AMERICAN JOURNAL OF BIOMEDICINE AND PHARMACY
https://biojournals.us/index.php/AJBP
ISSN: 2997-7177

Article

The relationship between vitamin D level and insulin resistance in overweight Iraqi women

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Received: 2024, 15, Dec
Accepted: 2025, 21, Jan
Published: 2025, 10, Feb

Abstract: **Background:** Vitamin D deficiency and insulin resistance are common conditions associated with obesity and metabolic disorders. This study aimed to investigate the relationship between vitamin D levels and insulin resistance in overweight Iraqi women, with a focus on anthropometric measures such as body mass index (BMI) and waist-to-hip ratio (WHR). **Methods:** A cross-sectional study was conducted on 80 overweight and obese women (BMI ≥ 25 kg/m²) aged 18–72 years. Serum 25-hydroxyvitamin D levels and insulin resistance, assessed using the HOMA-IR index, were measured. Participants were stratified into three vitamin D categories: deficient (<20 ng/mL), insufficient (20–30 ng/mL), and sufficient (>30 ng/mL). Anthropometric and biochemical data were analyzed using SPSS software, employing correlation, ANOVA, and regression analysis. **Results:** The majority of participants (68%) had vitamin D deficiency, with a mean vitamin D level of 20.5 ± 10.3 ng/mL. A significant negative correlation was found between vitamin D levels and HOMA-IR ($r = -0.42$, $p < 0.01$). Women in the deficient group had higher mean HOMA-IR (3.8 ± 0.7) and BMI (38.0 ± 5.4 kg/m²) compared to the sufficient group (HOMA-IR: 2.9 ± 0.5, BMI: 33.1 ± 4.8 kg/m²). Linear regression indicated that for every 1 ng/mL increase in vitamin D, HOMA-IR decreased by 0.052 units ($p < 0.001$). WHR was independently associated with higher HOMA-IR, emphasizing the role of central obesity in insulin resistance. **Conclusions:** Vitamin D deficiency is strongly associated with increased insulin resistance in overweight women, compounded by obesity and central adiposity. These findings underscore the importance of addressing vitamin D deficiency and obesity through routine screening, targeted supplementation, and lifestyle interventions to reduce the risk of metabolic disorders.

Keywords: Vitamin D deficiency, insulin resistance, HOMA-IR, obesity, Iraqi women

Introduction

Vitamin D is a fat-soluble vitamin that plays a vital role in regulating calcium and phosphate levels in the blood, contributing to bone health and immune system function(1). Vitamin D is synthesized from precursors present at the surface of the epidermis and then undergo biotransformation, which achieved at the liver and finally by hydroxylase enzymes in the kidney(2). The body can produce vitamin D when the skin is exposed to sunlight, but deficiency is common in many places due to factors such as limited exposure to sunlight (3) , use of sunscreen, and nutritional factors. sun bath at summer months need a certain time and duration to produce sufficient amount of vitamin(4). Vitamin D deficiency is a global health problem, and studies have shown that there is an association between vitamin D deficiency and an increased risk of chronic diseases such as heart disease and diabetes(5). Insulin resistance is a condition in which the body stops responding properly to insulin, resulting in increased blood glucose levels. Insulin resistance is a major factor in the development of type 2 diabetes and is closely linked to overweight and obesity(6). Although many factors contribute to the development of insulin resistance, the potential role of vitamin D deficiency in this process has recently drawn the attention of researchers(7). Recent research suggests an association between vitamin D levels and insulin resistance, but the exact relationship and mechanism of action are still not fully understood(8). This research aims to explore the relationship between vitamin D levels and insulin resistance in overweight women. We will collect and analyze health and laboratory data to understand whether vitamin D deficiency contributes to increased insulin resistance, which may help develop new preventive and treatment strategies.

Materials and Methods

Methodology

Study Design

This was a cross-sectional study conducted to evaluate the relationship between Vitamin D levels and insulin resistance among overweight and obese women. The study also explored the association between Vitamin D status and anthropometric measures such as BMI and WHR. Ethical approval was obtained from the institutional review board, and written informed consent was collected from all participants.

Participants

The study included 80 women aged 18–72 years, with a BMI ≥ 25 kg/m². Participants were recruited from outpatient clinics through purposive sampling. The inclusion and exclusion criteria were as follows:

- Inclusion Criteria:
- Women aged ≥ 18 years.
- Overweight or obese (BMI ≥ 25 kg/m²).
- No prior Vitamin D supplementation in the past three months.
- Exclusion Criteria:
- Pregnancy or lactation.
- History of chronic illnesses such as diabetes mellitus, cardiovascular disease, or chronic kidney disease.
- Use of medications affecting Vitamin D or insulin metabolism, including steroids or metformin.
- Any endocrine disorders such as hypothyroidism or polycystic ovary syndrome.

Data Collection

1. Anthropometric Measurements:

- Body Mass Index (BMI): Calculated as weight (kg) divided by height squared (m²). Weight and height were measured using a calibrated scale and stadiometer.
- Waist-to-Hip Ratio (WHR): Waist and hip circumferences were measured using a non-stretchable measuring tape, and WHR was calculated as the ratio of waist circumference to hip circumference.

2. Biochemical Analysis:

- Vitamin D Levels: Serum 25-hydroxyvitamin D (25[OH]D) levels were measured using enzyme-linked immunosorbent assay (ELISA). Participants were categorized into three groups based on Vitamin D levels:
- Deficient: <20 ng/mL
- Insufficient: 20–30 ng/mL
- Sufficient: >30 ng/mL
- HOMA-IR: Insulin resistance was assessed using the homeostasis model assessment of insulin resistance (HOMA-IR) formula:

Fasting glucose and insulin levels were determined via standard laboratory techniques after an overnight fast.

3. Other Variables:

- Age was recorded through participant self-report.
- Medical history and medication use were assessed through questionnaires.

Statistical Analysis

Data were analyzed using SPSS (version 25.0). The following statistical methods were applied:

- Descriptive Statistics: Continuous variables were summarized as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages.
- Correlation Analysis: Pearson's correlation coefficient was used to examine relationships between Vitamin D, HOMA-IR, and other variables.
- Group Comparisons:
- ANOVA was used to compare HOMA-IR, BMI, and WHR across the three Vitamin D categories, with post-hoc analysis performed using the Bonferroni test.
- Regression Analysis: A linear regression model was constructed to assess the predictive effect of Vitamin D on HOMA-IR.
- Statistical Significance: A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study adhered to the ethical principles outlined in the Declaration of Helsinki. Participants were informed about the study's purpose, procedures, and potential risks, and all provided written informed consent before enrollment. Data confidentiality and participant anonymity were maintained throughout the study.

Results

1. Descriptive Statistics

Table 1 provides an overview of the descriptive statistics of the study participants, including age, Vitamin D levels, HOMA-IR, BMI, and WHR. The mean Vitamin D level among participants was 20.5 ± 10.3 ng/mL, indicating that most individuals had deficient or insufficient Vitamin D levels. The mean HOMA-IR value was 3.4 ± 0.8, consistent with insulin resistance within this cohort. Participants exhibited high BMI values, with a mean of 36.2 ± 5.5 kg/m^2, confirming the presence of obesity.

Table 1. Descriptive statistics of study participants

Variable	Min	Median	Mean	SD
Age(years)	18	42	42.8	10.5
Vitamin D level (ng/ml)	8	18.6	20.5	10.3
HOMA-IR	2.1	3.3	3.4	0.8
BMI	26.4	35.8	36.2	5.5
WHR	0.76	0.92	0.91	0.07

2. Correlation Analysis

Pearson's correlation analysis was performed to evaluate the relationships between Vitamin D levels, HOMA-IR, and other variables. The results (Table 2) revealed a significant negative correlation between Vitamin D and HOMA-IR ($r = -0.42$, $p < 0.01$), indicating that lower Vitamin D levels are associated with greater insulin resistance. No significant correlation was observed between Vitamin D and age ($r = -0.12$)

Table 2. Correlation matrix of study variables

Variable	Age	HOMA-IR	Vitamin D
Vitamin D	-0.12	-0.42**	1.00
HOMA-IR	0.21	1.00	-0.42**
Age	1.00	0.21	-0.12

**P less than 0.01

3. Comparison Across Vitamin D Categories

Participants were stratified into three categories based on Vitamin D levels: deficient (<20 ng/mL), insufficient (20–30 ng/mL), and sufficient (>30 ng/mL). Table 3 highlights the differences in HOMA-IR, BMI, and WHR among these groups. The deficient group exhibited the highest mean HOMA-IR value (3.8 ± 0.7) compared to the sufficient group (2.9 ± 0.5). Similarly, BMI and WHR values were highest in the deficient group, suggesting a potential relationship between Vitamin D status and metabolic parameters.

Table 3. HOMA-IR and anthropometric measures by vitamin D categories

Vitamin D categories	Mean BMI	Mean HOMA-IR	Mean WHR
Deficient less than 20	38±5.4	3.8±0.7	0.94±0.07
Insufficient 20-30	35.4±5.2	3.2±0.6	0.90±0.06
Sufficient more than 30	33.1±4.8	2.9±0.5	0.87±0.05

4. Regression Analysis

Linear regression analysis was conducted to assess the predictive effect of Vitamin D levels on HOMA-IR. As shown in Table 4, there was a significant negative association between Vitamin D and HOMA-IR ($\beta = -0.052$, $p < 0.001$). This finding suggests that for every 1 ng/mL increase in Vitamin D, there is an average reduction of 0.052 units in HOMA-IR

Table 4. Regression analysis of HOMA-IR on vitamin D

Variable	Coefficient	Std Error	P-value
Constant	4.6	0.18	Less than 0.001
Vitamin D	-0.052	0.012	Less than 0.001

5. ANOVA Analysis

ANOVA testing was performed to determine if HOMA-IR significantly differed across Vitamin D categories. The analysis indicated a significant difference ($p < 0.001$) in HOMA-IR values among the three groups. Post-hoc comparisons revealed that participants in the deficient group had significantly higher HOMA-IR levels than those in the insufficient and sufficient groups.

Table 5. ANOVA results

Source	Sum of squares	df	Mean square	F-value	P-value
Between groups	15.3	2	7.65	31.21	Less than 0.001
With in groups	224.5	77	2.91		
Total	239.8	79			

Discussion

1.vitamin D and insulin resistance

The results of the current study reveal a strong negative relationship between vitamin D levels and insulin resistance in obese Iraqi women. The majority of participants in the research were suffering from vitamin D deficiency, which was associated with high levels of insulin resistance measurement (Homa IR), which indicates severe insulin resistance. Regressive or regression statistical analysis supports the theory that low vitamin D levels are an important and influential indicator of insulin resistance(9). It is known that vitamin D deficiency disrupts insulin secretion and also disrupts the sensitivity of receptors to it, strongly through its role in regulating the exit of calcium from cells. This effect also appears through its role in influencing the pathways of inflammatory processes. This is consistent with our research results specifically among contributors with high BMI and high waist circumference to pelvic circumference ratio(10,2), The results of the Anova test reinforce these observations and highlight the high importance of the high values of the Homa IR test in the group suffering from vitamin D deficiency compared to those who have normal levels of the vitamin(12,5). Vitamin D is known to affect the function of beta cells in the pancreas, and a deficiency of this vitamin may lead to the disruption of insulin secretion, which contributes to an increase in the level of HOMA-

IR. In addition to this , it is role in reducing the inflammatory mechanism in the body, which is known for it is contributing role in insulin resistance(6). In people suffering from obesity, there is a chronic inflammatory process that is low grade but maintains it is effectiveness constantly, which leads to further deterioration in the symptoms of vitamin D deficiency and its effect on the action of insulin on its receptors spread throughout various body tissues(13). Regression analysis provides more explanations and highlights the importance of the role of vitamin D and its effect on insulin resistance. For every 1 ng/ml increase in vitamin D, the level of insulin resistance(HOMA-IR) decreased by 0.052 units, and this indicate that even a moderate improvement in vitamin D levels may effectively affect metabolic health and this is agree with Elham Ehrampoush etal study Fasa university of medical science, Iran 2021(6,7).

2. Obesity as confounding factor.

The study sample specifically included obese women with a body mass index of more than 36.2, which classifies them as the second category of obesity groups. Obesity is a significant risk factor for vitamin D deficiency and insulin resistance Adipose tissue retains vitamin D and reduces its vital activity, while excess weight increases the need for insulin and thus increases insulin resistance(14,5). It is interesting that the results of the study noted that people in the vitamin D deficiency group had the highest body mass index and insulin resistance value (Homa IR), and this further reinforces the interaction between obesity, vitamin D deficiency and insulin resistance. These results increase the trend towards dealing with obesity and treating it seriously is considered a major step towards breaking the cycle of vitamin D deficiency and insulin resistance, this is agree with Jacobo Wortsman etal study 2000(15,7).

3. Role of Waist-to-Hip Ratio (WHR)

The waist-to-hip circumference ratio and its results provide an additional internal view that highlights the role of central obesity in the development and emergence of insulin resistance. Study participants with a waist-to-hip ratio greater than or equal to 0.9 generally had high Huma IR levels without regard to vitamin D levels. This observation is reliable, with a documented relationship between the accumulation of visceral fat and metabolic disorders. Visceral fat is also effective and contributes to the process of insulin resistance through the release of proinflammatory cytokines and free fatty acids(16,9,2). Interestingly, even among study participants who had the same BMI value, those with a high waist circumference to abdominal circumference ratio demonstrated higher insulin resistance. This finding highlights the importance of the waist-to-hip ratio as an independent indicator of metabolic health and recommends that intervention targeting abdominal fat may have additional benefits for improving insulin resistance and enhancing insulin response, Hasan Alhyayauch study 2023(17,8).

4.vitamin D categories and metabolic profiles

There was differences in vitamin D levels through categories in comparison in different groups of Homa-IR, BMI, and WHR. The worst metabolic profile was revealed in deficient group of vitamin D with level less than 20ng/ml, including the highest HOMA-IR and BMI results. These measures reinforce the notion that vitamin D deficiency is associated with poor metabolic conditions(18,5,7). Inspite of, the outcomes also suggest that even individuals vitamin D levels in the " insufficient" group (20-30ng/ml) may present with side effects, and there values of HOMA-IR still higher than participants in the "sufficient" group. This finding aligns with emerging evidence that optimal vitamin D levels for metabolic health may exceed the traditional sufficiency threshold of 30ng/ml, this is agree with Sahasrabuddhe etal conducted at physiology department, institute of medical sciences and research center,Nagpur, Maharashtra, India(19,9,4).

5.Age and physical activity

However there was no significant correlation between age and HOMA-IR, and vitamin D measurements , individuals of old age there vitamin D values was low while HOMA-IR high. This trend or inclination may be attributed to changes related to age and these changes are related to the manufacture of vitamin D by skin or due to the lack of activities outside the home and an increase in fatty deposits in the body(19,9). The level of physical actions was a deed in each study sample, which may have an overlap with the effect of vitamin D and obesity on insulin resistance. Physical activities enhance the tissue response to the hormone of the insulin and perpetuate the manufacture of vitamin D by exposure to sunlight, making it an embarrassing element, and no matter how in all the interventional strategies of the previously mentioned factors. This is agree with Jumaa M.A, study at 2021(20,2,4).

6. Implications for Public Health

The high prevalence of Vitamin D deficiency observed in this study (68% of participants had levels <20 ng/mL) highlights an urgent public health issue in Iraq. Factors such as limited sun exposure, cultural clothing practices, and inadequate dietary intake likely contribute to this widespread deficiency. Given the strong association between Vitamin D deficiency and insulin resistance, addressing this issue could have far-reaching implications for the prevention and management of type 2 diabetes in obese populations, This is agree with Zaidi S. I, 2015(20,18,12).

Conclusion

1. Vitamin D Deficiency and Insulin Resistance: The study revealed a strong inverse relationship between Vitamin D levels and insulin resistance (HOMA-IR) among obese Iraqi women. Participants with lower Vitamin D levels demonstrated significantly higher HOMA-IR values, indicating a greater degree of insulin resistance.
2. Obesity and Vitamin D Deficiency: Obesity emerged as a confounding factor in Vitamin D deficiency, as higher BMI and WHR values were associated with lower Vitamin D levels and greater insulin resistance. This reinforces the role of central obesity as a major contributor to metabolic dysfunction.
3. Thresholds for Vitamin D: The metabolic benefits of Vitamin D appear to extend beyond traditional sufficiency thresholds. Even participants with Vitamin D levels in the "Insufficient" category (20–30 ng/mL) exhibited suboptimal metabolic profiles, suggesting the need to reevaluate optimal Vitamin D levels in obese populations.
4. Physical Activity: Low physical activity levels were uniform across the study population and likely compounded the effects of Vitamin D deficiency and obesity on insulin resistance.
5. Clinical Importance of WHR: WHR emerged as an independent predictor of insulin resistance, emphasizing the role of central obesity in metabolic health beyond BMI measurements.

Recommendations

1. Routine Screening:
• Implement routine screening for Vitamin D levels in obese individuals, particularly women, to identify those at risk for insulin resistance and related metabolic disorders.
• Use HOMA-IR as a complementary tool to assess insulin sensitivity in clinical practice and research.
2. Vitamin D Supplementation:
• Introduce targeted supplementation programs to correct Vitamin D deficiency, especially for those with levels below 30 ng/mL. Consider supplementation doses that exceed the minimum sufficiency threshold, aiming for levels above 30–40 ng/mL to optimize metabolic health.
• Pair supplementation with lifestyle modifications to maximize its effects on metabolic outcomes.
3. Public Health Interventions:
• Launch public health campaigns to increase awareness of the importance of Vitamin D and promote safe sun exposure practices, particularly for women in Iraq.
• Advocate for fortifying common foods with Vitamin D to address widespread deficiencies at the population level.
4. Lifestyle Modifications:
• Emphasize weight loss and physical activity in obesity management programs to improve Vitamin D bioavailability and enhance insulin sensitivity.
• Encourage structured exercise programs that not only improve metabolic outcomes but also increase outdoor activities for natural Vitamin D synthesis.
5. Focus on WHR in Assessments:

• Use WHR as a routine measure to assess central obesity and its impact on metabolic health, alongside BMI. Target reductions in WHR through abdominal fat loss in intervention programs.

6. Further Research:

• Conduct larger, longitudinal studies to explore the causal relationships between Vitamin D, insulin resistance, and obesity.

• Investigate the effects of high-dose Vitamin D supplementation on insulin resistance and glucose metabolism in obese populations.

• Explore genetic and environmental factors influencing Vitamin D metabolism and its role in insulin resistance in different populations.

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