



## Original Research Article

# PREVALENCE OF OBESITY AND VITAMIN D DEFICIENCY AMONG YOUNG ADULTS IN INDIA: INVESTIGATING THEIR INTERRELATIONSHIP USING COMPREHENSIVE ANTHROPOMETRIC MEASURES

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### ABSTRACT

**Background:** Obesity and vitamin D deficiency have emerged as critical public-health concerns worldwide have been implicated in various Chronic conditions like insulin resistance, diabetes and cardiovascular diseases. High prevalence of obesity of 13.85% and abdominal obesity at 57.7% among adults in a national study added to a Vitamin D deficiency at 70% is of great concern. And there is a paucity of data utilizing the above anthropometric indices. Hence we aim to assess the prevalence of obesity and Vitamin D Deficiency among Young Adults in India and to investigate their interrelationship using comprehensive anthropometric measures.

**Materials and Methods:** Blood Vitamin D levels, BMI (Body Mass Index), Waist circumference (WC), Waist-hip ratio (WHR), Body fat% (BF%) were measured using appropriate methods from 80 young adults after consent. Serum vitamin D levels, BMI, BF%, WHR, and waist circumference were expressed as mean and standard deviation and as a percentage. Association of gender was assessed using a chi-square test. Association of serum vitamin D level with each anthropometric variable was measured using the student t test.

**Results:** Vitamin D deficiency was 40% and insufficiency 47%. Obesity, as measured BMI (22.5%), WHR (12.15%) and WC (67.5%), the BF % was remarkably high (42.8%, 65 %) No association between vitamin D and the various anthropometric measurements was seen (BMI  $-p=0.6$ , WHR  $p=0.6$ , BF%  $p=0.1$ ).

**Conclusion:** Vitamin D insufficiency was highly prevalent and needs to be addressed. Though obesity defined by BMI was low BF % was remarkably high indicating a trend to the normal weight obesity phenotype, another area of concern.

**Keywords:** Obesity, Vitamin D Deficiency, Young Adults, Body Mass Index, Waist Circumference, Waist-Hip Ratio.

## INTRODUCTION

Obesity and vitamin D deficiency have emerged as critical public-health concerns worldwide, affecting populations across diverse geographic and socioeconomic settings. In India, Vitamin D deficiency has reached alarming levels despite the

country's tropical climate and abundant sunlight. A study among young, healthy adults in western India found hypovitaminosis D (serum 25 (OH) D levels  $<20$  ng/mL) in approximately 70% of participants.<sup>[1]</sup> Vitamin D has been implicated in a range of chronic conditions including obesity, insulin resistance,

cardiovascular disease, and type 2 diabetes mellitus.<sup>[2]</sup>

One recent nationally representative analysis found the prevalence of obesity at 13.85% among adults aged 18–54 and abdominal obesity at 57.7% in the same sample.<sup>[3]</sup> Individuals with NWO have a normal BMI (BMI) but possess disproportionately high levels of body fat—particularly visceral or abdominal fat—and are consequently at increased risk for metabolic complications such as insulin resistance, dyslipidemia, and cardiovascular disease.<sup>[4,5]</sup> Studies from India and other South Asian countries have demonstrated that BMI often underestimates adiposity in this population due to differences in body composition, with higher fat mass and lower lean mass at any given BMI compared to Western counterparts.<sup>[6,7]</sup>

A growing body of literature indicates that both obesity and vitamin D deficiency are highly prevalent among young adults globally, and increasingly within India. This coexistence of obesity and vitamin D deficiency among Indian adults is an emerging concern, with potential implications for early onset of metabolic syndrome and related non-communicable diseases.<sup>[8]</sup> However, these studies include a broader age; ranging from 18–75 years.<sup>[9]</sup> Evidence specific to Indian young adults remains limited. Moreover, many existing studies rely primarily on BMI as a proxy for adiposity. There is a paucity of data utilizing comprehensive anthropometric indices which provide superior insights into body composition and fat distribution compared to BMI alone, which will address the well-documented limitations of BMI in distinguishing between fat and lean mass and in assessing fat distribution. Hence we aim to assess the prevalence of obesity and Vitamin D Deficiency among Young Adults in India and to Investigate their Interrelationship using comprehensive anthropometric measures. By elucidating the coexistence and interdependence of obesity and vitamin D deficiency among young adults, our study aims to contribute to the growing body of evidence on the metabolic health transition in low- and middle-income countries.

## MATERIALS AND METHODS

A cross-sectional study was conducted in 80 young adults of age group 18–22 years in a Tertiary care center in South India. Institutional ethical clearance was obtained and subjects were selected based on the inclusion and exclusion criteria after written informed consent.

**Inclusion Criteria:** Adults of age 18–22 years

**Exclusion Criteria:** Subjects with chronic liver diseases, chronic renal disease, malabsorption, history of ingestion of corticosteroids, use of illicit drugs, vitamin D or calcium supplementation, or drugs affecting vitamin D metabolism

The sample size was calculated as 80 subjects using a confidence level of 95% and the percentage of deficiency from previous Indian studies.<sup>[9]</sup> For measurement of WC; costal margins and iliac crest of the subject were marked with a cosmetic pencil and WC was measured as the smallest horizontal girth between the costal margins and iliac crest at minimal respiration with a no stretchable tape. Similarly Hip circumference was measured at the level of trochanters. Height was measured using a stadiometer with the subject's head positioned in the Frankfort Horizontal Plane, feet were kept together and heels kept against the backboard.

The following formulae were used to calculate anthropometric indices

$BMI = \text{Weight in Kg} / \text{Height in m}^2$

$WHR = \text{WC in cm} / \text{Hip circumference in cm}$

BF% was calculated from skin fold thickness which was converted to an estimated BF% with the help of the following formula.

Body Fat (Females) =  $1.0994921 - (0.0009929 \times \text{sum of skin folds}) + (0.0000023 \times (\text{sum of skin folds})^2) - (0.0001392 \times \text{age})$

From Db value, final BF% was calculated using the Siri Equation

$\text{Body Fat \%} = (4.95 / \text{Db} - 4.50) \times 100$

The serum samples of the participants were collected and vitamin D3 was estimated by the Chemiluminescent immunoassay (CLIA) technique. Vitamin D levels were categorized as follows- Deficient:  $\leq 20$  ng/ml, Insufficient: 20.1–29.9 ng/ml, Sufficient:  $\geq 30$  ng/ml

**Statistical Analysis:** Data were analysed using appropriate statistical software (SPSS Version 26.0). Continuous variables were assessed for normality using the Shapiro–Wilk test and visual inspection of histograms and Q–Q plots. Normally distributed variables were expressed as mean  $\pm$  standard deviation, while non-normally distributed variables were summarised as median and interquartile range. Categorical variables were expressed as frequencies and percentages.

Correlation between serum vitamin D levels and anthropometric parameters (BMI, waist circumference, waist-to-hip ratio, and body fat percentage) was assessed using Pearson correlation coefficient for normally distributed variables and Spearman rank correlation for non-parametric data. Multivariable regression models were adjusted for potential confounders including age and gender.

## RESULTS

**Table 1: Demographic characteristics of study participants**

	Total (80)	Females (53)	Males (27)
Age (year)	19.7 +/- 1.0	19.88 +/- 0.9	19.72 +/- 0.9
Body weight (kg)	55.59 +/- 12.03	55.94 +/- 9.96	66.74 +/- 12.71
Height (cm)	1.64 +/- 0.09	1.60 +/- 0.07	1.73 +/- 0.07
BMI (kg/m <sup>2</sup> )	22.31 +/- 3.0	21.92 +/- 3.6	22.1954 +/- 3.16
WHR	0.79 +/- 0.08	0.76 +/- 0.07	0.83 +/- 0.08
% Body fat (%)	27.50 +/- 7.15	31.59 +/- 3.69	18.79 +/- 4.34
Vitamin D	22.96 +/- 8.7	23.28 +/- 7.91	22.25 +/- 3.90

This cross-sectional study included 80 young adults aged 18–22 years, with a mean age of  $19.7 \pm 1.0$  years. Of the total participants, 27 (33.8%) were males and 53 (66.2%) were females.

**Table 2: Number and percentage of study participants in different category based on BMI**

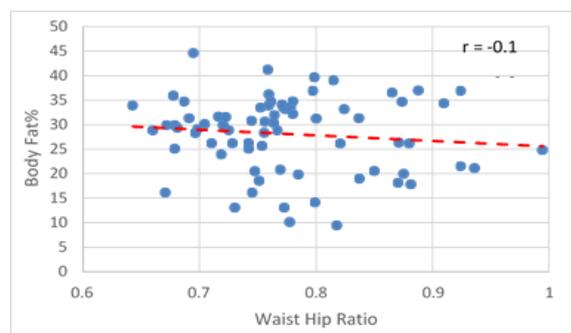
	Category	Females (Number&Percentage)	Males (Number&Percentage)	Total (Number&Percentage)
BMI	Underweight	8(15)	3(11)	11(14)
	Normal	28(53)	14(52)	42(52)
	Overweight	8(15)	6(22)	14(18)
	Obese	9(17)	4(15)	13(16)

Based on BMI classification, 14 (17.5%) participants were overweight and 13 (16.3%) were obese.

**Table 3: Number and percentage of study participants having Obesity by different anthropometric measures**

Measure of adiposity	Males	Females	Total
BF%	9 (38)	20 (41)	29(40)
WC	5(19)	11(21)	16(20)
WHR	4(15)	12(23)	16(20)

BF% was assessed in 23 male and 49 female subjects while WC and WHR were assessed in 80 study participants. High body fat percentage was observed in 29 (40%) participants. Central obesity based on WHR and WC criteria was observed in 16 (20%) participants. No statistically significant gender differences were observed in obesity prevalence based on WHR ( $p = 0.97$ ), WC ( $p = 0.40$ ), body fat percentage ( $p = 0.40$ ), or BMI ( $p = 0.80$ ).



**Figure 1: Correlation of BF% with WHR**

Body fat percentage showed a very weak negative correlation with WHR, which was not statistically significant ( $r = -0.10$ ,  $p = 0.30$ ) as shown in Figure 1.



**Figure 2: Correlation of WHR and BMI**

Body fat percentage showed a weak positive correlation with BMI ( $r = 0.30$ ,  $p = 0.003$ ). WHR demonstrated a moderate positive correlation with BMI ( $r = 0.40$ ,  $p < 0.001$ ) as in figure 2. Pearson correlation coefficient of 0.999 was obtained indicating an extremely strong positive linear relationship in males. In males, WHR and body fat percentage showed an extremely strong positive correlation ( $r = 0.999$ ). However, this finding should be interpreted cautiously given the small sample size of males included in the analysis. In females, a moderate positive correlation was observed between WHR and body fat percentage ( $r = 0.489$ ).

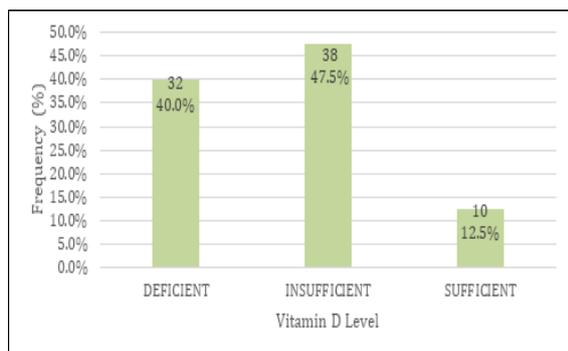


Figure 3: Vitamin D levels

Vitamin D deficiency was observed in 32 (40%) participants, while 38 (47.5%) had insufficient vitamin D levels. No statistically significant difference in vitamin D levels was observed between males and females ( $p = 0.30$ ). Males deficient or insufficient (Vitamin D  $<30$ ) was 25(93%) and only 2 had sufficient vitamin D levels. Females deficient or insufficient in Vitamin D ( $<30$ ) was 45(85%).

Table 4: Association of Vitamin D level with various Anthropometric Measures

	Deficient			Sufficient		
	DEFICIENT (n=32)	OTHERS (n=48)	P Value	SUFFICIENT (n=10)	OTHERS (n=70)	P Value
BMI	21.8 + 3.2	22.8 + 3.8	0.614	22.8 + 3.7	22.0 + 3.5	0.493
BF%	28.6 + 8.2	27.8 + 7.2	0.641	29.7 + 6.7	27.9 + 7.7	0.535
WHR	0.78 + 0.07	0.79 + 0.09	0.499	0.79 + 0.08	0.79 + 0.08	0.935

No statistically significant differences were observed in mean BMI, body fat percentage, WHR, or WC between participants with vitamin D deficiency and those with non-deficient vitamin D levels (all  $p > 0.05$ ). No statistically significant association was observed between vitamin D status and anthropometric measures including BMI, body fat percentage, and WHR.

## DISCUSSION

The present study looked into the prevalence of obesity by various anthropometric measures and its association with vitamin D status in young adults of India. As the body composition of South Asians differ from western people, the BMI standards often fail to reveal the adiposity in these population.

The combined prevalence of overweight and obesity has doubled over the last 35 years globally when overweight and obesity among children and adolescents.<sup>[10]</sup> This increasing trend was seen in India too. A nationwide study across 31 states and union territories over a span of 15 years reported that the overall prevalence of generalized obesity was 28.6% and abdominal obesity was 39.5%.<sup>[11]</sup> In our study obesity prevalence by BMI ( $\geq 25$  kg/m<sup>2</sup>) was low at 16.25%, with no gender association ( $p=0.8$ ). The lower prevalence observed in this study is likely attributable to the age disparity between cohorts; while the national ICMR-INDIAB study surveyed a broad adult population (ages 20+), our research specifically targeted young adults aged 18–22, a demographic that has had less cumulative exposure to the lifestyle and metabolic drivers of obesity. A third national study on adolescents alone reported an even lower prevalence of 6.8%.<sup>[12]</sup>

Bodyfat % (BF %) was remarkably high (male 38% and female 41 %). Females have a higher subcutaneous fat (SF) due to sex-related hormonal influences. Our study also showed a similar trend although the correlation was not statistically

significant( $p=0.4$ ). A multi-centric study on South Indian medical students done in 2021 found that BFP was higher in females (~34%) compared to males (~21%).<sup>[13]</sup>

Positive correlations emerged between BMI and BF% (BF%,  $r=0.3$ ,  $p=0.003$ ), affirming BMI as a reasonable proxy for adiposity in this group. WHR also correlated positively with BMI ( $r=0.4$ ), indicating that higher overall body mass aligns with central fat distribution. i.e. tendency for truncal obesity is more in persons with high BMI. Young adults (18-22 years) in our study likely have more uniform body compositions than mixed-age cohorts, yielding stronger BMI-WHR ties. BMI-BF% ( $r=0.3$ ,  $p=0.003$ ) and BMI-WHR ( $r=0.4$ ,  $p<0.0001$ ) correlations validate these as adiposity proxies. Although South Asian children exhibit a unique body composition, our reliance on BMI as a predictor of central adiposity is supported by the findings of Khadiilkar et al. (2014) and Misra et al. (2011). These studies demonstrated a strong positive correlation between BMI and WHR in Indian pediatric and adolescent cohorts, suggesting that BMI remains a robust indicator of abdominal fat distribution in this population.<sup>[14,15]</sup>

A correlation coefficient of 0.999 was obtained in males indicating an extremely strong positive linear relationship. This suggests that for this in young males, the WHR is a near-perfect predictor of total BF%. Interestingly, the relationship in this female dataset is slightly different from the male with a moderate Positive Correlation (0.489). The weaker correlation between WHR and BF% observed in females may be attributed to the lipogenic effects of estrogen, which promotes a gynoid fat distribution. In young women, essential fat is preferentially sequestered in the gluteofemoral region (hips and thighs); because this subcutaneous storage does not significantly increase the waist circumference, the WHR may remain relatively low despite an overall increase in body fat percentage.

The inverse correlation observed between WHR and BFP ( $r = -0.49$ ) is likely an artifact of sexual dimorphism within the study population. This statistical trend arises from the distinct adiposity phenotypes of the two sexes: females exhibited higher total BFP alongside lower, gynoid-pattern WHR values, whereas males presented with lower total BFP but higher, android-pattern WHR measurements.

The prevalence of Vitamin D deficiency among young adult college students was 40.0%, aligning with national estimates in South India where deficiency rates range between 50-80%. No significant gender difference emerged (males 93% vs. females 85%,  $p=0.9$ ), consistent with prior studies reporting similar non-sex-specific patterns driven by indoor lifestyles, limited sun exposure, and dietary habits.

No significant association appeared between Vitamin D deficiency and any obesity measure ( $p=0.9$  overall), mirroring mixed global evidence where links are inconsistent in non-elderly cohorts.<sup>[11]</sup>

Few limitations must be acknowledged. The cross-sectional design precludes causal inference. The modest sample size, particularly in subgroup analyses, may have limited statistical power to detect smaller effect sizes. Additionally, potential confounders including dietary intake, sunlight exposure duration, seasonal variation, and physical activity were not quantified, which may influence vitamin D status independently of adiposity.

## CONCLUSION

Vitamin D insufficiency is highly prevalent among young adults despite relatively modest levels of BMI-defined obesity. No significant association was observed between vitamin D status and anthropometric measures of adiposity in this cohort. These findings highlight the importance of addressing vitamin D deficiency as an independent public health concern in young adult populations.

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