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Original Article

Radiology Section

Correlation between Body Mass Index and Carotid Intima Media Thickness in Indian Population: A Hospital-based Cross-sectional Study

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ABSTRACT

Introduction: Cardiovascular Diseases (CVDs) continue to be the primary cause of death globally, with a rising burden in developing countries like India. Obesity, commonly assessed using Body Mass Index (BMI), is a well-established risk factor for CVD due to its association with metabolic disturbances and vascular changes. Carotid Intima Media Thickness (cIMT), measured non-invasively through ultrasonography, is a validated marker of subclinical atherosclerosis and an independent predictor of future cardiovascular events.

Aim: To investigate the relationship between BMI and cIMT in Indian population.

Materials and Methods: The present hospital-based cross-sectional study was conducted in People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India with 200 participants aged 30-50 years enrolled over one year and four months. A consecutive sampling strategy was employed, enrolling all individuals undergoing ultrasonography in the Department of Radiodiagnosis who met the inclusion criteria of being between 30 and 50 years of age. Patients with a history of stroke, myocardial infarction, chronic hypertension, chronic diabetes mellitus were systematically excluded to minimise confounding factors known to independently influence cIMT. Anthropometric measurements, including BMI and waist circumference, were recorded, and cIMT was assessed using high-resolution B-mode ultrasonography. Linear regression analysis was performed to determine the association between BMI, waist circumference, and cIMT.

Results: The mean age of participants was 36.8±5.8 years, with 60% females and 40% males. A weak but statistically significant positive correlation was observed between BMI and cIMT (R^2=0.029, p=0.016), with a 0.004 mm increase in cIMT per unit increase in BMI. Waist circumference showed a relatively stronger correlation with cIMT (R^2=0.054, p<0.001)compared to BMI, indicating its role as a more robust predictor of subclinical atherosclerosis. Additionally, male gender (p=0.033) and smoking (p=0.040) were significantly associated with elevated cIMT.

Conclusion: While BMI demonstrated a weak association with cIMT, waist circumference demonstrated a relatively stronger correlation with cIMT. These findings highlight the importance of incorporating both anthropometric and radiological assessments in cardiovascular risk stratification, particularly in Indian population with unique metabolic profiles.

Keywords: Atherosclerosis, Cardiovascular risk, Obesity, Waist circumference, Waist-hip ratio

INTRODUCTION

The CVDs remain the leading cause of morbidity and mortality globally, necessitating early identification and prevention strategies [1]. Among the numerous risk factors, obesity, often measured through BMI, is a key contributor to the development of atherosclerosis [2]. cIMT, a non-invasive ultrasound marker, serves as a reliable surrogate for assessing subclinical atherosclerosis and future cardiovascular event [3,4].

Previous studies have extensively explored the association of BMI with cIMT, demonstrating a positive correlation in various populations [1,3]. Research highlights that individuals with elevated BMI often exhibit increased cIMT, indicating early vascular changes that precede clinically evident CVD [4]. However, most studies have been conducted in Western populations, with limited representation from Asian cohorts, particularly in India, where the prevalence of central obesity and its associated metabolic risks differ significantly due to genetic, environmental, and lifestyle factors [5].

Despite the evidence linking BMI and cIMT, critical gaps remain in understanding this association in specific populations. The unique anthropometric thresholds for obesity in Asians warrant focused research to establish context-specific findings. Additionally, prior studies often fail to incorporate measurements of both BMI and central obesity metrics, leaving the relationship between generalised and localised adiposity with cIMT underexplored. These gaps underscore the need for targeted research in diverse cohorts, particularly in India, where the burden of non-communicable diseases is on the rise.

The present study addresses these gaps by investigating the correlation between BMI and cIMT in a hospital-based Indian population. Using high-resolution carotid ultrasound and robust anthropometric assessments, the research provides critical insights into subclinical atherosclerosis and its relationship with obesity in this demographic. The findings aim to inform targeted cardiovascular risk screening and prevention strategies tailored to South Asian populations.

MATERIALS AND METHODS

The present hospital-based cross-sectional study was conducted from November 2022 to March 2024 in the People's College of Medical Sciences and Research Centre, Bhopal, Madhya Pradesh, India. The study adhered to the ethical principles and was approved by the Insititutional Ethics Committee (Approval No. IEC-2022/118). Informed consent was taken from all participants after explaining them the procedure and the aim of the study.

Sample size calculation: Based on previous literature by Maher V et al., (2009), which reported a correlation coefficient of r=0.22 between BMI and cIMT in adults, the required sample size was calculated using the following parameters: two-sided significance level (α) of 0.05 and power (1-β) of 80% [4]. The calculated minimum required sample size was approximately 193. The final sample of 200 participants met this requirement, ensuring adequate power to detect the expected correlation. A consecutive sampling strategy was employed.

Inclusion and Exclusion criteria: All individuals undergoing ultrasonography in the Department of Radiodiagnosis, between 30 and 50 years of age, were included. Patients with a history of stroke, myocardial infarction, chronic hypertension, or chronic diabetes mellitus were systematically excluded to minimise confounding factors known to independently influence cIMT.

Study Procedure

Anthropometric measurements, including body weight, height, BMI, waist circumference, hip circumference, and Waist-To-Hip Ratio (WHR), were recorded using standardised procedures based on World Health Organisation (WHO) guidelines for the Asian population [6].

The cIMT was assessed using high-resolution B-mode ultrasonography with Siemens ACUSON NX2 or Voluson S6 ultrasound machines equipped with a high-frequency linear probe. Measurements were performed with participants in a supine position, with three readings taken within 1 cm of the carotid bulb on each side, and the average value was used for analysis. All cIMT measurements were performed by a single radiologist with two years of dedicated experience in ultrasound and Doppler vascular imaging. This ensured consistency in technique and minimised inter-observer variability.

Participants were categorised into "high" and "low" cIMT groups using a threshold of ≥0.6 mm, consistent with conventions used in epidemiological research to identify early subclinical atherosclerosis [7,8]. While cIMT is ideally interpreted as a continuous variable and normative values vary with age, sex, and population characteristics, the 0.6 mm threshold has been employed in prior studies [4,7,9] to mark early vascular changes in asymptomatic adults. This cut-off was selected for its sensitivity in detecting early arterial wall thickening in middle-aged adults. This threshold, although not a diagnostic criterion, serves as a research-based marker to detect early vascular remodeling and stratify cardiovascular risk in relatively healthy adults.

BMI and WHR were used to categorise participants into risk groups for obesity and abdominal adiposity, as detailed in [Table/Fig-1,2], respectively [10,11]. Additionally, Indian-specific cut-offs for various anthropometric indicators were applied (see [Table/Fig-3]) to ensure context-relevant risk stratification [Table/Fig-3] [11,12].

Categories	BMI
Underweight	<18.5 kg/m²
Normal weight	18.5-22.9 kg/m²
Overweight	23.0-24.9 kg/m²
Obese	>25 kg/m²

[Table/Fig-1]: WHO Classification of BMI for the Asian population [10].

Health risk	Women	Men
Low	0.80 or lower	0.95 or lower
Moderate	0.81-0.85	0.96-1.0
High	0.86 or high	1.0 or high

[Table/Fig-2]: Classification of Waist-Hip ratio [11].

STATISTICAL ANALYSIS

Data were analysed using descriptive statistics and linear regression to evaluate the correlation between BMI and cIMT, with statistical significance set at p <0.05. Jamovi Version 2.6.44. was used for the data analysis.

Parameters	Indian cut-off male	Indian cut-off female
Waist Circumference (WC)	>90	>80
Waist-Hip Ratio (WHR)	>0.9	>0.85
Wrist circumference	16.5 cm	15.7 cm
Neck circumference (NC)	35.25 cm	34.25 cm
Body fat percentage	>25%	>30%
Body Mass Index (BMI)	>23 kg/m²- Overweight, >25 kg/m²- Obesity	

[Table/Fig-3]: Indian cut-offs for various anthropometric indicators [11,12].

RESULTS

The study included 200 participants with a mean age of 36.8±5.8 years, comprising 120 females (60%) and 80 males (40%). The mean BMI was 23.3±4.6, ranging from 14.2 to 40.0, representing a spectrum from underweight to obesity. Among the participants, 78% had no chronic co-morbidities, while 22% reported conditions such as diabetes and hypertension [Table/Fig-4].

Sr. no.	Characteristic	Category	Frequency (n)	Percentage (%)
1.	Gender (N=200)	Male	80	40.0
		Female	120	60.0
		Missing	0	0.0
2.	Co-morbidity (N=200)	Present	44	22.0
		Absent	156	78.0
		Missing	0	0.0
3.	Smoking (N=200)	Present	21	10.5
		Absent	179	89.5
		Missing	0	0.0
4.	Alcoholism (N=198)	Present	26	13.1
		Absent	172	86.9
		Missing data	2	–
5.	Dietary habit (N=195)	Vegetarian	108	55.4
		Non-vegetarian	87	44.6
		Missing	5	–
6.	Lifestyle (N=196)	Sedentary	133	67.9
		Active	63	32.1
		Missing data	4	–

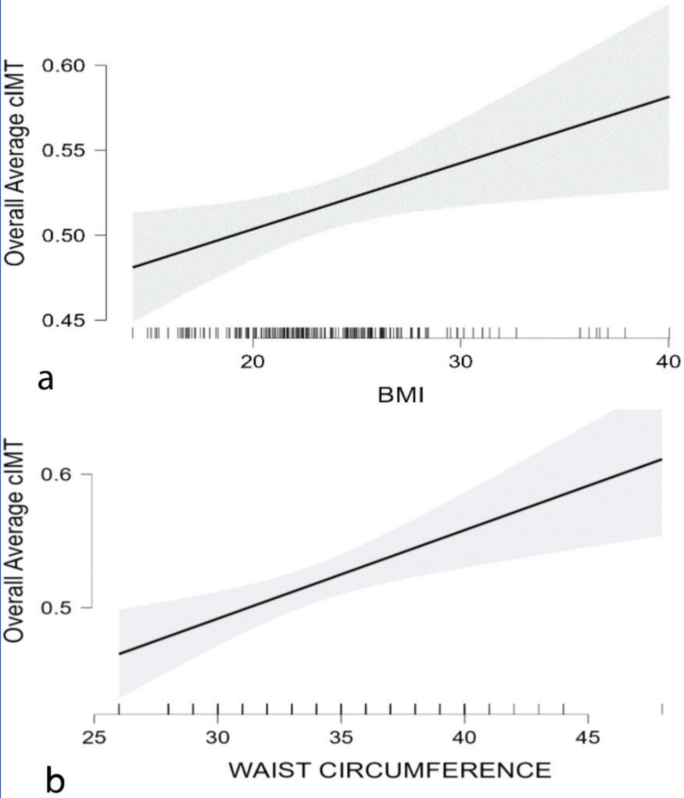
[Table/Fig-4]: Background profile of participants. Values represent frequency and percentage based on valid responses (subgroup N stated per characteristic). Missing values, where present, are noted and excluded from percentage calculations. Among the total 200 participants, complete data were not available for a few background variables. Specifically, data on alcohol consumption were missing for two participants, dietary habit data were missing for five participants, and lifestyle activity data were missing for four participants. These individuals were excluded from respective subgroup analyses. Percentages have been calculated based on available valid responses.

The analysis revealed significant associations between cIMT and gender, as well as smoking, as summarised in [Table/Fig-5]. Males exhibited high cIMT compared to females (χ^2=4.554, p=0.033). Similarly, smokers had significantly elevated cIMT compared to non-smokers (χ^2=4.206, p=0.040).

A weak but statistically significant positive correlation was found between BMI and cIMT (R^2=0.029, R^2=0.054, p<0.001), as illustrated in [Table/Fig-6a], which displays the marginal effect plot for BMI. For each unit increase in BMI, the overall average cIMT increased by 0.004 mm. However, BMI explained only 2.9% of the variability in cIMT, suggesting that other factors may play a more substantial role in influencing cIMT. In contrast, waist circumference demonstrated a stronger positive correlation with cIMT, explaining 5.4% of its variability (F=11.236, p <0.001). For every unit increase in waist circumference, cIMT increased by 0.007 mm, as shown in [Table/Fig-6b], underscoring the importance of central adiposity as a predictor of vascular changes.

Sr no.	Characteristics		cIMT High (≥0.6)	cIMT Low (0.6)	Chi-square test
1.	Gender	Male	21 (26.3)	59 (73.7)	χ^2=4.554 p=0.033*
		Female	17 (14.2)	103 (85.8)	
2.	Co-morbidity	Present	12 (27.3)	32 (72.7)	χ^2=2.509 p=0.113
		Absent	26 (16.7)	130 (83.3)	
3.	Smoking	Present	8 (34.8)	15 (65.2)	χ^2=4.206 p=0.040*
		Absent	30 (16.9)	147 (83.1)	
4.	Alcoholism	Present	8 (28.6)	20 (71.4)	χ^2=1.938 p=0.164
		Absent	30 (17.4)	142 (82.6)	
5.	Dietary habit	Vegetarian	21 (22.8)	71 (77.2)	χ^2=1.621 p=0.203
		Non-vegetarian	17 (15.7)	91 (84.3)	
6.	Lifestyle	Sedentary	14 (20.9)	53 (79.1)	χ^2=0.235 p=0.628
		Active	24 (18)	109 (82)	

[Table/Fig-5]: Association of background factors with cIMT.
*Significant with p-value <0.05



[Table/Fig-6 a,b]: Marginal effect of BMI; waist circumference on overall average cIMT.

DISCUSSION

A significant association between gender and cIMT was observed, with males exhibiting higher cIMT compared to females (χ^2=4.554, p = 0.033). This aligns with existing research by Myasoedova VA et al., and Memish ZA et al., suggesting that males are more predisposed to early vascular changes, possibly due to hormonal differences, genetic factors, and lifestyle behaviors [7,11]. These findings reinforce the need for gender-specific strategies in cardiovascular risk assessment and prevention. Similarly, smoking was found to be significantly associated with elevated cIMT (χ^2=4.206, p=0.040), supporting previous evidence by Messner B and Bernhard D, Howard G et al., and Kotsis VT et al., that smoking contributes to endothelial dysfunction and accelerates atherogenesis [8,12,13]. The detrimental vascular effects of smoking highlight the urgency of integrating smoking cessation programs into public health initiatives.

The analysis revealed a weak but statistically significant correlation between BMI and cIMT (R^2=0.029, p=0.016). While BMI has been widely recognised as an indicator of general obesity, its limited ability to explain cIMT variability suggests the need to consider other factors influencing vascular health. In contrast, waist circumference emerged as a stronger predictor, explaining 5.4% of the variance in cIMT (F=11.236, p <0.001). This underscores the significance of central adiposity in contributing to subclinical atherosclerosis, consistent with the hypothesis proposed by Maher V et al., and Wajchenberg BL that visceral fat is more metabolically active and proinflammatory, thereby exerting a greater impact on vascular health [4,14].

Additional studies have also highlighted the importance of anthropometric markers in predicting cardiovascular risk. For instance, Yusuf S et al., (2005) in the INTERHEART study demonstrated that abdominal obesity is strongly linked to myocardial infarction risk globally [15]. Furthermore, Oni ET et al., (2013) noted that cIMT correlates independently with metabolic syndrome components in multiple ethnic groups, reinforcing its role as a vascular biomarker [16]. In South Asian cohorts, Gupta R et al., (2012) also found central obesity to be a stronger determinant of subclinical atherosclerosis compared to BMI alone [17].

Other variables, including co-morbidities, alcoholism, dietary habits, and lifestyle, did not show significant associations with cIMT in this study. While these factors are known to influence cardiovascular health, their lack of statistical significance may be attributed to the sample size, confounding factors, or the limited scope of variables assessed. Future studies incorporating biochemical markers, such as lipid profiles, inflammatory markers, and insulin resistance, could provide a more nuanced understanding of the relationship between these factors and cIMT.

Limitation(s)

Another limitation is the absence of formal intra-observer variability assessment for cIMT measurements. While all ultrasonographic scans were performed by a single trained radiologist using a standardised protocol, we acknowledge that minor measurement variability could still occur, and future studies should incorporate repeat assessments to confirm reliability. Due to the limited number of participants with elevated cIMT (≥0.6 mm), we did not perform multivariate regression to adjust for potential confounders. Conducting such an analysis with insufficient outcome events would risk model overfitting and unreliable estimates. Future studies with larger sample sizes and more outcome events are needed to allow robust multivariable modeling.

CONCLUSION(S)

The present hospital-based cross-sectional study identified a statistically significant but weak correlation between BMI and cIMT, indicating a limited association between general adiposity and subclinical atherosclerosis. Waist circumference showed a relatively stronger correlation with cIMT, suggesting the added importance of central obesity as a risk indicator. However, the overall strength of associations was modest, and causality cannot be inferred due to the cross-sectional design. These findings highlight the need for more robust, prospective studies incorporating biochemical and imaging parameters for better cardiovascular risk prediction in the Indian population.

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