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Association of Random Blood Sugar with Body Mass Index and Central Adiposity Among Adults Attending a Non-Communicable Diseases Clinic of a Tertiary Care General Hospital in Western India: A Cross-Sectional Study

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ABSTRACT: Background: Body mass index (BMI) is widely used in non-communicable disease (NCD) screening, yet Asian Indians accumulate central fat at relatively low BMI. We examined the association of BMI and central adiposity indices with random blood sugar (RBS) among adults attending an NCD clinic in Western India.

Methods: In this cross-sectional study, 100 adults aged 30–70 years attending the NCD clinic of a tertiary care general hospital were studied. BMI, waist circumference (WC) and waist-to-height ratio (WHtR) were derived from measured anthropometry and classified using Asian Indian cut-offs. Associations with RBS were assessed by correlation and age- and sex-adjusted linear regression.

Results: Mean age was 42.97 ± 9.32 years; 51% were male. Mean BMI was 24.27 ± 4.30 kg/m² and mean RBS was 106.62 ± 16.77 mg/dL; 63% had BMI ≥ 23 kg/m², 63% had abdominal obesity and 73% had WHtR ≥ 0.5 . BMI was not significantly associated with RBS ($r = 0.139$, $P = 0.169$; adjusted $\beta = 0.449$ mg/dL per kg/m², 95% CI -0.326 to 1.223 , $P = 0.253$). WC ($r = 0.246$, $P = 0.014$; adjusted $\beta = 0.337$ mg/dL per cm, 95% CI 0.017 to 0.657 , $P = 0.039$) and WHtR ($r = 0.299$, $P = 0.002$; adjusted $\beta = 6.16$ mg/dL per 0.1

unit, 95% CI 1.00 to 11.32, $P = 0.020$) were positively associated with RBS. Among participants with BMI $<23 \text{ kg/m}^2$, 37.8% had abdominal obesity.

Conclusion: Central adiposity, particularly WHtR, was more closely associated with RBS than BMI. WC and WHtR should complement BMI in NCD-clinic screening.

INTRODUCTION

Non-communicable diseases (NCDs), particularly diabetes mellitus and cardiovascular disease, are now the leading contributors to morbidity and mortality in India. The Indian Council of Medical Research–India Diabetes (ICMR-INDIAB) study demonstrated wide state-level variation in diabetes and prediabetes and identified obesity, increasing age, hypertension and family history as important correlates [1]. The subsequent national ICMR-INDIAB report confirmed a high burden of metabolic NCDs, including generalised and abdominal obesity, across all Indian states [2]. Globally, obesity prevalence has risen steadily over three decades, with South Asia contributing substantially to this rise [3].

Excess adiposity promotes insulin resistance through increased flux of non-esterified fatty acids, pro-inflammatory adipokines and ectopic lipid deposition; progressive β -cell dysfunction then leads to dysglycaemia and type 2 diabetes mellitus [4]. Asian Indians exhibit a characteristic “thin-fat” phenotype, with greater total, truncal and visceral adiposity and greater insulin resistance at any given BMI than White Caucasians [5–7]. Consequently, the Asian Indian consensus statement recommends lower BMI thresholds than conventional World Health Organization (WHO) categories— 23.0 – 24.9 kg/m^2 for overweight and $\geq 25 \text{ kg/m}^2$ for obesity—together with sex-specific waist circumference (WC) cut-offs for abdominal obesity [8]. The WHO expert consultation likewise recognised that cardiometabolic risk in Asian populations rises at BMI values below 25 kg/m^2 [9].

BMI does not distinguish fat from lean mass or capture fat distribution, and individuals with a normal BMI may still carry excess central fat, a phenotype associated with increased mortality [10]. Simple measures of central adiposity, such as WC and the waist-to-height ratio (WHtR), have therefore been proposed as screening tools; a WHtR boundary of 0.5 has been suggested as a simple global threshold, and meta-analyses indicate that WHtR discriminates cardiometabolic risk better than BMI [11,12].

Random blood sugar (RBS) is the most frequently performed opportunistic glucose test in Indian outpatient settings. Although a random plasma glucose value permits a diagnosis of diabetes only when it is $\geq 200 \text{ mg/dL}$ with classic hyperglycaemic symptoms or hyperglycaemic crisis [13], sub-diagnostic RBS values carry prognostic information and predict subsequent diabetes [14]. Data from routine NCD-clinic populations in Western India comparing BMI with central adiposity indices as correlates of RBS are limited.

The primary objective of this study was to determine whether BMI was associated with RBS among adults attending an NCD clinic of a tertiary care general hospital in Western India. Secondary objectives were to describe the distribution of general and central adiposity, compare RBS across adiposity categories, and examine whether WC and WHtR were associated with RBS.

MATERIALS AND METHODS

Study design and setting

This cross-sectional observational study was conducted in the NCD clinic of a tertiary care general hospital in Gujarat, Western India, between October 2023 and January 2024. Data were prospectively collected. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies [15,16].

Study participants

Convenience sampling was done wherein adults aged 30–70 years attending the NCD clinic during the study period were eligible. Participants with known diabetes on treatment, pregnancy, acute illness, or other known co-morbidities such as

hypertension, bronchial asthma, cancer, or epilepsy, were excluded. Data on age, sex, height, weight, WC and RBS were collected.

Variables and measurements

Height (cm) measured barefoot with a wall-mounted stadiometer to the nearest 0.1 cm, weight (kg) on a calibrated scale to the nearest 0.1 kg, and WC (cm) measured at the midpoint between the lower costal margin and the iliac crest at the end of normal expiration with a non-stretchable tape were measured for each participant. BMI was calculated as weight in kilograms divided by the square of height in metres, and WHtR as WC divided by height (both in cm).

BMI was classified according to the Asian Indian consensus statement as underweight ($<18.0 \text{ kg/m}^2$), normal ($18.0\text{--}22.9 \text{ kg/m}^2$), overweight ($23.0\text{--}24.9 \text{ kg/m}^2$) and obesity ($\geq 25.0 \text{ kg/m}^2$); abdominal obesity was defined as WC $\geq 90 \text{ cm}$ in men and $\geq 80 \text{ cm}$ in women [8]. A WHtR ≥ 0.5 was considered elevated [11].

The outcome was RBS (mg/dL), analysed as a continuous variable. RBS was recorded using finger-prick method using glucometer, along with the time since last meal. RBS values were analysed as a continuous measure and were not used to diagnose diabetes or prediabetes [13].

Statistical analysis

Normality was assessed with the Shapiro–Wilk test. Continuous variables are presented as mean $\pm$ standard deviation (SD) and, for skewed variables, median (interquartile range [IQR]); categorical variables as frequencies and percentages. Sex differences were tested with the Mann–Whitney U test for non-normally distributed variables and Welch’s t-test for normally distributed variables (WC, WHtR); categorical variables were compared with Fisher’s exact test or a Monte Carlo chi-square test (20,000 permutations) where expected counts were small.

Because RBS was right-skewed, RBS was compared across BMI categories with the Kruskal–Wallis test and between abdominal obesity and WHtR groups with the Mann–Whitney U test. Correlations of BMI, WC and WHtR with RBS were assessed with Pearson’s r (95% confidence interval [CI] by Fisher’s z-transformation) and Spearman’s ρ (95% CI by percentile bootstrap with 5,000 resamples), overall and by sex. Separate linear regression models were fitted with RBS as the dependent variable and BMI (per kg/m^2), WC (per cm) or WHtR (per 0.1 unit) as the exposure, unadjusted and adjusted for age and sex (female as reference). Because model residuals were non-normal, three sensitivity analyses were performed: heteroscedasticity-consistent (HC3) standard errors [17], log-transformed RBS, and exclusion of the participant with the highest RBS (177 mg/dL). A model including both BMI and WC was examined with variance inflation factors (VIF), and effect modification by sex was tested with exposure $\times$ sex interaction terms. A two-sided $P < 0.05$ was considered statistically significant. Analyses were performed using Jamovi version 2.3.28.

Ethical considerations

The study was approved by the Institutional Ethics Committee for Human Research (IECHR) and was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from participants after explanation of the study purpose. No personally identifiable information was included in the analytic dataset.

RESULTS

Characteristics of participants

Of the 100 participants, 51 (51.0%) were male and 49 (49.0%) were female; the mean age was 42.97 ± 9.32 years (range 30–70). The mean BMI was $24.27 \pm 4.30 \text{ kg/m}^2$, WC $87.58 \pm 10.39 \text{ cm}$, WHtR 0.540 ± 0.068 and RBS $106.62 \pm 16.77 \text{ mg/dL}$ (median 102.50; IQR 98.00–114.00) (Table 1). The highest RBS was 177 mg/dL; no participant reached the random glucose threshold

of ≥ 200 mg/dL [13]. BMI and WC were not significantly different between sexes, whereas women had a higher WHtR (0.566 ± 0.061 vs 0.515 ± 0.066 ; $P < 0.001$) and higher RBS (median 106.00 vs 100.00 mg/dL; $P = 0.024$) than men.

Table 1. Characteristics of study participants by sex

Characteristic	Total (N = 100)	Male (n = 51)	Female (n = 49)	P value
Age (years)	42.97 $\pm$ 9.32	42.67 $\pm$ 11.05	43.29 $\pm$ 7.19	0.344 ^a
Height (cm)	162.66 $\pm$ 8.74	167.10 $\pm$ 8.66	158.04 $\pm$ 6.04	<0.001 ^a
Weight (kg)	64.22 $\pm$ 12.28	66.31 $\pm$ 13.83	62.04 $\pm$ 10.12	0.082 ^a
BMI (kg/m ²)	24.27 $\pm$ 4.30	23.62 $\pm$ 3.92	24.95 $\pm$ 4.61	0.579 ^a
Median (IQR)	23.92 (21.91–26.17)	24.11 (21.83–26.22)	23.73 (22.04–26.04)	
Waist circumference (cm)	87.58 $\pm$ 10.39	86.01 $\pm$ 11.88	89.20 $\pm$ 8.38	0.123 ^b
Waist-to-height ratio	0.540 $\pm$ 0.068	0.515 $\pm$ 0.066	0.566 $\pm$ 0.061	<0.001 ^b
Random blood sugar (mg/dL)	106.62 $\pm$ 16.77	103.41 $\pm$ 17.37	109.96 $\pm$ 15.61	0.024 ^a
Median (IQR)	102.50 (98.00–114.00)	100.00 (94.50–109.50)	106.00 (99.00–117.00)	
BMI category (kg/m²), n (%)				0.165 ^c
<18.0 (Underweight)	8 (8.0)	7 (13.7)	1 (2.0)	
18.0–22.9 (Normal)	29 (29.0)	13 (25.5)	16 (32.7)	
23.0–24.9 (Overweight)	29 (29.0)	13 (25.5)	16 (32.7)	
≥ 25.0 (Obesity)	34 (34.0)	18 (35.3)	16 (32.7)	
Abdominal obesity, n (%)	63 (63.0)	20 (39.2)	43 (87.8)	<0.001 ^d
WHtR ≥ 0.5 , n (%)	73 (73.0)	29 (56.9)	44 (89.8)	<0.001 ^d

Values are mean $\pm$ SD unless otherwise indicated. Abdominal obesity: WC ≥ 90 cm (men) or ≥ 80 cm (women). ^aMann–Whitney U test; ^bWelch's t-test; ^cMonte Carlo chi-square test; ^dFisher's exact test. BMI, body mass index; IQR, interquartile range; SD, standard deviation;

WHtR, waist-to-height ratio.

Distribution of general and central adiposity

Using Asian Indian cut-offs, 8 (8.0%) participants were underweight, 29 (29.0%) had normal BMI, 29 (29.0%) were overweight and 34 (34.0%) were obese; thus 63% had BMI ≥ 23 kg/m² (Table 1, Figure 1a). Abdominal obesity was present in 63 (63.0%) participants and WHtR ≥ 0.5 in 73 (73.0%), both far more frequent in women than in men (87.8% vs 39.2% and 89.8% vs 56.9%, respectively; both $P < 0.001$) (Figure 1b). Among the 37 participants with BMI < 23 kg/m², 14 (37.8%) had abdominal obesity and 18 (48.6%) had WHtR ≥ 0.5 .

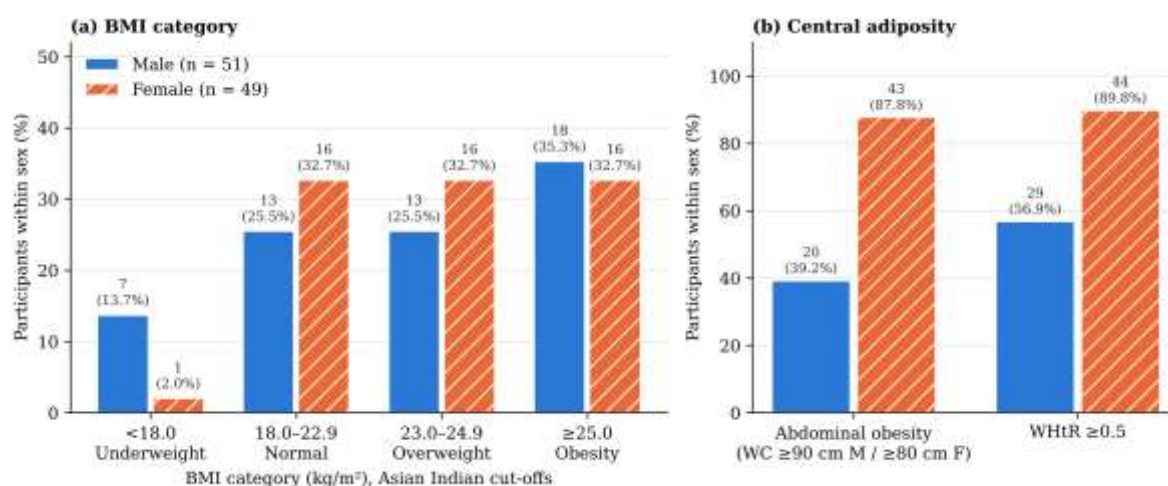


Figure 1. Distribution of (a) Asian Indian BMI categories and (b) central adiposity by sex. Values above bars are number (percentage within sex). Abdominal obesity was defined as waist circumference (WC) ≥ 90 cm in men and ≥ 80 cm in women. WHtR, waist-to-height ratio.

Random blood sugar across adiposity categories

Mean RBS rose from 101.25 mg/dL in underweight participants to 111.06 mg/dL in those with obesity, but the difference across BMI categories was not statistically significant (Kruskal–Wallis $H = 4.053$; $P = 0.256$) (Table 2, Figure 2a). RBS was higher in participants with abdominal obesity than in those without (median 106.0 vs 99.0 mg/dL; $P = 0.004$) and in those with WHtR ≥ 0.5 than in those with WHtR < 0.5 (median 106.0 vs 100.0 mg/dL; $P = 0.005$) (Figure 2b, c). After adjustment for age and sex, the differences were attenuated (abdominal obesity: $\beta = 5.44$ mg/dL, 95% CI -2.39 to 13.27 , $P = 0.171$; WHtR ≥ 0.5 : $\beta = 7.81$ mg/dL, 95% CI -0.03 to 15.65 , $P = 0.051$).

Table 2. Random blood sugar according to categories of general and central adiposity

Category	n	RBS, mean $\pm$ SD (mg/dL)	Median (IQR) (mg/dL)	Range	P value
BMI category (kg/m²)					0.256 ^a
<18.0 (Underweight)	8	101.25 $\pm$ 14.52	98.5 (90.2–107.2)	86–129	
18.0–22.9 (Normal)	29	105.24 $\pm$ 17.69	101.0 (94.0–111.0)	78–155	
23.0–24.9 (Overweight)	29	104.28 $\pm$ 10.45	102.0 (99.0–108.0)	87–136	

Category	n	RBS, mean $\pm$ SD (mg/dL)	Median (IQR) (mg/dL)	Range	P value
≥ 25.0 (Obesity)	34	111.06 $\pm$ 20.19	106.0 (99.2–117.5)	75–177	
Abdominal obesity					0.004 ^b
No	37	102.03 $\pm$ 18.74	99.0 (91.0–106.0)	75–177	
Yes	63	109.32 $\pm$ 15.01	106.0 (99.5–116.5)	84–154	
Waist-to-height ratio					0.005 ^b
<0.5	27	99.67 $\pm$ 15.99	100.0 (89.0–104.5)	75–155	
≥ 0.5	73	109.19 $\pm$ 16.42	106.0 (98.0–116.0)	84–177	
Overall	100	106.62 $\pm$ 16.77	102.5 (98.0–114.0)	75–177	

^aKruskal–Wallis test; ^bMann–Whitney U test. BMI, body mass index; IQR, interquartile range; RBS, random blood sugar; SD, standard deviation.

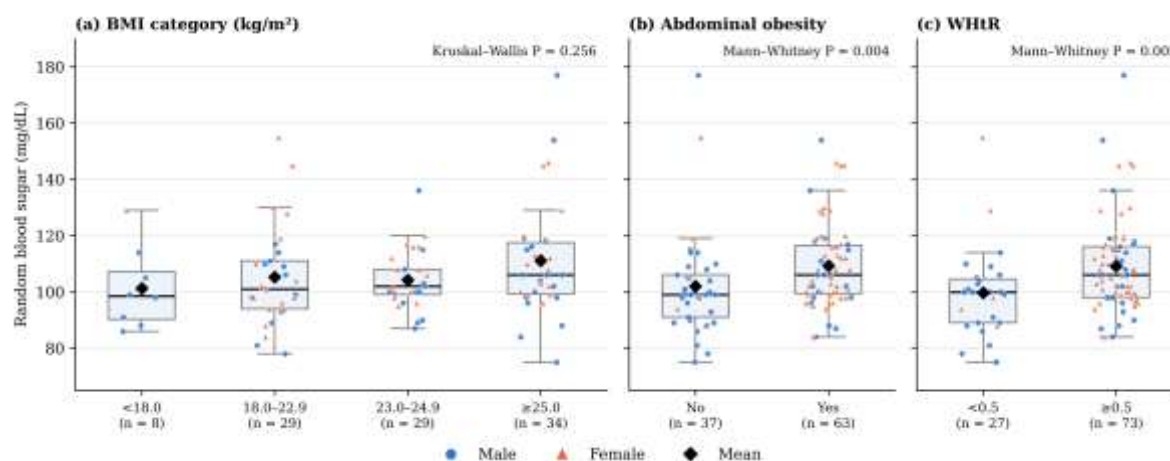


Figure 2. Random blood sugar according to (a) Asian Indian BMI category, (b) abdominal obesity and (c) waist-to-height ratio (WHtR). Boxes show median and interquartile range, whiskers extend to $1.5 \times$ IQR, diamonds indicate means, and points represent individual participants (circles, male; triangles, female).

Correlation of adiposity indices with random blood sugar

BMI showed a weak, non-significant correlation with RBS (Pearson $r = 0.139$, 95% CI -0.059 to 0.326 , $P = 0.169$; Spearman $\rho = 0.182$, $P = 0.070$). WC ($r = 0.246$, 95% CI 0.052 to 0.422 , $P = 0.014$; $\rho = 0.301$, $P = 0.002$) and WHtR ($r = 0.299$, 95% CI 0.109 to 0.468 , $P = 0.002$; $\rho = 0.343$, $P < 0.001$) were significantly and positively correlated with RBS (Table 3, Figure 3).

BMI and WC were strongly inter-correlated ($r = 0.745$, $P < 0.001$). In sex-stratified analyses, the correlations of WC and WHtR with RBS were significant in men but not in women.

Table 3. Correlation of BMI, waist circumference and waist-to-height ratio with random blood sugar, overall and by sex

Index / group	n	Pearson r (95% CI)	P value	Spearman ρ (95% CI)	P value
Body mass index					
Overall	100	0.139 (−0.059 to 0.326)	0.169	0.182 (−0.024 to 0.374)	0.070
Male	51	0.263 (−0.014 to 0.502)	0.062	0.226 (−0.066 to 0.491)	0.110
Female	49	−0.035 (−0.313 to 0.249)	0.811	0.111 (−0.214 to 0.421)	0.449
Waist circumference					
Overall	100	0.246 (0.052 to 0.422)	0.014	0.301 (0.092 to 0.489)	0.002
Male	51	0.331 (0.061 to 0.556)	0.018	0.369 (0.074 to 0.615)	0.008
Female	49	0.048 (−0.237 to 0.325)	0.744	0.180 (−0.134 to 0.477)	0.215
Waist-to-height ratio					
Overall	100	0.299 (0.109 to 0.468)	0.002	0.343 (0.149 to 0.515)	<0.001
Male	51	0.377 (0.113 to 0.591)	0.006	0.398 (0.120 to 0.630)	0.004
Female	49	0.087 (−0.199 to 0.359)	0.553	0.176 (−0.147 to 0.474)	0.227

95% CIs for Pearson r by Fisher's z -transformation and for Spearman ρ by percentile bootstrap (5,000 resamples). CI, confidence interval.

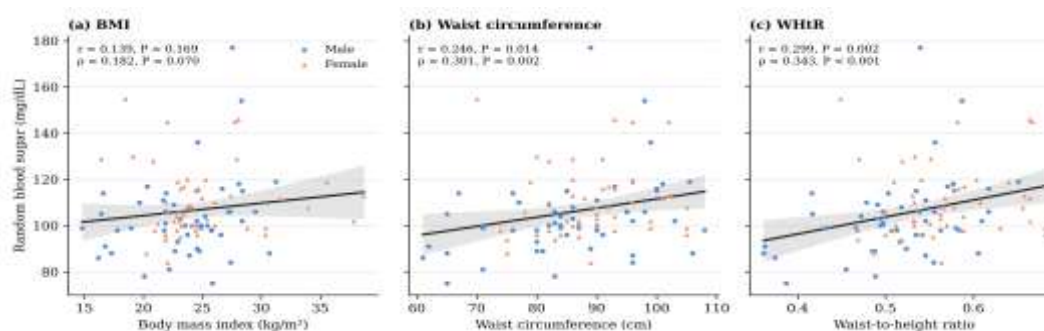


Figure 3. Scatter plots of random blood sugar against (a) body mass index, (b) waist circumference and (c) waist-to-height ratio ($N = 100$). Solid lines show the fitted least-squares regression line with 95% confidence band; circles, male; triangles, female.

Regression analysis

In unadjusted linear regression, BMI was not associated with RBS ($\beta = 0.541$ mg/dL per kg/m²; $P = 0.169$), whereas WC ($\beta = 0.397$ mg/dL per cm; $P = 0.014$) and WHtR ($\beta = 7.36$ mg/dL per 0.1 unit; $P = 0.002$) were (Table 4). After adjustment for age and sex, BMI remained non-significant ($\beta = 0.449$; 95% CI -0.326 to 1.223 ; $P = 0.253$), while WC ($\beta = 0.337$; 95% CI 0.017 to 0.657 ; $P = 0.039$) and WHtR ($\beta = 6.16$; 95% CI 1.00 to 11.32 ; $P = 0.020$) remained significantly associated with RBS. The WHtR model explained the most variance ($R^2 = 0.102$; adjusted $R^2 = 0.074$), compared with the WC ($R^2 = 0.091$) and BMI ($R^2 = 0.063$) models.

Table 4. Linear regression of random blood sugar (mg/dL) on BMI, waist circumference and waist-to-height ratio

Exposure	Unadjusted β (95% CI)	P value	Adjusted β (95% CI)	P value	Adjusted model R^2 (adj. R^2)
BMI (per 1 kg/m ²)	0.541 (-0.233 to 1.315)	0.169	0.449 (-0.326 to 1.223)	0.253	0.063 (0.033)
WC (per 1 cm)	0.397 (0.083 to 0.710)	0.014	0.337 (0.017 to 0.657)	0.039	0.091 (0.063)
WHtR (per 0.1 unit)	7.36 (2.65 to 12.06)	0.002	6.16 (1.00 to 11.32)	0.020	0.102 (0.074)

Each exposure was modelled separately; adjusted models include age (years) and sex (female as reference). In the adjusted BMI model, age $\beta = 0.199$ (95% CI -0.155 to 0.552 ; $P = 0.268$) and male sex $\beta = -5.830$ (95% CI -12.463 to 0.804 ; $P = 0.084$). β , regression coefficient; BMI, body mass index; CI, confidence interval; WC, waist circumference; WHtR, waist-to-height ratio.

Sensitivity and additional analyses

The association of WHtR with RBS was robust across sensitivity analyses: it remained significant with HC3 robust standard errors ($P = 0.039$), with log-transformed RBS (6.07% higher RBS per 0.1 unit; 95% CI 1.44 to 10.91 ; $P = 0.010$) and after excluding the participant with the highest RBS ($\beta = 5.44$; 95% CI 0.85 to 10.02 ; $P = 0.021$) (Supplementary Table S1). The WC association remained significant with log-transformed RBS ($P = 0.021$) and after excluding the highest RBS value ($P = 0.038$), but was borderline with HC3 standard errors ($P = 0.065$). BMI was not associated with RBS in any sensitivity analysis. When BMI and WC were entered together (VIF 2.38 and 2.44, respectively), the BMI coefficient became negative and non-significant ($\beta = -0.365$; $P = 0.535$), whereas WC retained a positive, borderline association ($\beta = 0.453$; $P = 0.069$). Interaction terms did not indicate significant effect modification by sex for WC ($P = 0.293$) or BMI ($P = 0.119$).

DISCUSSION

In this cross-sectional study of 100 adults attending an NCD clinic in Western India, BMI was only weakly and non-significantly associated with RBS, whereas the central adiposity indices WC and WHtR were significantly and positively associated with RBS, independent of age and sex. WHtR showed the strongest and most consistent association across correlation, regression and sensitivity analyses. Excess adiposity was highly prevalent: nearly two-thirds of participants had a BMI ≥ 23 kg/m² or abdominal obesity, and almost three-quarters had WHtR ≥ 0.5 .

The absence of a significant BMI–RBS association should not be interpreted as evidence that adiposity is unrelated to glycaemia. Large population surveys show a graded increase in diabetes prevalence with increasing BMI [18], and the mechanistic link between excess fat, insulin resistance and β -cell failure is well established [4]. Rather, our findings indicate that BMI captures the glycaemia-relevant component of adiposity less well than measures of central fat in this population. When BMI and WC

were modelled together, the BMI coefficient became negative while WC retained its positive association, suggesting that the modest unadjusted BMI–RBS relationship was largely carried by its shared variance with central adiposity.

These findings are consistent with the Asian Indian phenotype. At a given BMI, Asian Indians have more truncal and visceral fat and greater insulin resistance than White Caucasians [5–7], which underpins the lower BMI and population-specific WC thresholds recommended for this population [8,9,19]. Mohan et al. derived anthropometric cut points for cardiometabolic risk factors in a large urban South Indian population, supporting population-specific thresholds for both BMI and WC [20]. Meta-analyses have shown that central adiposity measures predict incident diabetes at least as well as BMI [21] and that WHtR outperforms both WC and BMI in discriminating cardiometabolic risk [12]. WHtR adjusts WC for stature and allows a single boundary value of 0.5 to be applied across sexes and ethnic groups [11], an attractive property in a clinic population with considerable variation in height.

A clinically important observation was that more than one-third of participants with a BMI <23 kg/m² had abdominal obesity, and nearly half had WHtR ≥0.5. Such “normal-weight central obesity” would be missed by BMI-based screening alone and has been associated with higher total and cardiovascular mortality than BMI-defined obesity without central fat accumulation [10]. Routine measurement of WC, which requires only a tape and a few seconds, could therefore improve risk identification in NCD clinics.

Women in this study had markedly higher prevalence of abdominal obesity and elevated WHtR than men, despite similar BMI, and also had higher RBS. The lower sex coefficient in the WHtR model than in the BMI model suggests that greater central adiposity may partly explain the higher RBS observed in women. The correlations of WC and WHtR with RBS were significant only in men; however, the formal interaction tests were non-significant, and the sex-stratified estimates are based on small subgroups. The weaker within-sex correlation among women may also reflect the narrow WHtR range in women, nearly 90% of whom exceeded the 0.5 threshold. These sex-specific findings should be regarded as exploratory.

The clinical interpretation of RBS requires caution. A random plasma glucose ≥200 mg/dL establishes diabetes only with classic hyperglycaemic symptoms or hyperglycaemic crisis; otherwise, confirmation with fasting plasma glucose, an oral glucose tolerance test or glycated haemoglobin (HbA1c) is required [13]. No participant had RBS ≥200 mg/dL, so this study describes variation in random glucose rather than diabetes status. Nonetheless, sub-diagnostic RBS elevations predict future diabetes [14], and the association of central adiposity with RBS supports prioritising individuals with abdominal obesity for confirmatory glycaemic testing.

Strengths and limitations

This study used real-world data from a routine NCD clinic, derived all adiposity indices from measured anthropometry, applied population-specific cut-offs, and compared general and central adiposity within the same participants. Results were consistent across parametric, rank-based and regression approaches and were tested in several sensitivity analyses, with effect estimates and confidence intervals reported throughout.

Several limitations should be considered. First, the modest single-centre sample limits precision and generalisability; with 100 participants the study had approximately 80% power to detect a correlation of about 0.28 at a two-sided α of 0.05, so a weaker true BMI–RBS association cannot be excluded. Second, the cross-sectional design precludes causal inference. Third, RBS is inherently variable, and time since the last meal was not available. Fourth, fasting plasma glucose and HbA1c were not measured. Fifth, potential confounders, including physical activity, diet, family history of diabetes, blood pressure, lipid profile and medication use, were not recorded. Sixth, several adiposity indices and subgroups were examined without correction for multiple comparisons, and the secondary and sex-stratified findings should be interpreted accordingly. Finally, anthropometric measures are indirect proxies for visceral fat.

Implications and future research

In NCD-clinic practice, a normal BMI should not be taken as reassurance about metabolic risk; WC and WHtR should be recorded alongside BMI, and abnormal RBS values should prompt confirmatory testing. Larger, adequately powered,

multicentre studies incorporating fasting glucose, HbA1c, direct measures of visceral fat and relevant lifestyle and clinical covariates are needed to define the optimal anthropometric screening strategy for Asian Indians.

CONCLUSION

Among adults attending an NCD clinic of a tertiary care general hospital in Western India, BMI was not significantly associated with random blood sugar, whereas waist circumference and, most consistently, waist-to-height ratio were positively associated with RBS independent of age and sex. Central obesity was common even among individuals with normal BMI. Simple measures of central adiposity should complement BMI in routine NCD screening of Asian Indian adults.

DECLARATIONS

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Ethics approval: The study was conducted after obtaining permission from the Institutional Ethics Committee for Human Research (IECHR). Informed consent was obtained from all participants.

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Supplementary Table S1. Sensitivity analyses for the association of adiposity indices with random blood sugar (models adjusted for age and sex)

Exposure	Main model β (95% CI); P	HC3 robust SE, P	Log-transformed RBS: % change (95% CI); P	Excluding RBS = 177 mg/dL: β (95% CI); P
BMI (per 1 kg/m ²)	0.449 (−0.326 to 1.223); 0.253	0.271	0.42 (−0.25 to 1.10); 0.219	0.287 (−0.404 to 0.978); 0.412
WC (per 1 cm)	0.337 (0.017 to 0.657); 0.039	0.065	0.33 (0.05 to 0.61); 0.021	0.301 (0.017 to 0.584); 0.038
WHtR (per 0.1 unit)	6.16 (1.00 to 11.32); 0.020	0.039	6.07 (1.44 to 10.91); 0.010	5.44 (0.85 to 10.02); 0.021

Mutually adjusted model (BMI + WC + age + sex): BMI β = −0.365 (95% CI −1.530 to 0.800; P = 0.535); WC β = 0.453 (95% CI −0.036 to 0.941; P = 0.069); VIF 2.38 (BMI) and 2.44 (WC). Sex interaction terms: WC $\times$ sex P = 0.293; BMI $\times$ sex P = 0.119. BMI, body mass index; HC3, heteroscedasticity-consistent standard errors; RBS, random blood sugar; VIF, variance inflation factor; WC, waist circumference; WHtR, waist-to-height ratio.