

Research Article

Exploring the relationship between pulse pressure and body mass index: a cross-sectional study at a tertiary care general hospital in central Gujarat

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ABSTRACT

Background: Pulse pressure (PP) reflects large-artery stiffness and predicts cardiovascular events. Obesity is highly prevalent in India, but its relationship with PP in Indian adults attending hospital services is poorly characterised.

Aim: To study the relationship between PP and body mass index (BMI) categories, and age-wise variation in both, in adults attending a tertiary care general hospital in central Gujarat.

Materials and methods: In this cross-sectional study, 261 adults aged above 30 years attending a tertiary care general hospital in central Gujarat were selected by simple random sampling. Blood pressure was measured with a mercury sphygmomanometer and PP was calculated. BMI was classified by Asian-Indian cut-offs as normal (18.0-22.9 kg/m²), pre-obese (23.0-24.9 kg/m²) or obese (25.0 kg/m² or more). Pearson correlation was applied within each category.

Results: Of 261 participants, 158 (60.5%) were women and 164 (62.8%) were obese. Mean PP was 58.9 ± 17.7 mmHg and mean BMI 27.0 ± 4.9 kg/m². BMI correlated positively with PP in pre-obese ($r = 0.49$; $P = 0.0025$) and obese participants ($r = 0.24$; $P = 0.0016$), but not in those with normal BMI ($r = 0.24$; $P = 0.33$). Mean PP rose from 44.4 mmHg at 30-39 years to 62.0 mmHg at 50-59 years.

Conclusion: BMI was positively associated with PP in pre-obese and obese adults attending a tertiary care hospital, and PP was higher with advancing age. PP, a no-cost bedside measure, may help identify overweight adults, particularly those above 50 years, needing closer cardiovascular risk assessment.

Keywords: Pulse Pressure, Body Mass Index, Obesity, Arterial Stiffness, Cardiovascular Risk, India.

INTRODUCTION

Obesity has become one of the defining public health problems of this century. A pooled analysis of 3,663 population-based studies showed that, between 1990 and 2022, the prevalence of obesity rose in most countries, and that obesity now exceeds underweight in many low- and middle-income nations [1]. India reflects this transition: the national ICMR-INDIAB survey reported that a large share of Indian adults have generalised or abdominal obesity, alongside high rates of diabetes and hypertension [2]. Cardiovascular diseases (CVDs) are now the leading cause of death in India, with ischaemic heart disease and stroke accounting for most of this burden across states

[3,4], and raised blood pressure is the single most important modifiable risk factor driving it [5].

Blood pressure is usually described by its systolic (SBP) and diastolic (DBP) components, but pulse pressure (PP), calculated as SBP minus DBP, carries distinct physiological information. PP is determined chiefly by left ventricular stroke volume, the compliance of the large elastic arteries and the timing of reflected pressure waves [6]. A widened PP therefore signals stiffening of the aorta and its major branches. In a national cohort of more than 30,000 adults, PP was independently associated with incident coronary heart disease [7] and with incident stroke [8]. In acute

coronary syndromes, PP measured at presentation carries prognostic information [9], and in a large cohort of people with diabetes PP predicted severe diabetic retinopathy more strongly than SBP [10]. Aortic stiffness, of which PP is a simple surrogate, predicts cardiovascular events and all-cause mortality in meta-analysis [11].

Excess adiposity can plausibly widen PP. Obesity activates the sympathetic nervous system and the renin–angiotensin–aldosterone system, impairs pressure natriuresis and raises cardiac output [12]. Dysfunctional adipose tissue releases pro-inflammatory adipokines and promotes oxidative stress, endothelial dysfunction and vascular stiffening [13]. Because Asian Indians carry more body fat and cardiometabolic risk at a given BMI than white populations, ethnic-specific cut-offs of 23 kg/m² for overweight and 25 kg/m² for obesity are recommended for India [14].

Indian evidence on adiposity and PP remains limited and inconsistent. In a multi-state general population survey, BMI showed only weak associations with PP compared with its associations with SBP and DBP [15], while a study of Gujarati adolescents found a positive correlation between adiposity and PP in boys but not in girls [16]. Few studies have examined this relationship separately within Asian-Indian BMI categories in adults attending hospital services, a group in whom risk stratification has direct clinical value. The present study was therefore undertaken to investigate the relationship between PP and BMI categories in adults attending a tertiary care general hospital in central Gujarat, and to describe how BMI and PP vary across age groups in this population.

MATERIALS AND METHODS

Study design, setting and period

This hospital-based, cross-sectional observational study was conducted at a tertiary care general hospital in central Gujarat, India, from June to August 2025.

Ethics

The study protocol was approved by the Institutional Ethics Committee. Written informed consent was obtained from every participant before data collection, and participant confidentiality was maintained throughout.

Participants

Adults aged above 30 years attending the hospital during the study period were eligible.

A total of 261 participants were selected by simple random sampling from hospital attendees. Individuals who were pregnant, with known valvular heart disease, severe anaemia, inability to stand for anthropometry or did not give consent, were not included.

Blood pressure measurement

Blood pressure was measured in the sitting position after a period of rest, on the right upper arm supported at heart level, using a standard mercury sphygmomanometer with an appropriately sized cuff, following recommended auscultatory technique [17]. SBP and DBP were recorded at the first and fifth Korotkoff sounds respectively. Pulse pressure was calculated as $PP = SBP - DBP$ and expressed in mmHg.

Anthropometry and BMI classification

Height was measured to the nearest 0.1 cm with a stadiometer with the participant barefoot, and weight was measured to the nearest 0.1 kg on a calibrated weighing scale with light clothing. BMI was calculated as weight (kg) divided by height squared (m²). Participants were classified according to the Asian-Indian consensus cut-offs [14] as normal (18.0–22.9 kg/m²), overweight or pre-obese (23.0–24.9 kg/m²) and obese (25.0 kg/m² or more).

Statistical analysis

Data were entered and analysed in Microsoft Excel version 2408 and Jamovi version 2.3.28. Categorical variables were expressed as frequency and percentage, and continuous variables as mean $\pm$ standard deviation (SD). The relationship between BMI and PP within each BMI category was assessed with Pearson's correlation coefficient (r), and 95% confidence intervals (CI) for r were obtained by Fisher's z -transformation. Correlation strength was interpreted as weak (0.10–0.39), moderate (0.40–0.69) or strong (0.70–0.89) [18]. Exact P values are reported, and a P value below 0.05 was taken as statistically significant.

RESULTS AND DISCUSSION

Results

A total of 261 participants were studied, of whom 103 (39.5%) were men and 158 (60.5%) were women. Most participants were obese (164; 62.8%), and 173 (66.3%) were between 50 and 70 years of age (Table 1). The mean PP of the study population was 58.9 ± 17.7 mmHg and the mean BMI was 27.0 ± 4.9 kg/m².

Table 1: Socio-demographic and anthropometric profile of the study participants (n = 261)

Characteristic	Number (n)	Percentage (%)
Sex		
Male	103	39.5
Female	158	60.5
Age group (years)		
30–39	23	8.8
40–49	46	17.6
50–59	86	32.9
60–69	87	33.3
70 and above	19	7.3
BMI category (Asian-Indian cut-offs)		
Non-obese (BMI below 25.0 kg/m ²)	97	37.2
Obese (25.0 kg/m ² or more)	164	62.8
Total	261	100.0

BMI: body mass index.

Mean BMI was lowest in participants aged 30–39 years (23.4 ± 4.0 kg/m²), peaked in those aged 50–59 years (28.2 ± 4.8 kg/m²) and declined slightly in older groups. Mean PP increased from 44.4 ± 10.4 mmHg at 30–39

years to 62.0 ± 17.7 mmHg at 50–59 years, and remained elevated at 57.4 ± 15.4 mmHg and 58.6 ± 20.8 mmHg in the 60–69 years and 70 years and above groups respectively (Table 2).

Table 2: Age-wise distribution of body mass index and pulse pressure (n = 261)

Age group (years)	BMI (kg/m ²), mean $\pm$ SD	Pulse pressure (mmHg), mean $\pm$ SD
30–39	23.41 ± 3.96	44.37 ± 10.42
40–49	26.62 ± 4.10	48.22 ± 13.69
50–59	28.17 ± 4.76	62.00 ± 17.67
60–69	26.41 ± 4.67	57.37 ± 15.40
70 and above	25.00 ± 3.74	58.62 ± 20.81
All participants	27.03 ± 4.94	58.93 ± 17.69

BMI: body mass index; SD: standard deviation.

Within BMI categories, a moderate positive correlation between BMI and PP was observed in pre-obese participants ($r = 0.49$; 95% CI

0.19 to 0.70 ; $P = 0.0025$) and a weak but statistically significant positive correlation in obese participants ($r = 0.24$; 95% CI 0.10 to

0.37; $P = 0.0016$). In participants with normal BMI, the correlation was weak and not

statistically significant ($r = 0.24$; $P = 0.33$) (Table 3).

Table 3: Correlation between body mass index and pulse pressure within BMI categories

BMI category	r	95% CI	P value
Normal	0.24	–	0.33
Overweight / pre-obese	0.49	0.19 to 0.70	0.0025
Obese	0.24	0.10 to 0.37	0.0016

r: Pearson's correlation coefficient; CI: confidence interval; BMI: body mass index; –: not reported.

Discussion

In this cross-sectional study of adults attending a tertiary care general hospital in central Gujarat, BMI was positively correlated with PP in overweight (pre-obese) and obese individuals, while no significant correlation was seen in those with normal BMI. PP was also higher in older age groups, rising most sharply between the fourth and sixth decades. Nearly two-thirds of participants were obese by Asian-Indian criteria and the mean PP of 58.9 mmHg was above the 50–55 mmHg range at which PP has been linked with higher coronary risk in cohort studies [7].

The high proportion of obesity in our sample is in keeping with national data showing a substantial and rising burden of generalised and abdominal obesity in Indian adults, particularly in urban areas and in states such as Gujarat [2,19]. As a hospital-based sample of adults above 30 years, our population would be expected to carry a greater cardiometabolic risk burden than the general community.

The age-related rise in PP observed here is consistent with the established physiology of vascular ageing. With advancing age, elastin fibres in the aortic wall fragment and are replaced by stiffer collagen, increasing pulse wave velocity; reflected waves then return earlier, during systole, augmenting SBP while DBP falls or plateaus, thus widening PP [6,20]. Longitudinal data from the Framingham cohort indicate that aortic stiffness precedes and predicts the rise in blood pressure and incident hypertension [21], supporting the view that stiffening is an early vascular event rather than only a consequence of hypertension [22]. In our study, the steepest increase in mean PP occurred between the 40–49 and 50–59 year groups, which also showed the highest mean BMI, suggesting that adiposity and age may act together on the arterial wall.

The positive BMI–PP correlation in pre-obese and obese participants, but not in those with normal BMI, may be explained by several mechanisms linking excess fat to arterial stiffness. Obesity raises sympathetic activity, activates the renin–angiotensin–aldosterone system and causes renal compression and sodium retention, increasing both stroke volume and arterial load [12,23]. Hypertrophic and inflamed adipose tissue, including perivascular fat, releases leptin, tumour necrosis factor- α and interleukin-6 while adiponectin falls; these changes promote endothelial dysfunction, reduced nitric oxide bioavailability and structural stiffening of the vessel wall [13]. Insulin resistance and advanced glycation end-products further cross-link collagen in the arterial media [13]. Together these processes reduce arterial compliance, which is reflected clinically as a wider PP.

The relationship between adiposity and arterial stiffness also appears to depend on age and duration of exposure. In healthy adults studied with magnetic resonance imaging, body fat was associated with lower aortic stiffness in young people but with higher stiffness after middle age [24]. In the Whitehall II cohort, both general and central adiposity predicted faster aortic stiffening over subsequent years [25]. Most of our participants were aged above 50 years, the age range in which the adverse vascular effect of adiposity is most evident, which may partly explain the positive correlations we observed. The stronger correlation in the pre-obese group than in the obese group should be interpreted cautiously: the pre-obese group was smaller and therefore had wider confidence intervals, and BMI correlates less closely with visceral fat and arterial stiffness at higher BMI values, where muscle mass, fat distribution and

antihypertensive treatment introduce more variability.

Our findings differ in part from the large multi-state Indian survey of adults aged 18–59 years, in which BMI was only weakly correlated with PP and central adiposity measures were more informative than BMI [15]. That survey studied a younger general population, in whom PP is narrower and less influenced by arterial stiffness. Our results are closer to those reported among Gujarati adolescent boys, in whom adiposity correlated positively with PP [16]. Taken together, these data suggest that the BMI–PP relationship strengthens in older and higher-risk groups, such as adults attending tertiary care hospitals.

These observations have practical relevance. PP can be calculated from a routine blood pressure reading at no extra cost, and widened PP is an independent marker of coronary, cerebrovascular and microvascular risk [7–11]. In overweight and obese adults attending hospital services, particularly those above 50 years, a wide PP may help identify individuals who warrant fuller cardiovascular risk assessment. Current hypertension guidelines emphasise weight reduction as a core lifestyle measure for blood pressure control [26]; whether such weight loss also narrows PP in this population deserves prospective study.

Strengths and limitations

The strengths of this study include random selection of participants, use of a mercury sphygmomanometer as the reference method, use of Asian-Indian BMI cut-offs appropriate to the population, and analysis of the BMI–PP relationship within each BMI category. The study also has limitations. Its cross-sectional design does not allow causal inference. It was conducted at a single tertiary care hospital, so the findings may not be generalisable to the wider community. Blood pressure was recorded on a single occasion. Antihypertensive and antidiabetic treatment, diabetes status, smoking and physical activity were not adjusted for, and these may confound the observed associations. BMI does not distinguish fat from lean mass or capture fat distribution, and central adiposity indices such as waist circumference and direct measures of arterial stiffness such as pulse wave velocity were not recorded. Finally, analysis was limited to correlation within subgroups; multivariable regression would allow the independent contributions of age, sex and BMI to PP to be estimated.

CONCLUSION

In adults attending a tertiary care general hospital in central Gujarat, BMI showed a moderate positive correlation with pulse pressure in pre-obese individuals and a weak positive correlation in obese individuals, with no significant correlation in those of normal BMI. Pulse pressure was higher with advancing age, particularly beyond 50 years. As a simple, no-cost measure, pulse pressure may help flag overweight and obese adults who need closer cardiovascular risk evaluation, and weight management remains a reasonable target for reducing their cardiovascular risk. Longitudinal studies with central adiposity indices and direct measures of arterial stiffness are needed to confirm these findings.

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Conflict of Interest

The authors declare no conflict of interest.

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