Original Article

Which obesity index is a better predictor for cardiometabolic risk factors in a young adult rural population of Telangana State, India?

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ABSTRACT

Background: Waist-to-height ratio (WHtR) has recently been found to be a useful marker of cardiovascular disease (CVD) risk in populations in developed countries; the comparison of various obesity indices, particularly WHtR, has received little study in India and other developing countries. **Aim:** This study aimed to compare the associations of common obesity indices, body mass index (BMI), waist circumference, waist-hip ratio (WHR), and WHtR, with cardiometabolic risk factors in a young, rural Indian population. **Subjects and Methods:** Anthropometric measurements and cardiometabolic risk factors (hypertension, diabetes, and dyslipidemia) were measured using standardized protocols at the baseline visit of the Longitudinal Indian Family hEalth Pilot Study, a population-based cohort study of child-bearing age women and their husbands in rural Telangana, India. **Results:** In comparison with most previously studied populations, this population sample (642 males and 980 females) was younger; had lower BMI; and lower rates of diabetes, hypertension, and abnormal lipids (exception of high rates of low high-density lipoprotein). With regard to each of the cardiometabolic risk factors, the associations across the obesity indices tended to be significant, but weak, and similar to each other, whereas the association with WHR was less strong. **Conclusion:** Although WHtR was not a better predictor of cardiometabolic risk than conventional obesity indices, in this young adult Indian population, it was equally good. This raises the prospect of using WHtR as an alternative to BMI for assessing cardiometabolic risk in Indians considering the ease with which it can be easily done and interpreted.

Keywords: Considered risk factors, obesity indices, waist-to-height ratio (WHtR)

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Introduction

Globally, overweight and obesity are the fifth leading cause of death.[1] Among populations aged 18 years and older in 2016, the prevalence of overweight was 39% and obesity was 13%.[2] This is increasing rapidly in developing countries.[1,3,4] Body mass

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index (BMI) is the standard international obesity index.[2] However, reviews have found that indices of central obesity, waist circumference (WC), and waist-to-hip ratio (WHR) are more strongly associated with cardiometabolic risk than BMI.[5-8] The waist-to-height ratio (WHtR) was superior to WC and BMI for detecting cardiometabolic risk.[9-11]

Southeast Asians experience higher cardiometabolic risk at lower BMI compared with other populations.[12-14] Data regarding the association of other obesity markers with cardiometabolic risk factors among Indians are sparse and inconsistent.[8,15-19] We cross-sectionally analyzed obesity indices as predictors of cardiometabolic risk factors, including hypertension, diabetes, and dyslipidemia, in a cohort of young adults in rural India.

Subjects and Methods

The present study was a cross-sectional analysis of the Longitudinal Indian Family hEalth (LIFE) cohort study in a rural area of Telangana State, India. The details are published elsewhere.[20]

Study setting and participant

The ongoing LIFE Study in rural Telangana State collected baseline data from 2009 to 2011. It is a population-based representative cohort of 1227 women belonging to the child-bearing age and 642 husbands followed prospectively to study birth outcomes. After excluding 247 women at the baseline who were pregnant during the time of recruitment, data for 980 women and 642 men were included in this analysis. The study was approved by the institutional ethics committee and written informed consent was obtained from all participants 07.06.2008.

Collection of field data and blood samples for analysis

The LIFE Study methods have been described in detail elsewhere.[20] Briefly, extensively trained male and female field workers performed the various exams; administered questionnaires in the local language, Telugu; and performed anthropometric measurements.

Anthropometric measurements
Height and weight were measured using a portable stadiometer and a portable calibrated scale (SECA scale designed by UNICEF); WC was measured in duplicate to 0.1 cm by using nonstretchable tailors tape at the narrowest point between the ribs and the hips or the umbilicus if there was no narrowest point; and hip circumference was measured at the widest part of the buttocks. The type of clothing worn during measurement was recorded. At the time of data analyses, subtractions were made to minimize errors because of clothing: for women, sari −1 cm and for men pants −0.7 cm and dhoti −3.0 cm.

Blood pressure
Blood pressure was measured thrice by an observer trained according to the Multiple Risk Factors Intervention

Trial(MRFIT) protocol,[21] using the OMRON HEM-705 automated blood pressure monitor (Omron Health care, INC. Bannockburn, IL, Made in China). The average of the second and third readings was used in the analysis.

Fasting blood sample collection and assay
One day before the test, all the participants were instructed to fast after 10:00 PM until their blood was drawn the following morning in a small, temporary study laboratory in the village office or school. From the antecubital fossa, 15 ml of blood (10 ml red top, 5 ml purple top vacutainers) was drawn. Immediately after collection, the fasting blood sample was transported to the MediCiti Hospital Laboratory, Society for Health Allied Research & Education India (SHARE INDIA). Standard clinical pathology protocols were used to measure fasting blood sugar (Dimension Xp and Plus auto analyzer, SIEMENS, New York, USA) and the lipid profile (Ximola auto analyser, Randox, Ireland) at the MediCiti Hospital Clinical Laboratory. If triglycerides were <500 mg/dl, the low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald formula.[22] If triglycerides were ≥500 mg/dl, the LDL cholesterol was estimated using an analyzer. Definitions and criteria used in this study are mentioned in Table 1.

Statistical analysis

Data entry was done using double key entry and analyzed using the Statistical Package for the Social Sciences software, version 17.0 and MedCalc, version 12.7.0, statistical program. Nonparametric Spearman's correlations were calculated. Continuous predictor variables were compared across groups using the student *t*-test/Wilcoxon rank-sum test. Categorical variables were presented as percentages and 95% confidence limits and compared with a Chi-square test.

The area under the receiver operating curve (AUROC) analysis was used to measure the association between outcome variables hypertension, diabetes, and dyslipidemia and obesity indices and to determine cut-off values. For AUROC analysis, outcome variables hypertension, diabetes, and dyslipidemia were used in a binary form. The optimal cut-off was measured by calculating the maximum sensitivity and specificity of the obesity index for various cut-offs. Z-statistics were used to compare AUROC of BMI with other central obesity indices.

Results

There were 1622 participants, including 642 men (40%) and 980 women (60%), in the present study. Their anthropometric and metabolic characteristics are shown in Table 2. Women were 5 years younger than men (22.0 ± 3.0) versus (27.7 ± 3.9). This was a lean population with men's mean weight being 61.1 kg and women's being 47.3 kg and men's BMI being 22.4 kg/m² and women's BMI being 20.4 kg/m².

In this younger population, the prevalence of cardiometabolic risk factors [Table 1] was relatively low, except for low high-density

lipoprotein cholesterol (HDL-C) and dyslipidemia prevalence, which were similar in men and women. In men, obesity-related indices significantly correlated with cardiometabolic risk factors [Table 3]. For each cardiometabolic risk factor, the strength of the correlations across BMI, WC, and WHtR was similar. In women [Table 3], the correlation of obesity-related indices with cardiometabolic risk factors was statistically significant, except for systolic blood pressure. As in men the correlation between WHR and cardiometabolic risk factors was weak in women too. Moreover, compared with men, the correlation between all obesity indices and cardio-metabolic risk factors were weaker in women.

Table 1: Prevalence of cardiovascular risk factors (*n*=1622)

	Men (*n*=642)	Women (*n*=980)	All subjects (*n*=1622)
	%	%	%
Hypertensive[a]	18.2	4.7	10
Diabetic[b]	3.1	1.1	1.9
Dyslipidemia[c]	71.3	70.0	70.0
BMI[d] ≥23	42.6	20.9	29.5
TC[e] ≥200 mg/dl	15.9	4.8	9.2
Tg[f] ≥150 mg/dl	32.4	5.1	15.9
Low HDL-C[g]	56.7	66.8	62.8
Men <40 mg/dl			
Women <50 mg/dl			
LDL-C[h] ≥130 mg/dl	14.2	7.2	10

[a]Hypertensive: Systolic blood pressure ≥140 or diastolic blood pressure ≥90 mmHg or taking antihypertensive medication[29]. [b]Diabetes: Fasting blood sugar ≥126 mg/dl or taking antidiabetic medication[30]. Prediabetes: Fasting blood sugar ≥100 mg/dl and <126 mg/dl and not taking antidiabetic medication[30]. Normal fasting blood sugar: fasting blood sugar ≤100 mg/dl and not taking antidiabetic medication[30]. [c]Dyslipidaemia: Total cholesterol ≥200 mg/dl (or) high-density lipoprotein cholesterol <40 mg/dl in men and high-density lipoprotein cholesterol <50 mg/dl in women (or) low-density lipoprotein cholesterol ≥130 mg/dl (or) triglycerides ≥150 mg/dl[31]. [d]BMI: Body mass index. [e]TC=Total cholesterol. [f]Tg=Triglycerides. [g]HDL-C=High-density lipoprotein cholesterol. [h]LDL- C=Low-density lipoprotein cholesterol

Table 2: Anthropometric and metabolic characteristics (*n*=1622)

Variables	Men (*n*=642)		Women (*n*=980)		All subjects (*n*=1622)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	27.7	3.9	22.0	3.0	24.3	4.4
Height (cm)	164.8	6.4	151.8	5.5	156.9	8.7
Weight (kg)	61.1	11.8	47.3	9.4	52.7	12.4
WC[a] (cm)	81.8	9.3	65.4	8.7	71.9	12.0
HC[b] (cm)	89.9	7.8	85.0	8.5	87.0	8.6
BMI[c] (kg/m²)	22.4	3.9	20.4	3.7	21.2	3.9
WHR[d]	0.90	0.05	0.76	0.06	0.82	0.08
WHtR[e]	0.49	0.05	0.43	0.05	0.457	0.06
SBP[f] (mmHg)	122.5	12.7	112.6	10.3	116.5	12.2
DBP[g] (mmHg)	78.8	10.2	73.9	8.5	75.8	9.5
FBS[h] mg/dl	93.8	22.3	89.6	19.6	91.2	20.8
TC[i] (mg/dl)	163.0	39.2	148.3	32.6	154.1	36.1
Tg[j] (mg/dl)	137.8	105.2	70.4	45.5	97.1	81.9
HDL-C[k] (mg/dl)	39.4	9.2	45.7	10.3	43.2	10.4
LDL- C[l] (mg/dl)	96.6	32.6	88.7	28.2	91.8	30.2

[a]WC=Waist circumference. [b]HC=Hip circumference. [c]BMI=Body mass index. [d]WHR=Waist-to-hip ratio. [e]WHtR=Waist-to-height ratio. [f]SBP=Systolic blood pressure. [g]DBP=Diastolic blood pressure. [h]FBS=Fasting blood sugar. [i]TC=Total cholesterol. [j]Tg=Triglycerides. [k]HDL-C=High-density lipoprotein cholesterol. [l]LDL- C=Low-density lipoprotein cholesterol

Table 3: Spearman's correlation coefficients between anthropometric indices and cardiometabolic risk factors in men (*n*=642) and women (*n*=980)

	Men				Women			
	WC[e]	BMI[f]	WHR[g]	WHtR[h]	WC	BMI	WHR	WHtR
SBP[i]	0.35[d]	0.39[d]	0.11[d]	0.32[d]	0.04[a]	0.05[a]	0.05[a]	0.03[a]
DBP[j]	0.39[d]	0.31[d]	0.19[d]	0.39[d]	0.13[d]	0.13 [d]	0.10[d]	0.13[d]
FBS[k]	0.19[d]	0.22[d]	0.12[d]	0.23[d]	0.12[d]	0.19[d]	0.05[d]	0.14[d]
TC[l]	0.38[d]	0.34[d]	0.15[d]	0.33[d]	0.20[d]	0.23[d]	0.13[d]	0.23[d]
Tg[m]	0.46[d]	0.46[d]	0.25[d]	0.46[d]	0.28[d]	0.29[d]	0.18[d]	0.30[d]
HDL-C[n]	−0.23[d]	−0.20[d]	−0.15[d]	−0.21[d]	−0.22[d]	−0.23[d]	−0.12[d]	−0.23[d]
LDL-C[o]	0.22[d]	0.21[d]	0.10[d]	0.21[d]	0.22[d]	0.26[d]	0.13[d]	0.25[d]

P values, a= >.05, b= <.05, c= <.01, d= <.001 [a]*P*≥0.05. [b]*P*≤0.05. [c]*P*≤0.01. [d]*P*≤0.001. [e]WC=Waist circumference. [f]BMI=Body mass index. [g]WHR=Waist-to-hip ratio. [h]WHtR=Waist-to-height ratio. [i]SBP=Systolic blood pressure. [j]DBP=Diastolic blood pressure. [k]FBS=Fasting blood sugar. [l]TC=Total cholesterol. [m]Tg=Triglycerides. [n]HDL-C=High-density lipoprotein cholesterol. [o]LDL- C=Low-density lipoprotein cholesterol

Cardiometabolic risk factors	Men (*n*=642)		Women (*n*=982)	
Table 4: Area under the receiver operating characteristic curve values with 95% CI in men and women (*n*=1624)				
	AUROCa (95% CI)	P comparison with BMIb	AUROC (95% CI)	P comparison with BMI
Hypertension				
BMI	0.661 (0.622-0.697)		0.542 (0.510-0.574)	
WC[c]	0.628 (0.589-0.665)	0.012[f]	0.571 (0.539-0.602)	0.219
WHR[d]	0.548 (0.508-0.587)	0.0003[f]	0.578 (0.546-0.608)	0.451
WHtR[e]	0.636 (0.597-0.673)	0.073	0.580 (0.549-0.612)	0.095
Diabetes				
BMI	0.650 (0.610-0.687)		0.583 (0.552-0.614)	
W[c]	0.693 (0.656-0.729)	0.156	0.648 (0.617-0.678)	0.270
WHR	0.698 (0.661-0.734)	0.499	0.730 (0.701-0.757)	0.212
WHtR	0.723 (0.687-0.757)	0.015	0.650 (0.619-0.680)	0.263
Dyslipidemia				
BMI	0.668 (0.630-0.765)		0.662 (0.632-0.692)	
WC	0.705 (0.668-0.741)	0.086	0.656 (0.625-0.686)	0.618
WHR	0.639 (0.600-0.676)	0.548	0.588 (0.556-0.619)	0.001*
WHtR	0.680 (0.642-0.716)	0.570	0.661 (0.631-0.691)	0.946

[a]AUROC=Area under the receiver operating characteristic curve, a statistical test (Z statistic) for heterogeneity in effect sizes between obesity indices (body mass index vs waist circumference; body mass index vs waist-to-hip ratio; body mass index vs waist-to-height ratio). [b]BMI=Body mass index. [c]WC=Waist circumference. [d]WHR=Waist-to-hip ratio. [e]WHtR=Waist-to-height ratio. [f]Significant difference at *P*<0.01

The AUROC was modest for all four anthropometric indices for predicting hypertension, diabetes, and dyslipidemia, particularly in women [Table 4]. None of the predictors were significantly stronger than BMI, except for WHtR, for predicting diabetes in men. The optimal cut-off values for sensitivity and specificity for each of the obesity indices [Table 5] generally had low predictive value for hypertension, diabetes, and dyslipidemia.

Discussion

In this community-based sample of rural young adults, comprising 642 men and 980 women, we compared the strength of obesity indices as predictors of cardiometabolic risk factors. Prevalence of dyslipidemia, primarily determined by low HDL, was high, whereas hypertension and diabetes were relatively low prevalence. All studied obesity indices were significant, though weakly or moderately correlated with the continuous cardiometabolic risk factors. In AUROC analyses for predicting hypertension, diabetes, and dyslipidemia, none of the predictors were significantly stronger than BMI, except for WHtR, for predicting diabetes in men. Similar findings were reported by Patel, *et al.*[19] in their analysis of baseline data of a large cohort of urban south Asians, including participants from India. They reported that none of the obesity indices were better than the others in their strength of association with cardiometabolic risk factors. However, WHtR had a stronger association with diabetes than hypertension. Although we found that WHtR was not better than BMI in its association with hypertension and dyslipidemia, the association between WHtR and diabetes was better than BMI. A recent study from Kerala, India, by Kapoor *et al.*,[23] also showed that the WHtR ratio had a better strength of association with diabetes than other obesity indices.

Our finding of similarity in the strength of association between various indices of obesity and the cardiometabolic risk factors are also in concurrence with the findings of the Japanese Epidemiology Collaboration group, which analyzed the association between various indices of obesity and cardiometabolic risk factors in more than 45,000 adults in Japan.[24]

However, the findings of this study are somewhat at variance with published results of the meta-analysis by Ashwell, *et al.*[11] and Browning, *et al.*,[10] who showed that WHtR had significantly greater discriminatory power for cardiometabolic risk factors than BMI; however, these differences maybe because of age, BMI, ethnicity, and sample size variation between this and previous studies.

Some strengths of our study are it was a population-based, large sample of women of child-bearing age and their husbands, it followed a standardized protocol that was consistent with international protocols,[25-32] and it offered the opportunity to study the associations of obesity indices and cardiometabolic risk factors in a population that was younger, less obese, and of a different ethnicity than previous populations that were usually used for such studies.[10-13]

Some studies have shown that age, a diverse ethnic group, and place modify the discriminative ability of anthropometric indices to identify subjects with cardiometabolic risk factors.[32,33]

The key finding from our study, which is consistent with other Indian studies, is that the utility of BMI and WHtR is similar for identifying individuals at risk for hypertension and dyslipidemia, but WHtR is slightly better than BMI in identifying individuals at risk for diabetes. Considering the ease with which the WHtR can be obtained with a measuring tape alone in contrast to the need for a measuring tape and a weighing scale for assessing BMI, the WHtR may be a good alternative to BMI in primary care facilities. More importantly, the WHtR is easy to interpret, as its cut-off, which is >0.5, can be communicated effectively to

Table 5: Optimum cut-off of obesity indices for maximum sensitivity and specificity for cardiometabolic risk factors									
		Hypertension			Diabetes Milletus			Dyslipidemia		
Obesity indices		Cut-off	Sensitivity (95% CI)	Specificity (95% CI)	Cut-off	Sensitivity (95% CI)	Specificity (95% CI)	Cut-off	Sensitivity (95% CI)	Specificity (95% CI)
BMI[a]	Men	>23.02	64.10 (54.7 to 72.8)	62.40 (58.1-66.6)	>25.92	50 (27.2-72.8)	81.94 (78.7-84.9)	>19.84	77 (73.1-80.6)	49.6 (41.1 to 58.2)
	Women	>27.03	17.39 (7.8-31.4)	94.75 (93.1-96)	>27.3	45.45 (16.7-76.6)	94.62 (93-96)	>18.06	73.45 (70-76.7)	35.44 (29.9-41.3)
WC[b]	Men	>85.5	50.86 (41.4-60.3)	71.62 (67.6-75.4)	>87.3	65 (40.8-84.6)	74.68 (71.1-78.1)	>84.5	43.6 (39.2 to 48.1)	81.56 (74.2-87.6)
	Women	>61.3	82.6 (68.6-92.2)	36.1 (33.1-39.4)	>80.3	45.5 (16.7-76.6)	93.5 (91.7-95)	>64.4	47.6 (43.9-51.9)	60.3 (54.4-66.1)
WHR[c]	Men	>0.9	63.7 (54.4-72.5)	46.5 (42.2-50.9)	>0.9	90 (68.3-98.8)	47.5 (43.5 to 51.5)	>0.88	74.75 (70.7-78.5)	40.4 (32.3-49)
	Women	>0.8	41.3 (27-56.8)	74.2 (76.5-81.8)	>0.78	81.8 (48.2-97.7)	69.0 (66-71.9)	>0.78	34.7 (31.2-38.4)	71.9 (66.3-77.1)
WHtR[d]	Men	>0.51	55.1 (45.7-64.4)	67.2 (63-71.2)	>0.52	65 (40.8 to 84.6)	71.1 (67.9-75.1)	>0.48	65.4 (61-69.6)	60.2 (51.7-68.4)
	Women	>0.4	84.7 (71.1-93.7)	34.3 (31.3-37.5)	>0.53	45.4 (16.7-76.6)	94.1 (92.4 to 95.5)	>0.42	51.0 (47.2-54.8)	57.8 (51.9-63.7)

[a]BMI=Body mass index. [b]WC=Waist circumference. [c]WHR=Waist-to-hip ratio. [d]WHtR=Waist-to-height ratio. Optimal cut-off values for all obesity indices were calculated by using the AUROC= Area under the receiver operating characteristic curve analysis separately for men and women to identify cardiometabolic risk

laypeople attending primary care centers by mentioning that if the waist measurement is greater than half of the height in an individual, it indicates a risk for development of hypertension, diabetes, and abnormal lipid profile.

In conclusion, the WHtR is like BMI in predicting cardiometabolic risk in this younger lean population of rural Indians. The utility of WHtR as a predictor of cardiovascular risk is promising, and it needs to be explored further in longitudinal studies across diverse settings.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflicts of interest

There are no conflicts of interest.

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