Association between Body Mass Index and Insufficient Levels of Vitamin D and B12 among Adolescents and Young Adults: An Early Opportunity to Prevent Metabolic Complications

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ABSTRACT

Obesity and overweight prevalence increased worldwide, especially among adolescents and young adults. Identification of modifiable environmental risk factors, including nutritional deficiencies, is a key step for early prevention of obesity related complications. Objective: This study explores the relation between body mass index categories and Vitamin D & Vitamin B12 status in adolescents and young adults. A cross-sectional descriptive analytical study conducted between January 2023 to March 2025 from a university hospital in Riyadh region. A sample of 232 healthy subjects aged 14 to 25 years of both sexes were included. Data collected from the laboratory investigations database of the hospital, and revised subjects' hospital files were categorized according to body mass index, and groups were compared regarding the standards of measured serum levels of Vitamin D and Vitamin B12. Among the studied population, 12.1% were underweight, 40.9% were of average weight, 28.9% were overweight, and 18.1% were obese. Vitamin D and Vitamin B12 serum levels have a statistically significant negative correlation with body mass index. In comparison to lean subjects, Vitamin B12 deficiency was higher in the obese group (31% vs 10.6%) while Vitamin B12 insufficiency was in the overweight group (40.9% vs 10.6%). While Vitamin D deficiency was statistically significant higher in obese (66.7%), overweight (65.1%), and underweight subjects (55.6%) in comparison to those with average weight (39.8%). Among adolescents and young adults, increased body mass index is strongly associated with low levels of both Vitamin D & B12, which is not limited to those with obesity but also occurs at a high rate in overweight subjects. Adolescents and young adults' nutritional screening allows early detection of nutritional insufficiency as an early opportunity to prevent metabolic complications.

Keywords: Obesity, overweight, Vitamin D, Vitamin B12, adolescents

INTRODUCTION

Chronic medical illness represents major health problems that have a great burden at the individual and community levels. Identification of high risky groups of population allows early diagnosis and interventions through applying preventive measures to decrease financial cost and reduce the disease progression, long-term morbidities, and mortality[1]. The pathophysiological processes underlying most chronic medical illnesses start at an earlier age, either during childhood or young adults. Chronic medical disorders are multifactorial, including complex interactions between genetic and environmental confounders. Nutrition is one of the modifiable environmental factors that are involved in the development of several chronic medical disorders as type 2 diabetes mellitus, hypertension, atherosclerosis, non-alcoholic fatty liver disease, cardiovascular stroke, and ischemic heart disease[2].

Despite that, adolescence and young adulthood are healthy, but health care screening revealed that about 53% of young adults aged 18-34 years have at least one chronic medical disorder, while about 22% have two or more medical disorders[3]. Most of these disorders are asymptomatic and hence are missed and underestimated. Delayed diagnosis exposes such subjects to complications that adversely affect their quality of life and their life span[4]. Risk seeking behavior, outdoor eating, poor compliance a healthy lifestyle and optimum nutrition, smoking, and over-growing rate of obesity make this age group is vulnerable to the development of chronic medical disorders with a higher incidence of severe complications and disabilities[5].

Vitamin D in the human body is not limited only to bone metabolism but also in many physiological processes. Evidence demonstrated that Vitamin D deficiency is strongly linked to the development, progression, complications, and severity of several non-communicable diseases. Insufficient Vitamin D level is associated with the development of autoimmune disorders, worsening of inflammation and oxidative stress, and contributes to the severity of metabolic syndrome[6.] Maintaining adequate Vitamin D intake is an important preventive strategy for all age groups. However, most of the health care efforts are directed to children and the elderly, with a lack of young adults[7]. Despite being a sunny country, the prevalence of Vitamin D insufficiency in Arab countries is high, ranging between 40-60%, affecting all age groups[8]. Evidence showed a high prevalence of Vitamin D insufficiency in obese subjects, which added more burdens to obesity complications[9]. Furthermore, high body mass index is associated with poor response to Vitamin D supplementation[10.]

Vitamin B12 is involved in many metabolic processes that regulate energy production and maintain cellular homeostasis. Furthermore, it plays a key role in nucleic acid methylation, that responsible for its epigenetic impact on the phenotypic presentation and severity of non-communicable diseases. Deficiency of Vitamin B12 contributes to oxidative stress, mitochondrial dysfunction, impaired hemoglobin biosynthesis, and neuronal myelination[11]. Vitamin B12 is involved in fatty acid metabolism thus, its deficiency has been associated with increased triglyceride levels, adiposity, the development of cardiometabolic disorders, and metabolic syndrome[12].

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The current study aimed to explore the relation between different body mass index categories and Vitamin D & Vitamin B12 status in adolescents and young adults.

METHODS

Study design and population

This cross-sectional descriptive analytical study included 232 healthy subjects were selected consecutively from outpatient clinics at Prince Sattam Bin Abdulaziz University Hospital in Alkharj city, Riyadh region during the period 2023-2025. Inclusion criteria: Individuals aged 14 to 25 years of both sexes who had been investigated for Vitamin D status (serum 25-hydroxy Vitamin D level) and vitamin B12 level at family medicine, medicine, and pediatric outpatient clinics of the university hospital between January 2023 to March 2025. Exclusion criteria: Subjects with history of acute or chronic medical illness, received Vitamin D or B12 supplementation, received medications affecting Vitamin D level as antiepileptics or corticosteroids, vegetarians, subjects with gastrointestinal problems impairs the absorption of Vitamin B12, those underwent gastrostomy, subjects with insufficient or missed data regarding their Vitamin D and Vitamin B12 serum levels.

The sample size of 208 or more subjects should be enrolled to obtain a confidence level of 85% that the real value is within ±5% of the measured/surveyed value based on the Riyadh region of 10.5 million population.

All included subjects were exposed to detailed history taking, including demographic data (age, sex, social status, education, and residence), nutritional history, and medical history. Complete physical examination was performed with stress on anthropometric measures of weight, height, and body mass index (BMI). BMI was calculated by dividing weight in kilograms by the square of height in meters. Based on BMI, subjects were categorized into underweight (<18.5 kg/m^2), average weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥30 kg/m^2) [13].
Assessment of serum Vitamin D and B12 status.

Under aseptic conditions, 5 ml of venous blood was collected and left to be clot for 30 min at 25°C, and serum was separated by centrifugation at 3000 rpm for 15 min. Serum was tested for Vitamin D (25-Hydroxy Vitamin D) and Vitamin B12 (Cobalamin) level using Chemiluminescent Immunoassay (COBAS e411). Serum level of 25-Hydroxy Vitamin D less than 20 ng/mL was considered deficient, level 20-60 ng/mL was considered normal, while Levels exceeding 60 ng/mL were considered high. Based on kit manufacture, serum cobalamin level <250 pg/ml was considered deficient, level 250-349 pg/ml was considered insufficient, level 350-1100 pg/ml was considered normal, while level exceeding1100 pg/ml was considered high.

Table 1. Comparison of age, sex, and vitamin D & B12 serum levels between different BMI categories

		Underweight	**Average weight**	**Overweight**	**Obese**	**One way ANOVA/chi square test**	
		n=28	**n=95**	**n=67**	**N=42**	**f/x2**	**p-value**
Vitamin D (ng/ml)	Min-Max	8.9-78	7.8-102.2	6.9-61	7.5-43	3.025	0.030*
	Mean±SD	23.57±14.54	24.28±13.27	21.31±8.76	18.22±7.70		
Vitamin B12 (pg/ml)	Min-Max	104.8-956.2	107-1270	71-1114	107-991	3.7	0.013*
	Mean±SD	438.32±176.15	437.31±172.41	362.74±150.52	367.83±170.56		
Age (years)	Min-Max	14-25	14-25	14-25	14-25	1.545	0.204
	Mean±SD	19.18±3.46	20.16±2.85	20.39±2.86	20.59±2.47		
Sex (N, %)	Male	10 (35.7%)	35 (36.8%)	26 (38.8%)	21 (50%)	2.394	0.495
	Female	18 (64.3%)	60 (63.2%)	41 (61.2%)	21 (50%)		

*significant

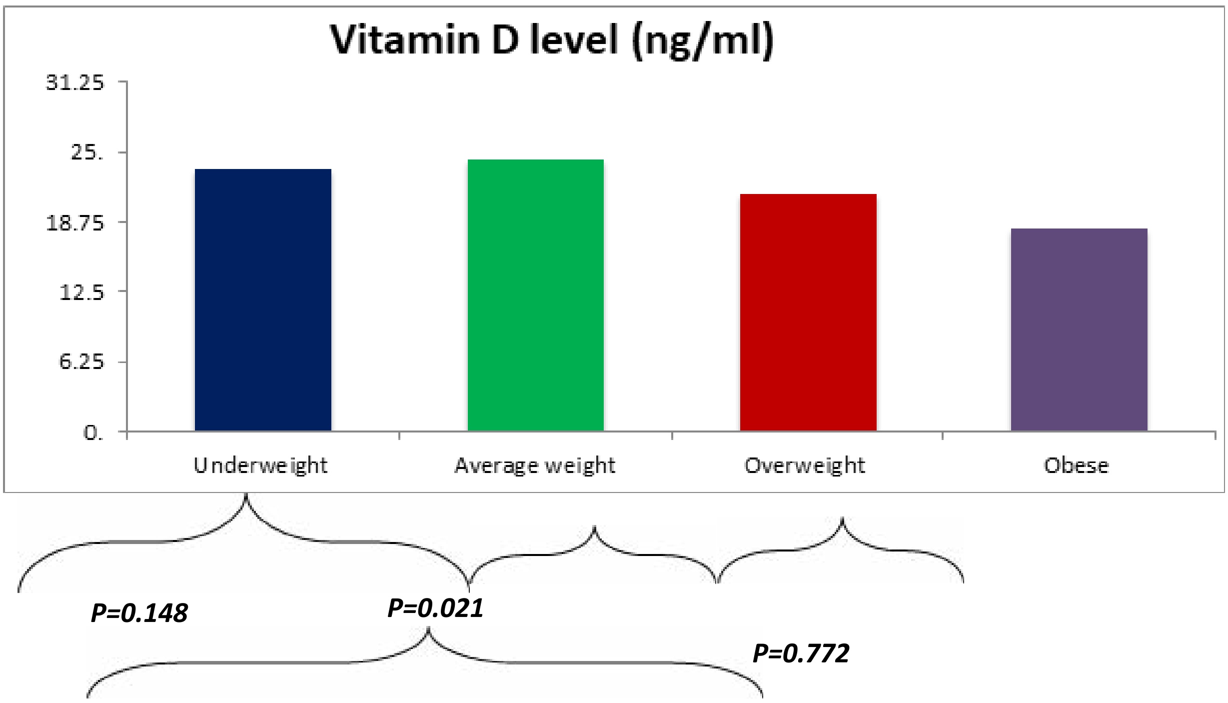

Figure 1. Serum Vitamin D level in relation to body mass index categories

Statistical analysis of data was performed using Statistical Package for Social Sciences (SPSS) software program (version 26). Chi-square test was used for categorical variables, independent student t-test and one-way analysis of variance (ANOVA) for continuous variables, and Pearson correlation analysis was used to compare data. P values of <0.05 will be accepted as levels of significance, and the results were presented in tables as mean ± SD for numerical data and percentage for non-numerical data. A 95% confidence interval will be used to evaluate the reliability of the association.

This study protocol was approved by Prince Sattam bin Abdulaziz University Research Ethics Committee [SCBR-407/2025].

RESULTS

The current study included 232 subjects, 140 were females and 92 were males. Their age ranged between 14-25 years, with a mean value of 20.19±2.88 years. Their BMI ranged between 14.3-44.7, with a mean value of 25.48±6.27; 28 of them were underweight (12.1%), 95 were of average weight (40.9%), 67 were overweight (28.9%), and 42 were obese (18.1%). Regarding Vitamin D, 117 out of 232 studied adolescents and young adults (50.4%) demonstrated a deficient level of Vitamin D, while 35 subjects (15.1%) had the deficient level of Vitamin B12, and 55 subjects (23.7%) had an insufficient level of Vitamin B12.

Both Vitamin D and Vitamin B12 levels were statistically significantly lower in the obese groups than in those with average weight. Furthermore, there is a statistically significant lower Vitamin B12 but not Vitamin D level in overweight than average weight subjects, and a statistically significant lower Vitamin D but not Vitamin B12 level in obese than overweight subjects. There is statistically significant lower Vitamin B12 but not Vitamin D level in obese than underweight subjects as shown in table 1 and Figure 1& Figure 2.

There is a statistically significantly higher frequency of Vitamin B12 deficiency in the obese group (31%) and a higher rate of Vitamin B12 insufficiency (40.9%) in the overweight group in comparison to the average weight and underweight groups. While the frequency of Vitamin D deficiency was statistically significantly higher in obese (66.7%), overweight (65.1%), and underweight subjects (55.6%) in comparison to those with average weight (39.8%), as shown in Table 2.

There were 2 subjects with a high level of Vitamin B12 were excluded from the comparison

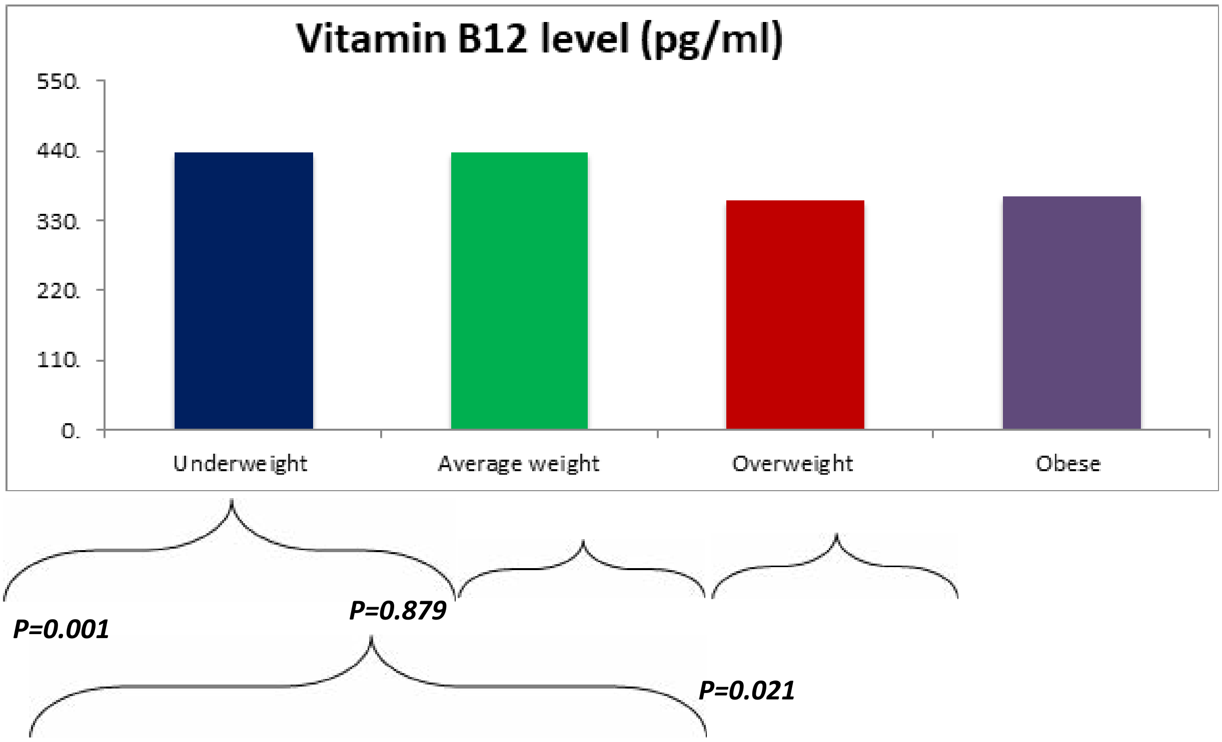

Figure 2. Serum Vitamin B12 level in relation to body mass index categories

Table 2. The frequency of Vitamin D and B12 deficiency/insufficiency in relation to BMI categories

Vitamin B12	Underweight	Average weight	Overweight	Obese	Chi square test	
	n=28	n=94	n=66	N=42	x2	p-value
Deficient <250 pg/ml	4 (14.3%)	10 (10.6%)	8 (12.1%)	13 (31%)	25.427	<0.0001
Insufficient 250-349 pg/ml	5 (17.9%)	15 (16%)	27 (40.9%)	8 (19%)		
Normal 350-1100 pg/ml	19 (67.9%)	69 (73.4%)	31 (47%)	21 (50%)		
Vitamin D	Underweight	Average weight	Overweight	Obese	Chi square test	
	n=27	n=93	n=66	N=42	x2	p-value
Deficient <20 ng/ml	15 (55.6%)	37 (39.8%)	37 (56.1%)	28 (66.7%)	9.700	0.021
Normal 20-60 ng/ml	12 (44.4%)	56 (60.2%)	29 (43.9%)	14 (33.3%)		

There were 4 subjects with a high level of Vitamin D were not included in the comparison

There is statistically significant negative correlation between both Vitamin D & Vitamin B12 levels and BMI in the studied population as shown in Table 3. Stepwise logistic regression analysis showed a strong association between BMI and lower levels of Vitamin D and Vitamin B12 as shown in Table 4.

DISCUSSION

In the current study we detect a strong association between low levels of both Vitamin D & B12 and increased BMI. This association was not limited only to obesity but was also detected in those with overweight. About 47% of our studied population is overweight (28.9%) and obese (18.1%), which is consistent with the reported global increased rate of obesity among adolescents and young adults[14]. Alsulami et al[15] demonstrated that one-third of the adult Saudi Arabian population is overweight and one-quarter is obese.

Despite of statistically insignificant difference in Vitamin D level between overweight and average weight subjects but the frequency of Vitamin D deficiency was significantly higher in overweight subjects when compared to those with average weight. This is against previous reports that the vitamin deficiency rate is similar in overweight and lean subjects[16,17]. Turer et al[18] found that the prevalence of Vitamin D deficiency was 21% in average weight subjects, 29% in overweight, 34% in obese, and 49% in morbidly obese subjects. The higher prevalence in our study could be related to the difference in age group. On the other hand, some studies revealed an insignificant association between Vitamin D status and BMI categories[19]. These contradictions are related to differences in age group, cutoff points, and methods of Vitamin D assay. Several studies demonstrate the strong association between Vitamin D deficiency, high BMI, and obesity related complications[20,21]. Volumetric dilution, in addition to trapping of active Vitamin D in the adipose tissue, limits its bioavailability even when given as a supplement and predisposes obese/overweight subjects to Vitamin D deficiency[22,23]. Furthermore, obese and overweight subjects have a lower rate of Vitamin D increase after sun exposure compared to lean subjects. Adiposity decreases the cutaneous synthesis of Vitamin D on exposure to ultraviolet rays and blunts the seasonal increase in Vitamin D level in summer months[24]. Our study demonstrated the insignificant difference in Vitamin D deficiency prevalence between overweight (65.1%) and obese subjects (66.7%), indicating that overweight subjects have the same risk for development of Vitamin D deficiency as those with obesity. The lack of the immunomodulation anti-inflammatory effect of Vitamin D increases the susceptibility of such subjects to develop obesity related complications.

Table 3. Correlation between age, Vitamin D & B12 serum levels and BMI in the studied population

	BMI	
	r	**p-value**
Vitamin D level (ng/ml)	-0.174	0.008
Vitamin B12 level (pg/ml)	-0.23	<0.0001
Age (years)	0.108	0.101

Our study revealed significantly lower Vitamin B12 levels in both obese and overweight subjects than in average-weight subjects. Vitamin B12 deficiency was significantly higher in the obese (31%), while Vitamin B12 insufficiency was significantly higher in an overweight group (40.9%). The higher rate of Vitamin B12 deficiency/insufficiency in obese and overweight subjects compared to underweight subjects suggests that this low level is caused by adiposity-related factors rather than poor oral intake. Chakraborty et al[25] reported a significant negative correlation between BMI and Vitamin B12 level with higher frequency of Vitamin B12 deficiency in overweight (39.8%) and obese (51.2%) than in normal weight adolescents (28.1%). Allin et al[26] revealed a significant association between high BMI and decreased serum Vitamin B12 level regardless of genetic variables. Aureli et al[12] reported a significant negative correlation between serum Vitamin B12 level and BMI, with significantly lower serum vitamin levels in obese than lean subjects. Despite lower Vitamin B12 levels in the overweight population than lean population but the difference was statistically insignificant. In comparison to those with normal weight, Abu–Samak et al[27] demonstrated lower Vitamin B12 levels in overweight but not obese adults. On the other hand, Mercantepe et al[28] reported an insignificant association between obesity and BMI. This contradiction is related to the selection bias of the included populations, which was limited to the overweight and obese population. Several mechanisms have been suggested to explain the association between low Vitamin B12 level and obesity includes the epigenetic impact of Vitamin B12 through DNA methylation, increase homocysteine level, adipose tissue dysfunction in addition to insufficient intake caused by unhealthy diet consumption[29].

Vitamin D and B12 deficiency are considered aggravating contributors to the development and progression of obesity-related metabolic complications[30]. Unhealthy diet, outdoor junk food, sedentary life, and a lack of sports activity are responsible for this high rate of obesity and overweight among adolescents and young adults. Over the last decades, several adiposity-related complications were identified to start even before BMI reaches an obesity level. Most cardiovascular and metabolic complications develop slowly over several years before the actual onset of symptoms[31]. Identification of modifiable environmental confounders for the development of non-communicable diseases is a key step for preventive measures, especially in high-risk and vulnerable population[32].

Table 4. stepwise linear regression analysis for the association between Vitamin D & B12 serum levels and BMI

Coefficients[a]								
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**P-value**	**95.0% Confidence Interval for B**	
		B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
1	(Constant)	27.670	0.883		31.350	0.0001	25.931	29.409
	Vitamin D	-0.098	0.035	-0.181	-2.794	0.006	-0.168	-0.029
2	(Constant)	29.338	1.189		24.672	0.0001	26.995	31.681
	Vitamin D	-0.081	0.036	-0.149	-2.247	0.026	-0.152	-0.010
	Vitamin B12	-0.005	0.002	-0.137	-2.075	0.039	-0.010	0.000
a. Dependent Variable: BMI								

CONCLUSION

Vitamin D and B12 deficiency is not only limited to those with obesity but also occurs at a high rate in overweight subjects. Adolescents and young adults with overweight/obesity need regular screening for identification of modifiable nutritional risk factors and apply early intervention strategies to prevent the development of non-communicable diseases later on.

Acknowledgments: The author thanks the Deanship of Scientific Research at Prince Sattam bin Abdulaziz University. Also, grateful to all who contributed to the success of this research.

Authorship Contribution: The author efforts covered all contribution towards (1) substantial contributions to conception and design, acquisition, analysis and interpretation of data; (2) drafting the article and revising it critically for important intellectual content; and (3) final approval of the manuscript version to be published. Yes.

Potential Conflicts of Interest: None

Competing Interest: None

Acceptance Date: 02 June 2025

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