https://paperpile.com/c/XINzeu/ROpX), who reported that obese children with hypovitaminosis D had significantly elevated triglyceride and LDL cholesterol levels. Similarly, [(Huang et al. 2015)](https://paperpile.com/c/XINzeu/FtWp) found that serum 25(OH)D was inversely associated with lipid parameters, particularly in adolescents with obesity and insulin resistance. The present results reinforce these patterns, suggesting a potential role for vitamin D in lipid regulation and metabolic health in pediatric populations.

A moderate positive correlation (r = 0.35) was observed between vitamin D and magnesium levels, while a weaker positive association (r = 0.28) was noted between vitamin D and calcium. These results support the biological interplay between vitamin D and mineral metabolism. [(Dominguez et al. 2025)](https://paperpile.com/c/XINzeu/9JrA) explained that magnesium is an essential cofactor for the enzymatic conversion of vitamin D into its biologically active form. Consequently, magnesium deficiency may impair vitamin D function even when serum levels appear adequate. [(Al-Ajlan et al. 2023)](https://paperpile.com/c/XINzeu/cczq)also identified hypomagnesemia as a common finding among adolescents with vitamin D deficiency, particularly in regions with limited nutritional diversity. The positive correlation observed between vitamin D and calcium is similarly expected, given that vitamin D facilitates calcium absorption in the intestine. This correlation, although modest, may reflect the dual burden of deficiency affecting both parameters in the studied cohort.

Other correlations within the matrix also reveal meaningful patterns. The positive correlation between cholesterol and triglycerides (r = 0.55) reflects a common metabolic phenotype in obesity characterized by dyslipidemia, which has been reported in multiple studies including [(Vlad, Istrate-Grigore, and Pacurar 2025)](https://paperpile.com/c/XINzeu/wME5). Additionally, magnesium and calcium levels were positively correlated (r = 0.32), reinforcing their interconnected metabolic roles. Weak negative correlations between calcium and lipid parameters (r = -0.25 with triglycerides, r = -0.20 with cholesterol) suggest that mineral imbalance may be indirectly associated with lipid disturbances, although the strength of these associations was limited.

# CONCLUSIONS

This study demonstrates a high prevalence of vitamin D deficiency among morbidly obese children in Diwaniyah, Iraq, with 86% of participants exhibiting serum 25(OH)D levels below the deficiency threshold. The findings highlight significant associations between low vitamin D levels and elevated triglyceride and cholesterol concentrations, as well as reduced levels of calcium and magnesium. These biochemical patterns suggest that vitamin D deficiency in obese children is part of a broader metabolic disturbance. Monitoring vitamin D status alongside lipid and mineral profiles may provide a valuable early indicator for metabolic risk. Early detection and targeted nutritional intervention are essential to prevent long-term complications in this vulnerable population.

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# DECLARATIONS

**DATA AVAILABILITY** All datasets generated or analyzed during this study are included in the manuscript.

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