



HIGH PREVALENCE OF CENTRAL OBESITY AND EARLY CARDIOMETABOLIC DERANGEMENTS AMONG APPARENTLY HEALTHY YOUNG MEDICAL STUDENTS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Asian Indians develop adiposity-related cardiometabolic risk at lower body-mass thresholds than European populations, and central fat accumulation may precede overt disease even in apparently lean young adults. We assessed the burden of generalized and central obesity and of early derangements in blood pressure (BP) and fasting glucose among young medical students, with particular attention to the metabolically-obese-normal-weight (MONW) phenotype.

Methods: In this cross-sectional study, 311 MBBS students aged 18–24 years were assessed using a standardized morning protocol. Height, weight, waist (WC), hip and neck circumferences (NC) were measured, and body-mass index (BMI), waist–hip ratio (WHR) and waist–height ratio (WHtR) were derived. BP was recorded by mercury sphygmomanometry and fasting capillary glucose (FBG) by validated glucometer. Obesity was classified using WHO Asian-specific BMI cut-offs and Asian-Indian central-obesity criteria; BP by the 2017 ACC/AHA thresholds and FBG by American Diabetes Association criteria.

Results: Mean BMI was 22.5 ± 3.7 kg/m². Overweight or obesity (BMI ≥ 23 kg/m²) was present in 47.9%, while WHtR-defined central obesity (≥ 0.5) affected 44.4%. Elevated BP or hypertension was found in 48.2%, and impaired fasting glucose or diabetes-range values in 26.7%. SBP, DBP and FBG rose progressively across BMI categories (all $P < 0.001$, one-way ANOVA). A substantial subset with normal BMI met central-obesity criteria, consistent with the MONW phenotype.

Conclusions: Nearly half of these apparently healthy young students showed central obesity and early cardiometabolic derangements, frequently masked by a normal BMI. BMI alone underestimates risk in this population; anthropometric screening that incorporates central-adiposity measures is warranted.

KEYWORDS: Central Obesity, Waist–height Ratio, Cardiometabolic Risk, Medical Students, Metabolically Obese Normal Weight, Blood Pressure.

Introduction

Obesity has emerged as a principal driver of non-communicable disease in India, and Asian Indians display a characteristic adiposity phenotype excess body fat, abdominal and intra-abdominal fat, and ectopic fat deposition that confers cardiometabolic risk at a lower body mass than in white European populations [1]. Recognizing this, a WHO expert consultation endorsed lower BMI action points for Asian populations, at which the risk of type 2 diabetes and cardiovascular disease becomes substantial [2]. These risks increasingly manifest at younger ages, yet screening in young adults still relies predominantly on BMI.

BMI is convenient but does not capture body-fat distribution. Central adiposity, which reflects visceral and hepatic fat, is more closely linked to cardiovascular risk than generalized adiposity. In the INTERHEART study, waist-hip ratio was a stronger predictor of myocardial infarction than BMI across all major ethnic groups, and adjustment for it abolished much of the BMI-infarction association [3]. In an Indian cross-sectional analysis, central adiposity was a more important determinant of blood pressure and hypertension than general adiposity, particularly beyond young adulthood [4]. Simple, translation-friendly indices of central fat notably the waist-height ratio have therefore been proposed as screening tools [7].

The South Asian “thin-fat” phenotype describes preserved or excess body fat with low lean mass and a propensity to insulin resistance that is evident from birth and persists into later life [5,6]. This phenotype underlies the metabolically-obese-normal-weight (MONW) state, in which individuals with an acceptable BMI nonetheless carry central adiposity and its metabolic consequences. Young adults including medical students exposed to sustained academic stress, sedentary behaviour and irregular sleep are plausibly vulnerable, and early elevations in blood pressure and fasting glucose tend to track into adulthood. Prior Indian studies have reported a high burden of overweight, obesity and elevated blood pressure among medical students [8] and a clear obesity-blood-pressure association in Indian populations [9].

Despite this, the combined burden of generalized and central obesity together with early derangements in blood pressure and fasting glucose and specifically the MONW phenotype remains under-characterized in young medical students assessed with multiple anthropometric indices simultaneously. We therefore quantified the prevalence of generalized and central obesity (using BMI, WC, WHR, WHtR and NC) and of elevated blood pressure and dysglycaemia in 311 young medical students, and examined how these varied by body-mass category and sex. The comparative predictive performance of the individual anthropometric indices is reported separately in a companion analysis from the same cohort.

Materials and Methods

Study design and setting

This cross-sectional study was conducted in the Department of Physiology, Santosh Medical College & Hospital, Santosh Deemed to be University, Ghaziabad, Uttar Pradesh, India, over approximately 15 months. All assessments were performed during early-morning hours in a temperature-controlled, well-ventilated research laboratory. The study is reported in accordance with the STROBE guidance for cross-sectional studies.

Participants

Undergraduate MBBS students aged 18–24 years were eligible. Inclusion criteria were age 18–24 years, willingness to participate, and availability in the fasting state on the assessment day. Exclusion criteria were a known history of hypertension, diabetes, chronic kidney disease or other chronic illness; use of antihypertensive, antidiabetic, lipid-lowering or systemic corticosteroid therapy; acute febrile or systemic illness; pregnancy or lactation; and incomplete anthropometric or physiological data. The final analytic sample comprised 311 participants.

Sample size

The sample size was based on an expected prevalence of elevated blood pressure and of overweight/central obesity of approximately 30–40% among young Indian adults. Assuming a 95% confidence level, 80% power and an absolute precision of about 6–7%, with adjustment for anticipated non-response and incomplete data, a minimum of 260–280 participants was required; 311 were enrolled.

Anthropometric and physiological measurements

All measurements used calibrated, standardized instruments. Standing height was measured without footwear using a stadiometer with the head in the Frankfort horizontal plane (to 0.1 cm), and body weight using a digital scale (to 0.1 kg) calibrated daily. BMI was calculated as weight (kg) divided by height squared (m^2). Waist circumference was measured at the midpoint between the lowest rib and the iliac crest in the mid-axillary line at end-expiration, and hip circumference at the widest part of the buttocks (both to 0.1 cm); WHR was WC/HC and WHtR was WC (cm)/height (cm). Neck circumference was measured just below the laryngeal prominence with the head in the Frankfort plane.

Blood pressure was measured with a mercury sphygmomanometer using the auscultatory technique and an appropriately sized cuff, after at least 5 minutes of seated rest, with the right arm supported at heart level; systolic and diastolic pressures were taken at Korotkoff phases I and V, and two readings at least 2 minutes apart were averaged. Fasting capillary blood glucose was measured with a validated glucometer (Accu-Chek, Roche Diagnostics) after an overnight fast of at least 8 hours, with periodic quality-control checks.

Operational Definitions

BMI was categorized by WHO Asian cut-offs as underweight (< 18.5), normal (18.5 – 22.9), overweight (23.0 – 24.9) and obese (≥ 25.0 kg/m²) [2]. The small number of underweight participants (BMI < 18.5 kg/m²) were combined with the normal-weight participants to form a single normal-weight reference category (BMI < 23.0 kg/m²) for all group comparisons. Central obesity was defined as WC ≥ 90 cm (men) or ≥ 80 cm (women) [1]; WHR ≥ 0.90 (men) or ≥ 0.85 (women); WHtR ≥ 0.5 [7]; and NC ≥ 37 cm (men) or ≥ 34 cm (women). Blood pressure was classified by the 2017 ACC/AHA guideline as normal (< 120 / < 80), elevated (120 – 129 / < 80), stage 1 hypertension (130 – 139 or 80 – 89) and stage 2 hypertension (≥ 140 or ≥ 90 mmHg); “elevated BP or hypertension” was analysed as a composite burden measure [10]. Fasting glucose was classified by American Diabetes Association criteria as normal (< 100), impaired fasting glucose (100 – 125) and diabetes-range (≥ 126 mg/dL); dysglycaemia denoted FBG ≥ 100 mg/dL [11].

Statistical Analysis

Analyses were performed in Stata MP 17. Continuous variables are presented as mean $\pm$ standard deviation (SD) and categorical variables as counts and percentages. Normality was assessed using histograms, Q–Q plots and the Shapiro–Wilk test. Group comparisons used the

independent t-test or one-way ANOVA (with Tukey post-hoc comparisons), or their non-parametric equivalents, and the chi-square or Fisher exact test for categorical variables. A two-sided $P < 0.05$ was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee (IEC No. SU/R/2024/1350). Written informed consent was obtained from all participants, who were assured that participation was voluntary and would not affect their academic standing. Confidentiality was maintained using unique study codes, with identifiers stored separately from the analytic dataset. Participants with markedly elevated blood pressure or fasting glucose were counselled and advised to seek further clinical evaluation.

Results

Participant Characteristics

The 311 participants had a mean age of 20.8 ± 1.7 years and comprised 155 men (49.8%) and 156 women (50.2%), drawn from the first, second and third MBBS years. A family history of hypertension, diabetes or both was reported by 28.6% of students. Descriptive anthropometric characteristics are shown in Table 1. The BMI distribution was right-skewed with a modal peak in the normal-to-near-overweight range, while WHtR clustered around 0.48 with a substantial fraction at or above the 0.5 threshold.

Table 1: Descriptive anthropometric characteristics of the study participants (n = 311)

Parameter	Mean	SD	Range
Weight (kg)	63.2	11.5	41–102
Height (cm)	167.1	9.1	149–189
BMI (kg/m ²)	22.5	3.7	16.4–34.2
Waist circumference (cm)	79.8	10.2	63–114
Hip circumference (cm)	95.3	8.7	82–119
Waist–hip ratio	0.84	0.06	0.72–1.03
Waist–height ratio	0.48	0.06	0.36–0.69
Neck circumference (cm)	32.8	3.1	28–42

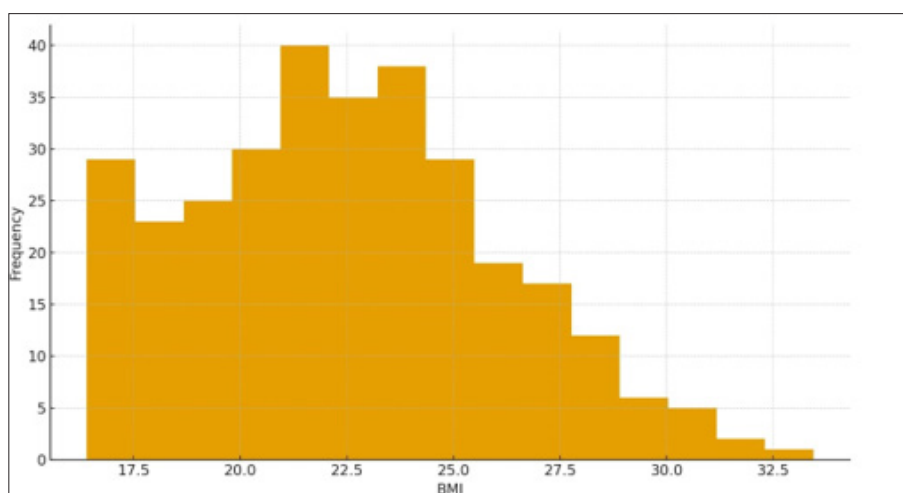


Figure 1. Distribution of body-mass index (BMI) among the 311 participants. The distribution is right-skewed, clustered in the upper-normal to overweight range with a tail into the obese range

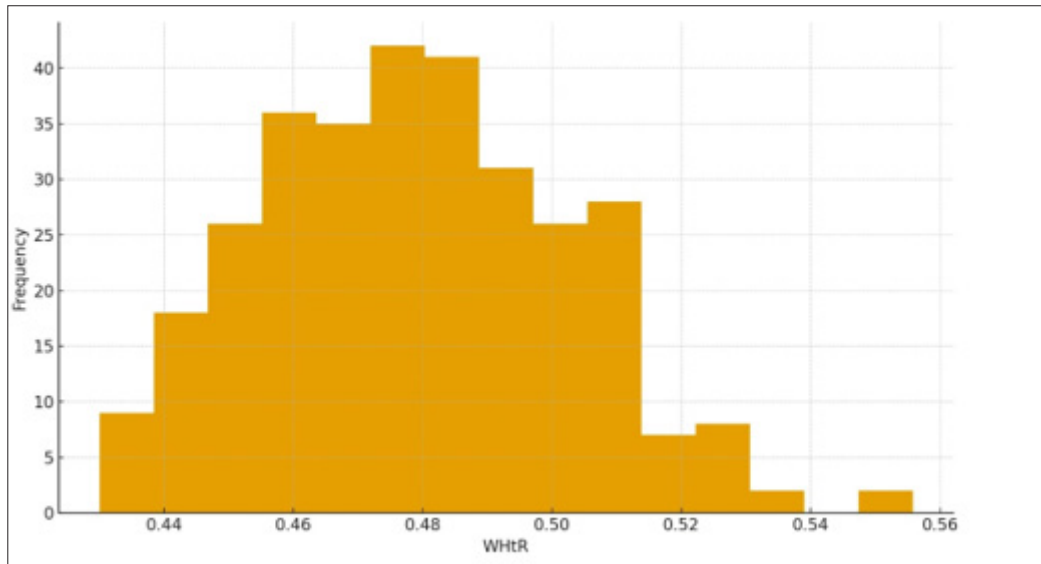


Figure 2. Distribution of waist–height ratio (WHtR). Values cluster near 0.48, with a substantial fraction at or above the high-risk threshold of 0.5, illustrating central adiposity despite frequently normal BMI

Prevalence of generalized and central obesity

By WHO Asian BMI criteria, 162 students (52.1%) were of normal weight (BMI < 23.0 kg/m², including a small number of underweight students), 81 (26.0%) were overweight and 68 (21.9%) were obese, so that 47.9% had an elevated BMI (≥ 23 kg/m²). Central obesity by WC was present in 38.2% of men and 41.0% of women, WHtR-defined central obesity (≥ 0.5) in 44.4% overall, and high-risk NC in 31.5% of men and 28.4% of women. WHtR identified the largest at-risk fraction, and a notable proportion of students with a normal BMI met WHtR or WC central-obesity criteria, consistent with the MONW phenotype. Prevalence estimates are summarized in Table 2.

Table 2: Prevalence of obesity indices, elevated blood pressure and dysglycaemia (n = 311)

Variable	Category / criterion	Prevalence
BMI (WHO Asian)	Normal weight (< 23.0)†	162 (52.1%)
	Overweight (23.0–24.9)	81 (26.0%)
	Obese (≥ 25.0)	68 (21.9%)
	Overweight or obese (≥ 23)	149 (47.9%)
Central obesity – WC	Men ≥ 90 cm	38.2% of men
	Women ≥ 80 cm	41.0% of women
Central obesity – WHtR	≥ 0.5	138 (44.4%)
Central obesity – NC	Men ≥ 37 cm	31.5% of men
	Women ≥ 34 cm	28.4% of women
Blood pressure (ACC/AHA)	Elevated BP or hypertension	150 (48.2%)
Dysglycaemia (ADA)	FBG ≥ 100 mg/dL	83 (26.7%)

† Includes a small number of underweight participants (BMI < 18.5 kg/m²), merged with the normal-weight group for analysis. WC, waist circumference; WHtR, waist–height ratio; NC, neck circumference; FBG, fasting blood glucose.

Blood pressure and fasting glucose distributions

Mean SBP was 118.4 ± 12.6 mmHg and mean DBP 77.2 ± 8.5 mmHg. By ACC/AHA criteria, 161 students (51.8%) had normal blood pressure, 109 (35.0%) elevated blood pressure, 31 (10.0%) stage 1 hypertension and 10 (3.2%) stage 2 hypertension; thus 48.2% had elevated blood pressure or hypertension. Mean FBG was 93.4 ± 10.1 mg/dL: 228 students (73.3%) were normoglycaemic, 77 (24.8%) had impaired fasting glucose and 6 (1.9%) had diabetes-range values, giving a dysglycaemia prevalence of 26.7%.

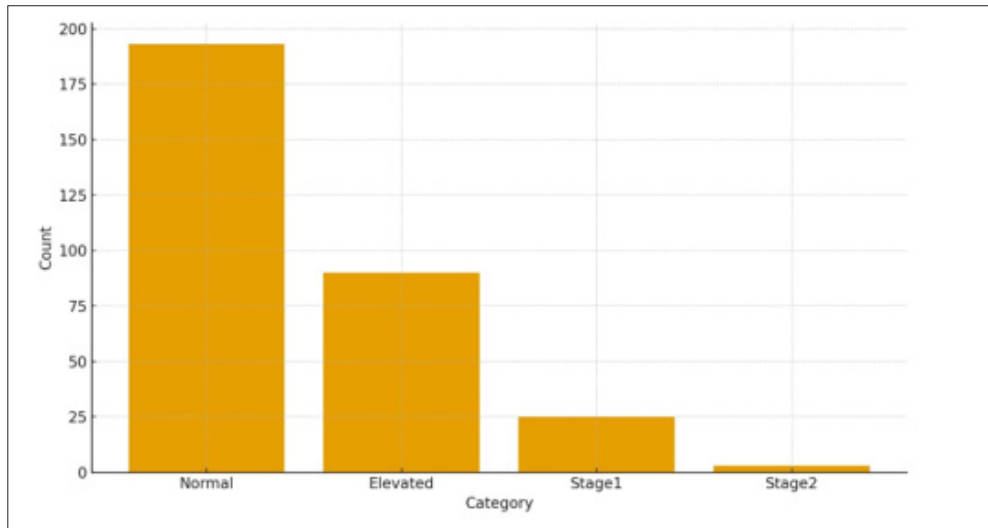


Figure 3. Distribution of blood-pressure categories (2017 ACC/AHA) among participants. Nearly half fell into the elevated, stage 1 or stage 2 categories

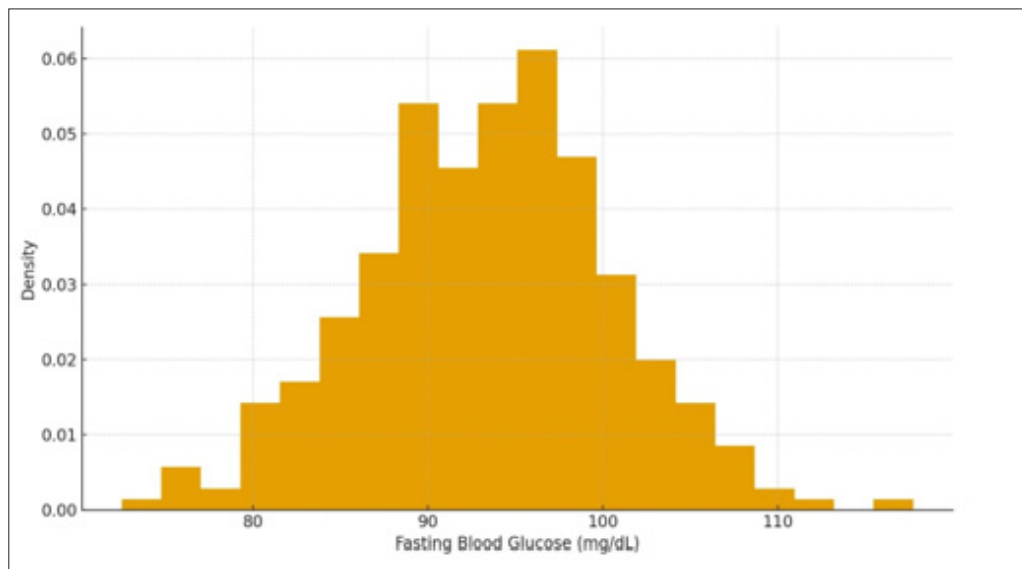


Figure 4. Distribution of fasting blood glucose (FBG). Although most values were normal, a distinct density lies in the 100–125 mg/dL impaired-fasting-glucose range

Cardiometabolic parameters across BMI categories

SBP, DBP and FBG increased progressively across normal-weight, overweight and obese categories (Table 3). One-way ANOVA showed significant variation across groups for SBP [$F(2,308) = 36.09$, $P < 0.001$], DBP [$F(2,308) = 27.86$, $P < 0.001$] and FBG [$F(2,308) = 19.68$, $P < 0.001$]. Tukey post-hoc comparisons confirmed significantly higher values in the obese group relative to both normal-weight (SBP, DBP and FBG all $P < 0.001$) and overweight students (SBP $P = 0.002$; DBP $P = 0.004$; FBG $P = 0.011$), and in overweight relative to normal-weight students (SBP $P < 0.001$; DBP $P < 0.001$; FBG $P = 0.007$). This graded pattern indicates a rise in cardiometabolic burden with increasing body mass, even within this young cohort.

Table 3: Blood pressure and fasting glucose across BMI categories (mean $\pm$ SD)

Parameter	Normal (n = 162)	Overweight (n = 81)	Obese (n = 68)
SBP (mmHg)	114.6 $\pm$ 10.8	121.8 $\pm$ 11.7	128.4 $\pm$ 13.2
DBP (mmHg)	74.8 $\pm$ 7.4	78.9 $\pm$ 8.1	83.1 $\pm$ 8.7
FBG (mg/dL)	90.7 $\pm$ 8.9	94.6 $\pm$ 9.7	99.1 $\pm$ 10.3

One-way ANOVA: SBP $F(2,308) = 36.09$, $P < 0.001$; DBP $F(2,308) = 27.86$, $P < 0.001$; FBG $F(2,308) = 19.68$, $P < 0.001$.

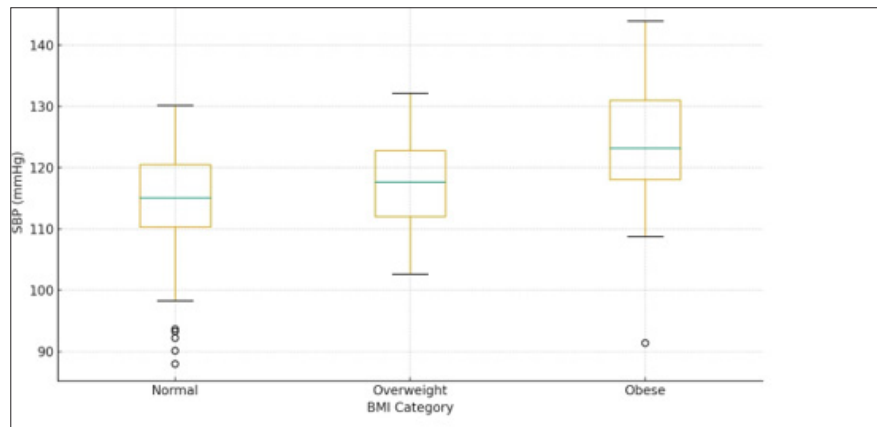


Figure 5. Systolic blood pressure (SBP) across BMI categories. Median SBP and its spread rise stepwise from normal-weight to overweight to obese students

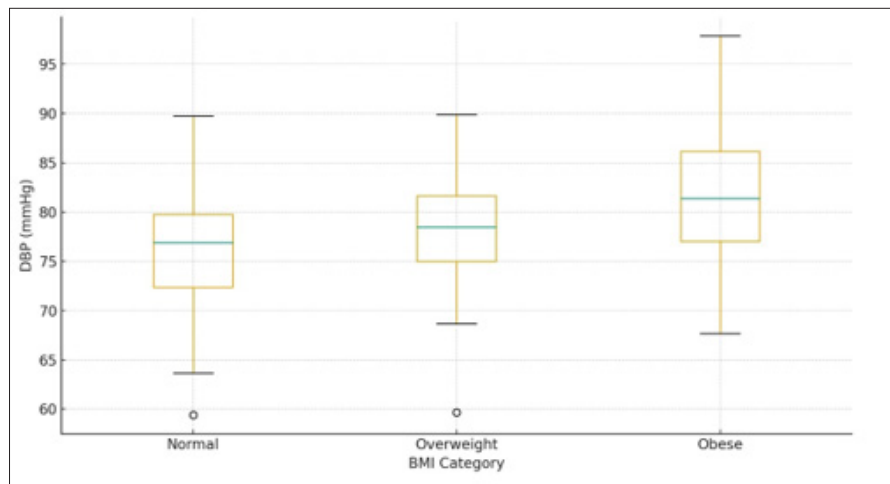


Figure 6. Diastolic blood pressure (DBP) across BMI categories, showing the same graded increase with rising body mass

Discussion

In this cohort of apparently healthy medical students aged 18–24 years, we found a substantial co-burden of adiposity and early cardiometabolic derangements: nearly half were overweight or obese, about 44% had central obesity by WHtR, close to half had elevated blood pressure or hypertension, and roughly one in four had dysglycaemia. These derangements are more common than might be expected in a young, ostensibly low-risk group, and challenge age-based assumptions of metabolic safety.

A central observation is that WHtR identified a larger at-risk fraction than BMI, and that a meaningful subset of students with a normal BMI nonetheless met central-obesity criteria the MONW phenotype. This aligns with the South Asian “thin-fat” phenotype, in which visceral fat and insulin resistance are present at low body mass and are detectable from early life[5,6], and with evidence that central adiposity is a stronger determinant of blood pressure than general adiposity in Indian adults[4] and of myocardial infarction risk across ethnic groups[3]. Mechanistically, visceral fat promotes insulin resistance, increased free-fatty-acid flux, sympathetic and renin–angiotensin–aldosterone activation

and subclinical inflammation, providing a coherent link between central adiposity and early rises in blood pressure and fasting glucose.

Our prevalence estimates are broadly consistent with, and at the higher end of, prior Indian data. In undergraduate medical students in North India, overweight/obesity was reported in about 29% and prehypertension in about 41%[8], and obesity has been consistently associated with elevated blood pressure in Indian populations[9]. The higher elevated-BP burden observed here partly reflects the lower ACC/AHA thresholds and may also reflect regional and lifestyle factors specific to this cohort. The narrower, lower Asian-Indian adiposity cut-offs used throughout[1,2] are important for avoiding underestimation of risk in this population.

These findings have practical implications. BMI alone underestimates cardiometabolic risk in young Asian-Indian adults, and campus-based screening would be strengthened by incorporating simple central-adiposity measures such as WHtR, which requires only a tape measure and height and uses a single population-independent boundary value[7]. Early identification could enable timely lifestyle intervention in a group whose risk trajectory is still modifiable. A

formal comparison of the discriminative performance of the individual indices is presented in a companion analysis from the same cohort.

Strengths and limitations: Strengths include a reasonable sample size, a standardized measurement protocol, the simultaneous use of multiple anthropometric indices, and the application of Asian-specific cut-offs. Limitations include the cross-sectional design, which precludes causal inference; recruitment from a single institution, which may limit generalizability; the use of capillary glucometer readings, which are appropriate for screening but not diagnosis; single-visit blood-pressure measurement, which may overestimate prevalence; the exclusion of self-reported lifestyle variables from the primary analysis owing to their subjectivity; and the absence of formal socioeconomic classification.

Conclusion

Nearly half of these apparently healthy young medical students showed central obesity and early cardiometabolic derangements, frequently masked by a normal BMI (the MONW phenotype). Anthropometric screening that extends beyond BMI to central-adiposity measures, together with early lifestyle intervention, is warranted in this young and under-recognized at-risk group.

Declarations

Ethics Approval and Consent to Participate

Approved by the Institutional Ethics Committee (IEC No. SU/R/2024/1350); written informed consent was obtained from all participants.

Funding

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Author Contributions per ICMJE Criteria

Dr. Rohit Saroha* (*Corresponding Author) - conceptualization, analysis, drafting and critical revision.
Dr Ritish Gupta - conceptualization, data collection, analysis, drafting and critical revision.

Dr Manisha Gupta - conceptualization, analysis and critical revision.

Dr Vijay Swarup Gautam - data collection, analysis and drafting.

Ms. Gauri mudgal - data collection, analysis and drafting.

Data Availability

Available from the corresponding author on reasonable request.

Conflicts of interest

The authors declare no conflicts of interest.

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