

RELATION OF BODY MASS INDEX WITH BLOOD PRESSURE AND LIPID PROFILE WITH PREHYPERTENSION IN YOUNG ADULTS

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ABSTRACT

Hypertension is a complex metabolic disorder. Many humoral mechanisms and risk factors are involved in the pathogenesis of hypertension. Increased body mass index is important modifiable risk factor for hypertension.

Objectives: This study is planned to investigate the association of body mass index (BMI) with blood pressure and serum lipid profile among young adults with prehypertension.

Material and Methods: This cross-sectional study was approved by the board of studies and the ethical review committee, Institute of Molecular Biology and Biotechnology (IMBB), The University of Lahore. A total of 100 young adults with prehypertension were included in the study. Written informed consent was obtained from all participants. BMI was calculated from measured height and weight. Blood pressure was measured using a mercury sphygmomanometer, with the mean of three readings obtained at appropriate intervals used as the final value. Serum lipid parameters were estimated by an end-point colorimetric method. The data recorded from all participants were entered into a standardized performa. Comparison within the groups were analyzed by ANOVA and independent t test. Pearson's correlation and multiple linear regression analyses were performed. Regression analysis for blood pressure were adjusted for age and sex.

Results: The mean age of participants was approximately 19.5 years and the participants were predominantly male. BMI was not significantly correlated with total cholesterol ($r=-0.057$, $p=0.572$), triglycerides ($r=0.041$, $p=0.688$), high density lipoproteins ($r=-0.037$, $p=0.716$) and low density lipoproteins ($r=-0.123$, $p=0.224$). Body mass index (BMI) demonstrated a weak positive but non-significant correlation with systolic blood pressure ($r=0.137$, $p=0.174$). In contrast, BMI was significantly and positively correlated with diastolic blood pressure ($r=0.303$, $p=0.002$). After adjustment for age and sex, BMI showed independent association with diastolic blood pressure ($p=0.002$), whereas the association with systolic blood pressure was not significant ($p=0.238$). The adjusted model explained 8.5% of the variance in diastolic blood pressure. No significant differences in lipid parameters were observed across BMI categories.

Conclusions: These results suggested that BMI-related alterations in blood pressure may be detectable before significant changes in the conventional lipid profile become apparent. Assessment of BMI together with blood pressure and measures of central adiposity may enable earlier identification of cardiometabolic risk in young adults.

KEYWORDS: Body mass index; prehypertension; blood pressure; diastolic blood pressure; lipid profile; young adults; cardiometabolic risk; Asian BMI.

INTRODUCTION

Hypertension is the leading cause of cardiovascular diseases. Hypertension contributes substantially to global morbidity and mortality. Prehypertension is referred as a state of elevated blood pressure or high-normal blood pressure. It characterizes an intermediate phase among normotension and hypertension. Individuals with prehypertension are at an increased risk of developing hypertension, and cardiovascular events if not addressed timely.^{1,2}

Obesity has emerged as a major health concern worldwide. It plays central role in the pathogenesis of hypertension and cardiovascular disease. Body mass index (BMI) has steadily been associated with elevated blood pressure, insulin resistance, and metabolic abnormalities.³ Excess adipose tissue stimulates sympathetic nervous system activation, renin-angiotensin system activation, endothelial dysfunction, and oxidative stress. All of these contribute to blood pressure elevation and adverse cardiovascular outcomes.⁴

Dyslipidemia is an important cardiovascular risk factor frequently observed in obese people. Dyslipidemia is typically described as reduced high-density lipoprotein cholesterol (HDL-C) and elevated serum total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDL-C). The concurrence of increased BMI and dyslipidemia markedly accelerates the risk of developing coronary artery disease and stroke.⁵

Several studies have demonstrated a positive association between BMI and adverse lipid profile in the general population.^{6,7} Increased adiposity is associated with reduced HDL-C levels and elevated triglyceride and LDL-C

concentrations. However, evidence specifically evaluating this relationship among prehypertensive individuals is relatively limited, particularly in South Asian populations.⁸

Early identification of metabolic irregularities in prehypertensive individuals will provide an opportunity for timely lifestyle modification and preventive measures before the onset of hypertension. Therefore, the present study was planned to determine the correlation of body mass index with lipid profile and blood pressure among prehypertensive subjects.

Material and Methods Study design and setting

The present cross-sectional study was conducted at the Department of Institute of Molecular Medicine and Biotechnology (IMMB), The University of Lahore, Lahore, Pakistan. A total of 100 young adults fulfilling the eligibility criteria for prehypertension were enrolled in the study. Ethical approval was obtained from the ethical review committee of The University of Lahore. Written informed consent was obtained from all participants after explaining the purpose of the research and the confidentiality was maintained throughout the study.

Inclusion Criteria: Young adults studying in different colleges and universities were enrolled after assessment of their blood pressure and confirmation of prehypertension. Physically and mentally fit subjects were enrolled in the study.

Exclusion Criteria: Subjects below 16 years and above 23 years of age, physically unfit, and using antihypertensive medication were excluded from the study. The subjects with a history of any chronic disease like diabetes mellitus were also excluded from the study.

Data collection

A standardized questionnaire was used for data collection. Relevant demographic and clinical information was recorded from each participant. Anthropometric measurements, blood pressure readings and biochemical investigations were recorded systematically using the study proforma.

Blood pressure measurement and definition of prehypertension

Blood pressure was measured using a mercury sphygmomanometer following standardized procedure. Blood pressure was measured with the participant in a standardized resting position. Three blood pressure readings were obtained at appropriate intervals, and the mean of the three readings was calculated as the final systolic and diastolic blood pressure. 9,10 Prehypertension was defined as a systolic blood pressure of 120–139 mmHg and/or a diastolic blood pressure of 80–89 mmHg according to the JNC-VII criteria.¹¹

Anthropometric measurements and body mass index

Body weight and height were measured using standardized procedures. BMI was calculated as body weight in kilograms divided by the square of height in meters:

$$\text{BMI (kg/m}^2\text{)} = \text{Weight (kg)} / \text{Height}^2 \text{ (m}^2\text{)}$$

BMI was categorized according to South-Asian classification for comparison of lipid parameters across BMI categories.¹²

Blood sampling and serum lipid profile

Venous blood samples were collected from the participants as per study protocol. Serum lipid profile included total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C). Serum lipid parameters were analyzed using Randox (Randox Laboratories Ltd., United Kingdom) diagnostic reagents.¹³

Statistical analysis

Data were entered using SPSS-25. Continuous variables are presented as mean $\pm$ standard deviation (SD). Categorical variables are presented as frequencies and percentages.

Pearson's correlation coefficient (r) was used to assess the linear relationship of BMI with serum lipid parameters as well as SBP and DBP. Multiple linear regression analysis was performed to determine whether BMI independently predicts SBP and DBP after adjustment for age and sex. Differences in lipid parameters between BMI categories were assessed using one-way analysis of variance (ANOVA). A p-value <0.05 was considered statistically significant.

RESULTS

A total of 100 prehypertensive young adults participated in the study. The demographic, anthropometric and biochemical characteristics are presented in Table 1. Participants were subsequently classified according to the South Asian BMI classification into underweight (n=14), normal weight (n=31), overweight (n=19), obese I (n=19) and obese II (n=17). Comparison of lipid parameters among BMI categories demonstrated no statistically significant differences in total cholesterol (p=0.912), triglycerides (p=0.780), HDL cholesterol (p=0.947) or LDL cholesterol (p=0.863) (Table 2). The correlation analysis demonstrated weak relations between BMI and serum lipid parameters. BMI showed weak negative correlations with total cholesterol, high and low density lipoproteins, while a weak positive correlation was observed with triglycerides. None of these correlations reached statistical significance (Table 3).

BMI was not independently associated with total cholesterol, triglycerides, HDL cholesterol or LDL cholesterol after adjustment. Similarly, age, systolic blood pressure and diastolic blood pressure were not significant predictors of lipid parameters. Male sex showed a trend toward higher total cholesterol and LDL cholesterol; however, these associations did not reach statistical significance (Table 4).

BMI demonstrated a weak positive correlation with systolic blood pressure ($r = 0.137$, $p = 0.174$), which was not statistically significant (Table 5, Figure 1). In contrast, BMI showed significant positive correlation ($r = 0.303$, $p = 0.002$) with diastolic blood pressure (Table 6, Figure 1). In adjusted multiple linear regression models controlling for age and sex, BMI demonstrated independent association with diastolic blood pressure ($B = 0.240$, 95% CI: 0.090–0.389, $p = 0.002$), whereas no significant independent association was observed with systolic blood pressure ($B = 0.228$, 95% CI: -0.153 – 0.609 , $p = 0.238$). The adjusted model explained 8.5% of the variance in diastolic blood pressure (adjusted $R^2 = 0.085$) but only 1.0% of the variance in systolic blood pressure (Adjusted $R^2 = 0.010$) as shown in Table 6.

Table 1: Baseline characteristics of the study participants (n = 100)

Variable	Value
Age (years), Mean $\pm$ SD	19.52 $\pm$ 1.72
Male, n (%)	79 (79.0)
Female, n (%)	21 (21.0)
Systolic BP (mmHg), Mean $\pm$ SD	125.97 $\pm$ 9.43
Diastolic BP (mmHg), Mean $\pm$ SD	83.38 $\pm$ 4.82
BMI (kg/m ²), Mean $\pm$ SD	24.00 $\pm$ 4.08
Total Cholesterol (mg/dL), Mean $\pm$ SD	180.80 $\pm$ 7.63
Triglycerides (mg/dL), Mean $\pm$ SD	136.16 $\pm$ 6.29
HDL-C (mg/dL), Mean $\pm$ SD	36.10 $\pm$ 1.59
LDL-C (mg/dL), Mean $\pm$ SD	117.33 $\pm$ 6.51

Table 2: Comparison of lipid profile according to WHO Asian BMI categories

BMI category	n	Cholesterol (Mean $\pm$ SD)	Triglycerides (Mean $\pm$ SD)	HDL cholesterol (Mean $\pm$ SD)	LDL cholesterol (Mean $\pm$ SD)
Underweight (<18.5 kg/m ²)	14	181.57 $\pm$ 6.14	136.07 $\pm$ 5.25	36.21 $\pm$ 1.31	118.29 $\pm$ 5.30
Normal (18.5–22.9 kg/m ²)	31	181.23 $\pm$ 6.93	136.16 $\pm$ 5.39	36.13 $\pm$ 1.45	118.03 $\pm$ 5.34
Overweight (23.0–24.9 kg/m ²)	19	179.32 $\pm$ 7.92	135.11 $\pm$ 7.58	35.89 $\pm$ 1.73	116.58 $\pm$ 7.07
Obese I (25.0–29.9 kg/m ²)	19	181.21 $\pm$ 9.86	136.05 $\pm$ 6.72	36.32 $\pm$ 1.89	117.11 $\pm$ 8.42
Obese II (≥ 30.0 kg/m ²)	17	180.59 $\pm$ 7.91	137.88 $\pm$ 7.03	36.06 $\pm$ 1.60	116.35 $\pm$ 6.83
p value	—	0.244	0.439	0.183	0.321

Table 3: Linear correlation between BMI and lipid profile

Variable	BMI	
	Pearson's r value	p-value
Total cholesterol	-0.057	0.572
Triglycerides	0.041	0.688
HDL cholesterol	-0.037	0.716
LDL cholesterol	-0.123	0.224

Table 4: Adjusted multiple linear regression showing the association between BMI and lipid profile

Outcome	Adjusted β	95% CI	p-value
Total cholesterol	-0.169	-0.502 to 0.165	0.319
Triglycerides	-0.020	-0.296 to 0.256	0.886
HDL cholesterol	-0.027	-0.096 to 0.042	0.433

LDL cholesterol	-0.209	-0.489 to 0.071	0.142
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Table 5: Linear correlation between BMI and blood pressure

Variable	n	Pearson's value	r	p-value
BMI vs. Systolic BP	100	0.137		0.174
BMI vs. Diastolic BP	100	0.303		0.002

Table 6: Adjusted Multiple Regression Analysis showing association between BMI and Blood pressure

Outcome	R	R ²	Adjusted R ²	F(3,96)	p
SBP	0.199	0.040	0.010	1.320	0.272
DBP	0.336	0.113	0.085	4.072	0.009

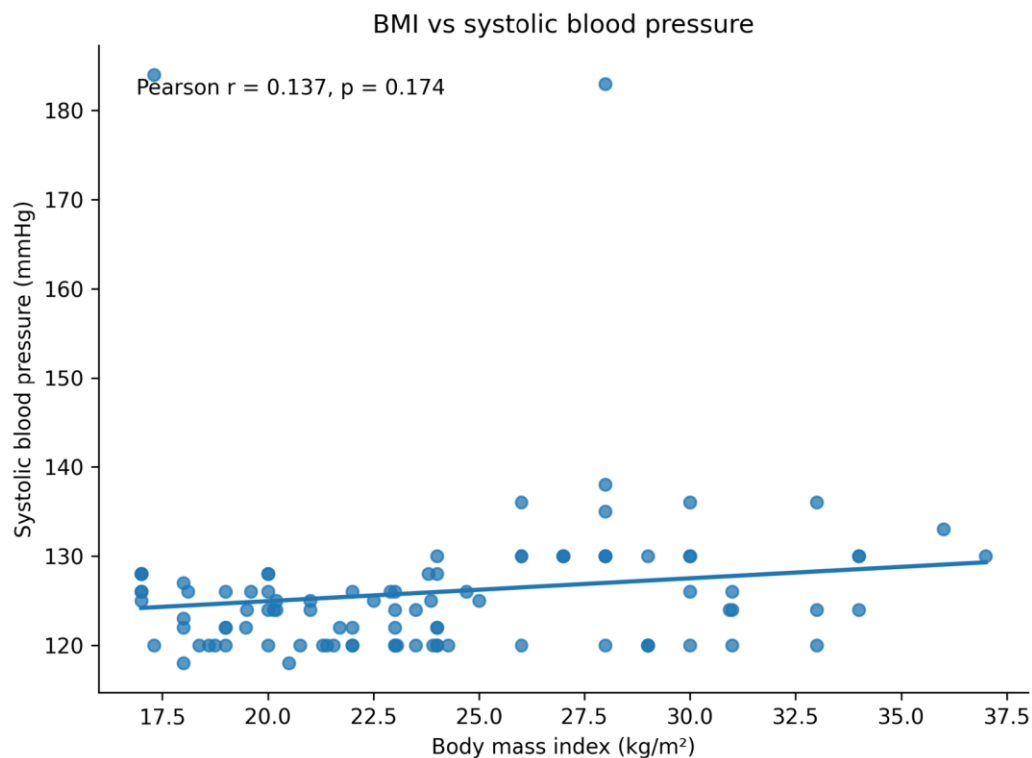


Figure 1: Relationship between BMI and Systolic blood pressure.

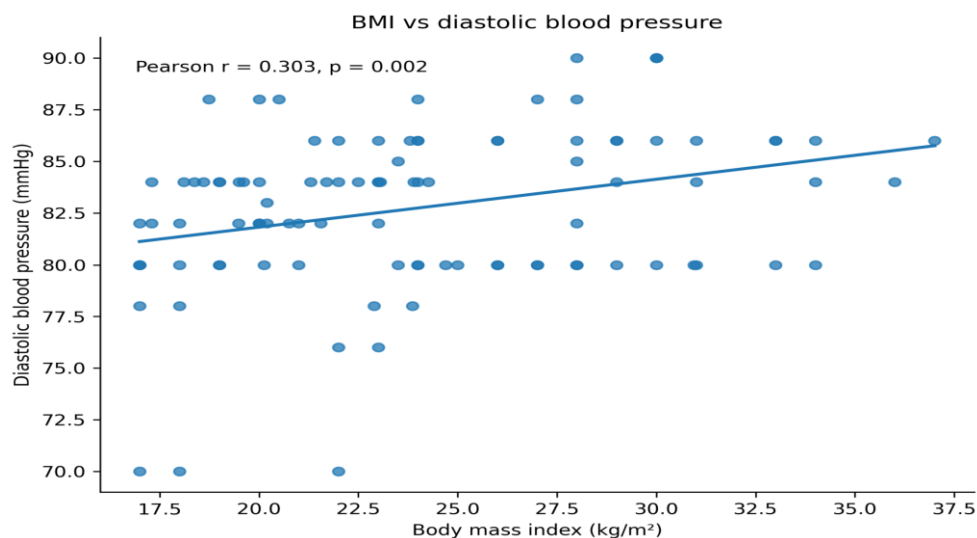


Figure 2: Relationship between BMI and Diastolic blood pressure.

DISCUSSION

The present study assessed the relationship of BMI with serum lipid profile and blood pressure among prehypertensive young adults. The body mass index revealed no statistically significant association with total cholesterol ($r = -0.057$, $p = 0.572$), triglycerides ($r = 0.041$, $p = 0.688$), high-density lipoprotein cholesterol ($r = -0.037$, $p = 0.716$), or low-density lipoprotein cholesterol ($r = -0.123$, $p = 0.224$). These results show that the body mass index alone was not an important determinant of variation in the lipid parameters in young prehypertensive subjects. These findings contrast with the evidence from adult populations in which intentional weight reduction has been associated with reductions in triglycerides and low-density lipoprotein cholesterol and increases in high-density lipoprotein cholesterol.¹⁴

The absence of a significant association between BMI and lipid parameters in the present study indicates that the body mass index is not a perfect surrogate marker for metabolically active adipose tissue in young adults. The body mass index does not differentiate between fat mass and lean mass. It only provides limited information regarding the distribution of adipose tissue. Visceral adipose tissue may provide additional information regarding cardiovascular risk beyond body mass index.¹⁵ The absence of significant associations with lipid parameters may be related to the relatively young age of the participants. The disturbances in lipid parameters may advance gradually with prolonged exposure to excess adiposity, insulin resistance, dietary risk and physical inactivity. Consequently, young individuals may have elevated body mass index without substantial abnormalities in lipid concentrations.

Body mass index demonstrated a weak positive relationship which was not statistically significant with systolic blood pressure ($r = 0.137$, $p = 0.174$). In contrast, BMI showed a moderate significant positive correlation with diastolic blood pressure ($r = 0.303$, $p = 0.002$). In the adjusted regression model, each 1 kg/m² increase in BMI was related with an estimated 0.240 mmHg increase in DBP. The adjusted model explained 8.5% of the variability in diastolic blood pressure (adjusted $R^2 = 0.085$) compared to only 1.0% of the variability in systolic blood pressure (adjusted $R^2 = 0.010$). Thus, BMI showed more evident relationship with DBP than SBP in this young prehypertensive adults.

These findings are consistent with evidence from South Asian populations. A meta-analysis found generally higher risks of hypertension with increasing adiposity among South Asians.¹⁶ Although the present study did not demonstrate a statistically significant association between BMI and SBP, the direction of the association was positive. This discrepancy may be due to the young age, and relatively small sample size.

South Asians may develop cardiometabolic abnormalities at lower levels of BMI than Western population. Differences in visceral adipose tissue contribute substantially to ethnic differences in cardiometabolic risk.¹⁷ This is supported by a recent study that showed a high burden of abdominal and visceral adiposity and cardiovascular risk among South Asian populations.¹⁸ Both general and central adiposity were positively associated with hypertension and cardiovascular disease.¹⁶ Waist-based indices may deliver additional information beyond body mass index. Waist-to-height ratio has demonstrated useful associations with cardiometabolic risk in South Asian adults and may complement BMI in clinical assessment.¹⁹

The South Asians have a disproportionately high burden of cardiovascular ailment.²⁰ The literature therefore emphasizes comprehensive cardiometabolic assessment rather than dependence on a single anthropometric measure.²¹

Limitations

The sample size was relatively small ($n = 100$), which may have limited the statistical power to detect weak BMI–lipid associations. BMI does not directly measure visceral adiposity, body-fat percentage or fat distribution. The cross-sectional design prevents determination of causal relationships.

Strength of the study

Despite limitations, the study focused specifically on young adults with prehypertension, an important population for early cardiovascular prevention. It examined BMI both as a continuous variable and according to Asian BMI categories and used complementary statistical approaches. The persistence of the BMI–DBP association strengthens the evidence for an independent association within this sample.

CONCLUSION

In conclusion, BMI demonstrated a significant positive association with DBP. These findings suggest that BMI-related blood-pressure alterations may be detectable even when conventional lipid parameters do not show significant BMI-related variation.

Recommendations

The future studies should incorporate measures of central adiposity rather than relying exclusively on BMI. Future longitudinal studies involving larger Pakistani and South Asian populations should incorporate waist circumference, waist-to-height ratio, body-fat percentage, dietary factors, physical activity and insulin resistance to determine whether measures of central or metabolic adiposity provide greater predictive value than BMI alone.

Conflict of Interest

The authors declare no conflict of interest.

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