

Comparative Discriminative Performance of Anthropometric Indices for Detecting Elevated Blood Pressure and Dysglycaemia in Young Medical Students: Waist-To-Height Ratio Versus Body-Mass Index

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ABSTRACT:

Background: Body-mass index (BMI) is the usual screening measure of adiposity but does not capture central fat distribution, which is more strongly linked to cardiometabolic risk, particularly in Asian Indians. We compared the discriminative performance of five anthropometric indices for detecting elevated blood pressure (BP) and dysglycaemia in young medical students.

Methods: Cross-sectional study of 311 MBBS students aged 18–24 years (the same cohort as our companion burden analysis). BMI, waist circumference (WC), waist–hip ratio (WHR), waist–height ratio (WHtR) and neck circumference (NC) were related to systolic and diastolic BP and fasting blood glucose (FBG) using Pearson and age/sex-adjusted partial correlations, multiple linear regression, logistic regression, and receiver-operating-characteristic (ROC) analysis. Elevated BP (composite of elevated BP or hypertension, 2017 ACC/AHA) and dysglycaemia (FBG $\geq$ 100 mg/dL, ADA) were the binary outcomes.

Results: WHtR showed the strongest correlations with SBP ($r = 0.58$), DBP ($r = 0.53$) and FBG ($r = 0.37$; all $P < 0.001$), exceeding WC, BMI, WHR and NC; the ranking persisted after adjustment for age and sex. In regression, WHtR and WC were independent

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predictors, whereas BMI lost significance once central-adiposity measures were included, and categorical high-risk analyses were directionally concordant. WHtR had the highest area under the ROC curve (AUC) for both elevated BP (0.80; 95% CI 0.75–0.85) and dysglycaemia (0.74; 0.67–0.81), followed by WC (0.74, 0.69), with BMI (0.66, 0.61) and NC (0.63, 0.58) lowest.

Conclusions: WHtR was the best-performing simple anthropometric screen for early elevated BP and dysglycaemia in young adults and outperformed BMI. Campus and community screening should incorporate WHtR, operationalized by the message “keep your waist below half your height.”

Keywords: waist–height ratio; ROC analysis; anthropometric indices; cardiometabolic risk; body-mass index; young adults

Introduction

Screening for cardiometabolic risk in young adults relies heavily on body-mass index (BMI), yet BMI reflects overall mass and does not distinguish central from peripheral fat. In Asian Indians this limitation is consequential, because cardiometabolic risk rises at lower BMI values than in European populations [1], and a characteristic “thin-fat” phenotype combines visceral adiposity and insulin resistance with a relatively low body mass [2,3].

Central adiposity is a stronger correlate of cardiovascular risk than overall adiposity. In the INTERHEART study, waist–hip ratio predicted myocardial infarction more strongly than BMI, and adjustment for it abolished much of the BMI association [4]; in Indian data, central adiposity was a more important determinant of blood pressure than general adiposity [5]. Among central-adiposity measures, the waist–height ratio (WHtR) has attracted particular interest because it is simple, requires only a tape measure and height, and uses a single, largely population-independent boundary value of 0.5—captured in the public-health message “keep your waist to less than half your height” [6,7,8].

Although several indices are available (BMI, WC, WHR, WHtR and neck circumference [NC]), they are seldom compared head-to-head for their ability to discriminate early cardiometabolic derangements in young adults, and rarely in medical students, a group exposed to sustained

academic stress and sedentary behaviour. In a companion analysis of this cohort we documented a high burden of central obesity and early elevations in blood pressure and fasting glucose. Here we directly compare the correlational, regression-based and discriminative (ROC) performance of the five indices for detecting elevated blood pressure and dysglycaemia, to identify the most useful single screening measure for this population.

Materials and Methods***Study design, participants and measurements***

This cross-sectional study analysed 311 MBBS students aged 18–24 years assessed in the Department of Physiology, Santosh Medical College & Hospital, Santosh Deemed to be University, Ghaziabad, India. The setting, eligibility criteria, standardized morning measurement protocol and instrument calibration are identical to, and described in full in, our companion burden analysis of the same cohort; they are summarized here to avoid duplication. In brief, height and weight (from which BMI was derived), waist, hip and neck circumferences were measured with calibrated instruments; WHR was WC/HC and WHtR was WC divided by height. Blood pressure was measured by mercury sphygmomanometry (mean of two readings) and fasting capillary glucose by validated glucometer after an ≥ 8 h fast. The study is reported in line with STROBE,

with attention to the STARD principles for the diagnostic-accuracy component.

Outcomes and index definitions

Two binary outcomes were analysed: elevated blood pressure, defined as the composite of elevated BP or stage 1/2 hypertension by the 2017 ACC/AHA guideline [9]; and dysglycaemia, defined as FBG $\geq$ 100 mg/dL (impaired fasting glucose or diabetes range) by American Diabetes Association criteria [10]. High-risk categories of each index were defined a priori: BMI $\geq$ 23 kg/m² (WHO Asian) [1]; WC $\geq$ 90 cm (men) or $\geq$ 80 cm (women) [2]; WHR $\geq$ 0.90 (men) or $\geq$ 0.85 (women); WHtR $\geq$ 0.5 [6]; and NC $\geq$ 37 cm (men) or $\geq$ 34 cm (women).

Statistical analysis

Analyses were performed in Stata MP 17. Linear associations between each continuous index and SBP, DBP and FBG were quantified using Pearson correlation coefficients, and again as partial correlations adjusted for age and sex. Multiple linear regression identified independent predictors of SBP, DBP and FBG, with adjustment for age, sex and relevant history; multicollinearity among indices was assessed using variance inflation factors, and highly collinear indices were not entered simultaneously (models containing WHtR and WC were evaluated separately from those containing BMI). Logistic regression estimated adjusted odds ratios for elevated BP and dysglycaemia associated with each high-risk index category. The discriminative

performance of each index for the two binary outcomes was assessed by ROC analysis; the area under the curve (AUC) was interpreted as poor (0.5–0.6), fair (0.6–0.7), acceptable (0.7–0.8), excellent (0.8–0.9) and outstanding (> 0.9), and its 95% confidence interval (CI) was estimated by the method of Hanley and McNeil [16]. Because the anthropometric indices are measured on different scales, age/sex-adjusted partial correlation coefficients are used as standardized measures of association, allowing the indices to be compared on a common footing. A two-sided $P < 0.05$ was considered significant. Ethical approval was obtained (IEC No. SU/R/2024/1350) with written informed consent.

Results

Correlations of anthropometric indices with blood pressure and glucose

WHtR showed the strongest linear associations with all three outcomes, followed by WC, while WHR and NC were weakest and BMI intermediate (Table 1, Figure 1). All zero-order correlations were significant ($P < 0.001$, except NC–FBG, $P = 0.001$), as were the age/sex-adjusted partial correlations ($P < 0.001$, except WHR–FBG $P = 0.001$ and NC–FBG $P = 0.014$). The ordering was preserved after adjustment for age and sex, indicating that the superiority of central-adiposity measures was not explained by age or sex differences.

Table 1. Pearson (r) and age/sex-adjusted partial (r_p) correlations of anthropometric indices with SBP, DBP and FBG, with exact P -values ($n = 311$).

Index	Outcome	Pearson r (P)	Partial r_p (P)
BMI	SBP	0.42 (<0.001)	0.36 (<0.001)
	DBP	0.38 (<0.001)	0.32 (<0.001)
	FBG	0.29 (<0.001)	0.24 (<0.001)
WC	SBP	0.51 (<0.001)	0.47 (<0.001)
	DBP	0.46 (<0.001)	0.42 (<0.001)
	FBG	0.34 (<0.001)	0.31 (<0.001)
WHR	SBP	0.33 (<0.001)	0.28 (<0.001)

	DBP	0.31 (<0.001)	0.26 (<0.001)
	FBG	0.22 (<0.001)	0.18 (0.001)
WHtR	SBP	0.58 (<0.001)	0.53 (<0.001)
	DBP	0.53 (<0.001)	0.48 (<0.001)
	FBG	0.37 (<0.001)	0.34 (<0.001)
NC	SBP	0.27 (<0.001)	0.23 (<0.001)
	DBP	0.25 (<0.001)	0.20 (<0.001)
	FBG	0.18 (0.001)	0.14 (0.014)

Partial correlations are adjusted for age and sex. P-values were computed from the coefficients and sample size (t-distribution, df = 309 for Pearson and 307 for partial correlations).

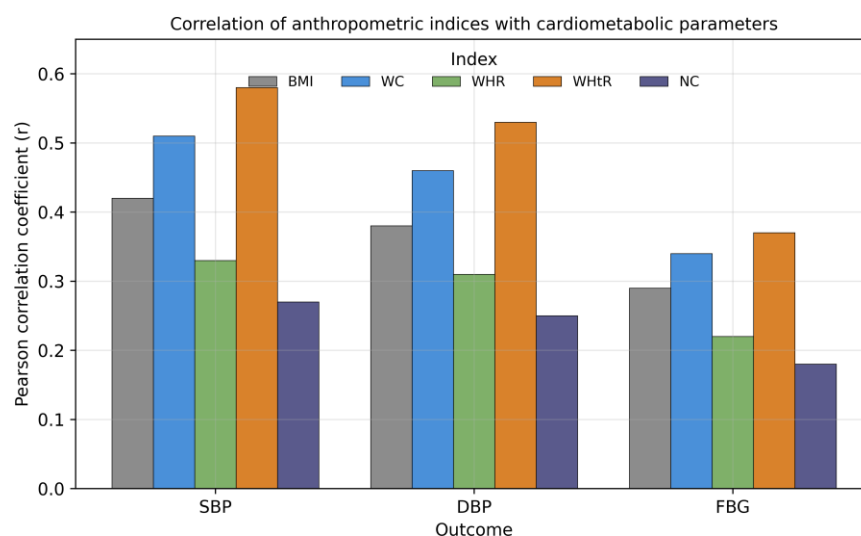


Figure 1. Correlation of anthropometric indices with SBP, DBP and FBG (Pearson r). WHtR shows the strongest associations across all three outcomes, followed by WC; NC and WHR are weakest.

Independent predictors (multiple linear regression)

In multiple linear regression adjusting for age, sex and relevant history, central-adiposity measures were the dominant independent predictors: WHtR and WC remained significantly associated with SBP, DBP and FBG, whereas BMI lost statistical significance once WHtR and WC were included in the model. Variance inflation factors were used to avoid the simultaneous inclusion of highly collinear indices. Because the indices are measured on different scales, the age/sex-adjusted partial correlations in Table 1 serve as standardized effect sizes: on this common footing WHtR showed the largest independent association with every outcome (partial $r = 0.53$, 0.48 and 0.34 for SBP, DBP and FBG), exceeding WC (0.47 , 0.42 , 0.31) and BMI (0.36 , 0.32 , 0.24).

Categorical risk associations

Analyses using dichotomized high-risk categories were directionally concordant with the continuous-variable findings: the adjusted odds of elevated blood pressure and of dysglycaemia were highest for the WHtR ≥ 0.5 and high-risk WC categories and lowest for BMI, WHR and NC. Because confidence intervals for these adjusted odds ratios cannot be derived from the available summary data, formal inference here rests on the correlation and ROC analyses rather than on the odds ratios.

Discriminative performance (ROC analysis)

WHtR had the highest AUC for both outcomes— 0.80 (95% CI 0.75 – 0.85 ; excellent) for elevated blood pressure and 0.74 (0.67 – 0.81 ; acceptable) for dysglycaemia—followed by WC

(0.74 and 0.69). BMI (0.66, 0.61), WHR (0.68, 0.63) and NC (0.63, 0.58) were the weakest discriminators (Table 2, Figure 2). For elevated blood pressure, the 95% CI for WHtR (0.75–0.85) did not overlap that of BMI (0.60–0.72), consistent with materially better discrimination

by WHtR; a formal paired comparison (DeLong test) would require individual-level data. Across correlational, regression and ROC analyses, WHtR consistently ranked first, WC second, and BMI, WHR and NC lower.

Table 2. Area under the ROC curve (AUC) with 95% CI for each index, for elevated blood pressure and dysglycaemia (n = 311).

Index	Elevated BP AUC (95% CI)	Dysglycaemia AUC (95% CI)
BMI	0.66 (0.60–0.72)	0.61 (0.54–0.68)
WC	0.74 (0.68–0.80)	0.69 (0.62–0.76)
WHR	0.68 (0.62–0.74)	0.63 (0.56–0.70)
WHtR	0.80 (0.75–0.85)	0.74 (0.67–0.81)
NC	0.63 (0.57–0.69)	0.58 (0.51–0.65)

AUC interpretation: 0.5–0.6 poor, 0.6–0.7 fair, 0.7–0.8 acceptable, 0.8–0.9 excellent, > 0.9 outstanding. 95% CIs estimated by the Hanley–McNeil method [16]. An empirically optimal cut-off (Youden index) and DeLong between-index comparisons require individual-level data; the pre-specified WHtR boundary of 0.5 was applied [6,7].

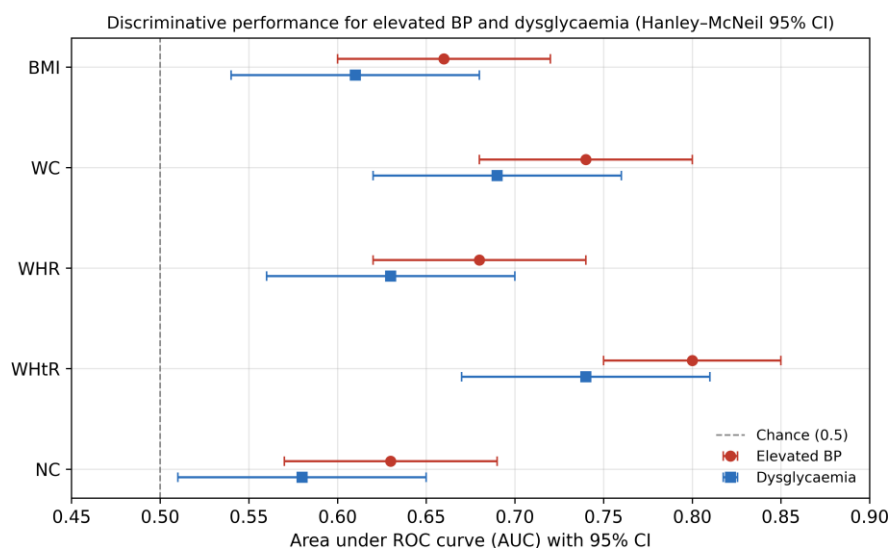


Figure 2. Discriminative performance (AUC with Hanley–McNeil 95% CI) of each index for elevated blood pressure and dysglycaemia. WHtR has the highest AUC for both outcomes; the dashed line marks chance (0.5).

Discussion

Across four complementary analytic approaches—correlation, partial correlation, regression, and ROC—WHtR was consistently the best-performing anthropometric index for

detecting early elevated blood pressure and dysglycaemia in young medical students, with WC second and BMI, WHR and NC lower. The persistence of this ranking after adjustment for age and sex, and the loss of BMI's independent

significance once central-adiposity measures were included, indicate that fat distribution rather than overall mass drives the associations in this population.

These findings align with a large international evidence base. A systematic review of 78 studies and a subsequent meta-analysis found WHtR to be a better global screening tool than WC or BMI for cardiometabolic outcomes, with a mean AUC exceeding that of BMI and a boundary value near 0.5 [6,7]. Our AUCs (WHtR 0.80 for elevated BP, 0.74 for dysglycaemia) sit at the upper end of this range, plausibly because a young cohort without established disease shows adiposity effects that are not yet obscured by treatment or comorbidity. Studies in Asian Indians similarly support simple central-adiposity indices, including WHtR, for metabolic risk [8,11].

Mechanistically, visceral and ectopic fat—better captured by WHtR and WC than by BMI—drive hepatic and systemic insulin resistance, increased free-fatty-acid flux and low-grade inflammation, linking central adiposity to rising fasting glucose [13,14]; and obesity raises blood pressure through renal sodium retention, renin–angiotensin–aldosterone activation and sympathetic overactivity [15]. The attenuation of BMI after adjustment for central adiposity reproduces, within a single young cohort, the pattern seen for myocardial infarction in INTERHEART and for blood pressure in Indian adults [4,5].

Neck circumference performed weakest here. This contrasts with reports that NC and neck-height ratio predict metabolic syndrome in older Asian Indian adults [12], and may reflect the younger age and lower absolute adiposity of our students, in whom upper-body fat deposition is less developed. WHR was also comparatively weak, consistent with the view that ratios anchored to hip circumference are less informative than height-anchored measures in this setting.

The practical implication is direct: for young Asian-Indian adults, WHtR is the single most informative simple screen and should be preferred over BMI. It needs only a tape measure and height, uses one population-independent

cut-off, and is easily communicated as “keep your waist below half your height” [7]. Incorporating WHtR into routine campus and community screening could flag at-risk individuals—including those with a normal BMI—while their risk trajectory is still modifiable.

Strengths and limitations. Strengths include the head-to-head comparison of five indices against two outcomes using multiple analytic methods, a standardized protocol and Asian-specific cut-offs. Limitations include the cross-sectional design, which precludes causal or predictive (incident-risk) inference; single-centre recruitment; capillary glucometer readings, appropriate for screening but not diagnosis; and single-visit blood-pressure measurement. Analytically, AUC confidence intervals were estimated from the AUC values and case counts by the Hanley–McNeil method rather than from individual-level data, so a formal DeLong comparison between indices and an empirically optimal WHtR cut-off with sensitivity and specificity could not be derived; the established boundary value of 0.5 was applied instead. Confidence intervals for the adjusted odds ratios were likewise not obtainable, so inference rests on the correlation and ROC analyses. External validation in independent young-adult cohorts, ideally with prospective follow-up, is warranted.

Conclusion

In young medical students, WHtR was the best-performing simple anthropometric index for detecting early elevated blood pressure and dysglycaemia, outperforming BMI, WC, WHR and NC across correlation, regression, odds-ratio and ROC analyses. WHtR merits adoption as the primary anthropometric screen in this population, operationalized by the message “keep your waist below half your height.”

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.

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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.

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