Research Article

Abdominal volume index and conicity index in predicting metabolic abnormalities in young women of different socioeconomic class

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Abstract

Background: Obesity is one of the strong risk factors in development of metabolic disorders such as type-2 diabetes or hypertension (HTN) in individuals. However, central obesity or overall obesity is the primary risk factor associated with metabolic disorder and not well-established. Hence, this study was planned to investigate the anthropometric parameters such as body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), abdominal volume index (AVI), Conicity index (CI), and skinfold thickness as surrogates in predicting the metabolic disorders in young population.

Objective: To assess the ability of anthropometric parameters mainly AVI and CI, to identify young women at risk of developing diabetes and HTN in future, and to compare the anthropometric measurements among the different socioeconomic status.

Materials and Methods: Eighty-four women in reproductive age group of 20–40 years were assessed for different anthropometric parameters such as weight, height, WC, skinfold thickness, and derived values of BMI, WHR, AVI, and CI. They were also investigated for fasting blood glucose and triglyceride levels, and supine blood pressure was recorded. The population was of different socioeconomic class as classified by Modified Kuppuswamy classification; the study was designed to predict metabolic abnormalities such as diabetes mellitus and HTN based on laboratory and blood pressure values (prediabetes: fasting blood glucose, 100–126 mg/ dL; preHTN, systolic blood pressure, 120–139 mm Hg and/or diastolic blood pressure, 80–89 mm Hg; hypertriglyceridemia, triglycerides >150 mg/dL; or a combination of risk factors). The data were analyzed by analysis of variance (ANOVA) and receiver-operating characteristic curve.

Result: The mean BMI was 24.84 ± 5.34 kg/m^2; WC: 96.64 ± 11.5 cm; WHR: 0.96 ± 0.07; AVI: 18.94 ± 4.78; CI: 1.42 ± 0.48; and sum of skinfold thickness: 11.19 ± 3.16 mm. All the mean parameters of the study mentioned earlier were found to have no significant difference when tested by one way ANOVA. Twenty-nine people were detected with metabolic abnormalities that showed significant difference in BMI, AVI, CI, and skin fold thickness.

Conclusion: Our results suggested that obesity is prevalent in all the classes of society irrespective of their social class. BMI is the best indicator for predicting the metabolic abnormality. AVI, CI, and WC can also be used along with the BMI in predicting metabolic abnormality for early management

KEY WORDS: Body mass index, abdominal volume index, Conicity index

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Introduction

The metabolic syndrome, which is defined by a cluster of risk factors that include obesity, hypertension, hyperglycemia, and dyslipidemia, identifies individuals at increased risk of type 2 diabetes and cardiovascular disorders.[1,2] As obesity has become more common, the prevalence of the metabolic syndrome has increased, and these trends are likely to continue.[3–5] The prevalence of obesity is at an increasing trend in India. Although for decades undernutrition was a major problem, in recent days, owing to lifestyle modification in semiurban and urban areas, obesity is on higher trends. According to the National Family Health Survey (NFHS), the percentage of women aged 15–49 years, who are overweight or obese, increased from 11% in NFHS-2 to 15% in NFHS-3. Along with this, another interesting finding is that undernutrition and obesity are both higher for women when compared with men.[6]

Body mass index (BMI; in kg/m^2) is widely used to measure overweight and obesity, and the WHO and the National Institutes of Health (NIH) use similar BMI cutoffs to define overweight (BMI >25) and obesity (BMI >30). It is now accepted that the distribution of body fat is an important determinant of metabolic abnormalities, possibly more so than the degree of excess weight as measured by BMI.

In particular, intraabdominal obesity or visceral fat is strongly associated with metabolic disturbances and insulin resistance. Hence, in view of abovementioned observation, a study designed to evaluate abdominal volume index (AVI) and Conicity index (CI), which reflect adipose tissue in viscera and abdominal organs, will be a useful criterion for early identification of metabolic abnormalities and help in taking measures of further progress in the state of condition.

This study compares the relation of AVI and CI calculated using anthropometric measurements along with measures of lipids, fasting glucose, and blood pressure among 20–40 years healthy female subjects.

Materials and Methods

One hundred young women drawn from different socioeconomic status of population residing around Thiruvalla, Kerala, were included in the study after obtaining informed consent. Each woman was interviewed by the observer to gather a brief medical history and a detailed description of socioeconomic status, which included the details of education, housing conditions, family size, and occupation. Later, anthropometric measurements were taken in suitable light clothes and preferably in early morning in the fasting state (overnight of 12 h).

A fasting venous blood sample was collected upon arrival at the study clinic; fasting blood glucose (FBG), triglycerides, and total cholesterol were assessed immediately. Blood pressure was measured with a standard manual sphygmomanometer in sitting position.

Prediabetes was defined if FBG was in the range of 100–125 mg/dL and diabetes if FBG >126 mg/dL [American Diabetes Association (ADA)].[7]

High blood pressure as systolic blood pressure (SBP) of 120–139 mm Hg and/or diastolic blood pressure (DBP) of 80–89 mmHg was considered prehypertension, and SBP >140 mm Hg and/or DBP >90 mm Hg was considered hypertension.

Triglyceride level >150 mg/dL will be considered as hypertriglyceridemia.

Weight, height, waist, hip, arm circumferences, and skinfold thickness were measured precisely using standard procedures.[8] Weight was measured in light clothing without shoes to the nearest 100 g on a digital scale. Height was measured in standard position with a portable stadiometer and recorded to the nearest millimeter. Waist, hip, and mid-arm circumference measurements taken to the nearest millimeter with a pliable measuring tape. Waist circumference (WC) was measured midway between the lowest rib and the iliac crest, with no garments in measurement. Hip circumference was measured in undergarments at the place of largest circumference around the buttocks. Mid-arm circumference was measured at the midpoint between the acromion and olecranon processes. Skinfold thickness measurements were taken at four sites—triceps, biceps, subscapular, and suprailiac—using Lange skinfold calipers.

BMI was calculated as: body weight in kg /height in m^2

Waist-to-hip ratio (WHR) was calculated by dividing the WC by the hip circumference.

The four-site skin fold measurements were summed for an estimate of total body fat [summed skin fold thickness (SST)] Skin fold thickness measurements were taken at four sites—triceps, biceps, subscapular, and suprailiac sites.

AVI was calculated as [2 cm × (waist)^2 + 0.7 cm × (waist–hip)^2]/1000 and CI as WC/[0.1093 sqrt (weight/height)].

Preobese and obesity were defined as BMI = 25.0–29.9 kg/m^{-2} and BMI >30.0 kg/m^{-2}, respectively.

To predict risk of future disease, the values followed were prediabetes: fasting blood glucose 100–126 mg/dL, prehypertension: systolic blood pressure of 120–139 mm Hg and/or diastolic blood pressure 80–89 mm Hg; hypertriglyceridemia: triglycerides >150 mg/dL; or a combination of risk factors.

Result

This study was completed with a sample of 84 eligible candidates fulfilling our criterion. The mean age of the study sample was 34.15 years, but we did not find any significant difference of the age among the different socioeconomic groups as classified according to Kuppuswamy classification. The mean BMI was 24.84 ± 5.34 kg/m^2; WC: 96.64 ± 11.5 cm; WHR: 0.96 ± 0.07; AVI: 18.94 ± 4.78; CI: 1.42 ± 0.4; and sum of skin fold thickness: 11.19 ± 3.16 mm. All the mean parameters of the study mentioned earlier were found to have no significant difference when tested by one way analysis of variance (ANOVA) as shown in Table 1.

The study detected 29 people with metabolic abnormalities who were found to have values as described in Table 2. The subjects to have prediabetic were five in number, and anthropometric parameters of WC, AVI, and CI were statistically significant on comparison to control group; similarly, 21 people were determined to show prehypertension and anthropometric parametric with significant difference found with BMI and sum

Table 1: Comparison on anthropometric parameters in different socioeconomic status

Parameter	Socioeconomic status					ANOVA "*F*" value
	I	II	III	IV	V	
Sample size (*n* = 84)	22	15	16	17	14	
Age (years)	35.88 ± 4.8	31.3 ± 7.3	35.64 ± 6	31.67 ± 6.9	36.33 ± 3.7	1.9
BMI (kg/m²)	25.38 ± 3.8	23.34 ± 3.9	26.9 ± 7.4	24.2 ± 7.4	24.5 ± 4.2	0.62
Waist circumference (WC) (cm)	94.41 ± 7.3	93.2 ± 8.4	104.2 ± 17.8	95.83 ± 16.3	95.56 ± 7.7	1.3
Waist-to-hip ratio (WHR)	0.97 ± 0.08	0.96 ± 0.07	0.95 ± 0.08	0.99 ± 0.07	0.96 ± 0.08	0.28
Abdominal volume index (AVI)	17.9 ± 2.7	17.5 ± 3.2	22.2 ± 8.1	18.8 ± 7.0	18.3 ± 2.9	1.42
Conicity index (CI)	1.37 ± 0.8	1.40 ± 0.8	1.47 ± 0.1	1.45 ± 0.1	1.42 ± 0.6	2.34
Sum of skinfold thickness (mm)	11.14 ± 3.2	10.42 ± 3.2	11.8 ± 3.12	11.5 ± 2.92	11.1 ± 3.36	2.15

All values are expressed as mean ± standard deviation.

Table 2: Distribution of anthropometric parameters in metabolic abnormalities

Parameters	Prediabetes mellitus	PreHTN	Hypertriglyceridemia
Sample size	5	21	3
Age (years)	34.15 ± 6.12	37.19 ± 3.28	40.1 ± 0.2
BMI (kg/m²)	28.16 ± 13.64*	26.97 ± 5.59*	30.7 ± 023*
Waist circumference (cm)	117.6 ± 27.93*	99.5 ± 17.3	101.0 ± 0.3
Waist-to-hip ratio (WHR)	0.96 ± 0.05	0.94 ± 0.07	0.91 ± 0.6
Abdominal volume index (AVI)	28.9 ± 12.5*	20.39 ± 7.7	20.4 ± 0.32
Conicity index (CI)	1.6 ± 0.03*	1.38 ± 0.09	1.36 ± 0.52
Sum of skinfold thickness (mm)	12.6 ± 1.87	11.41 ± 2.5*	11.2 ± 0.22

All values are expressed as mean ± standard deviation.
*Statistically significant ($P < 0.01$).

Table 3: Area under the receiver-operating characteristic curve (ROC) for each anthropometric index and metabolic alteration

Parameter	Area under curve (AUC)		
	Prediabetes mellitus	PreHTN	Hypertriglyceridemia
BMI (kg/m²)	0.74	0.68	0.71
Waist circumference (WC)	0.63	0.64	0.71
Waist-to-hip ratio (WHR)	0.59	0.64	0.62
Abdominal volume index (AVI)	0.64	0.59	0.61
Conicity index (CI)	0.70	0.68	0.59
Sum of skinfold thickness	0.56	0.70	0.66

of skin fold thickness, but the number of people found with hypertriglyceridemia were three in number; however, no anthropometric parameter predicted any statistically significant difference on comparison.

As observed in Table 3, the receiver-operating characteristic analysis of curve (ROC), there was no statistically significant difference in area under curve (AUC) on comparison between the anthropometric parameters of BMI, WC, WHR, AVI, and CI along with sum of skinfold thickness, where we found maximized sensitivity and specificity for all the parameters around 60% to 70% of the value observed under AUC as depicted in Figures 1 and 2.

Discussion

In this sample of population, we observed the prevalence of obesity being 28% in female subjects, which is similar to the percentage of people who are overweight or obese based on data from 2007 NFHS in Kerala which is around 34%.[6] Thus, it indicates the presence of obesity in all class of socioeconomic groups of society, which is mainly owing to improved living standards, altered food habits, and better medical facilities.

It was hypothesized that all measures of obesity will be positively correlating the metabolic abnormalities detected in

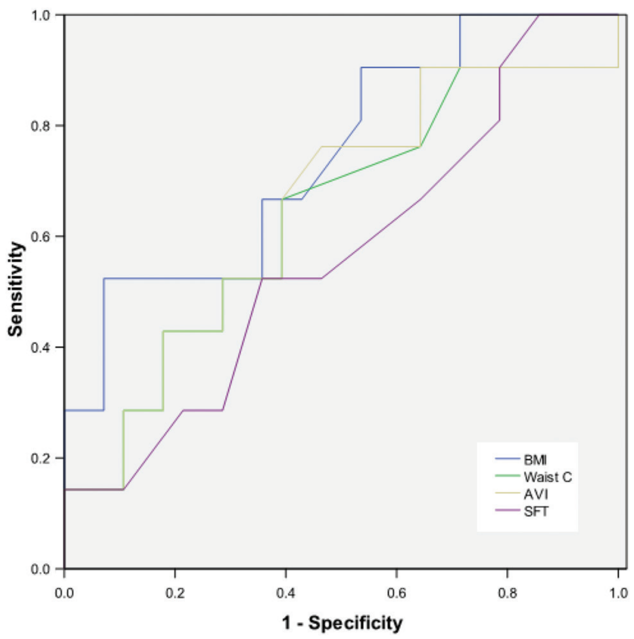

Figure 1: ROC for BMI, WC, AVI, and sum of skinfold thickness.

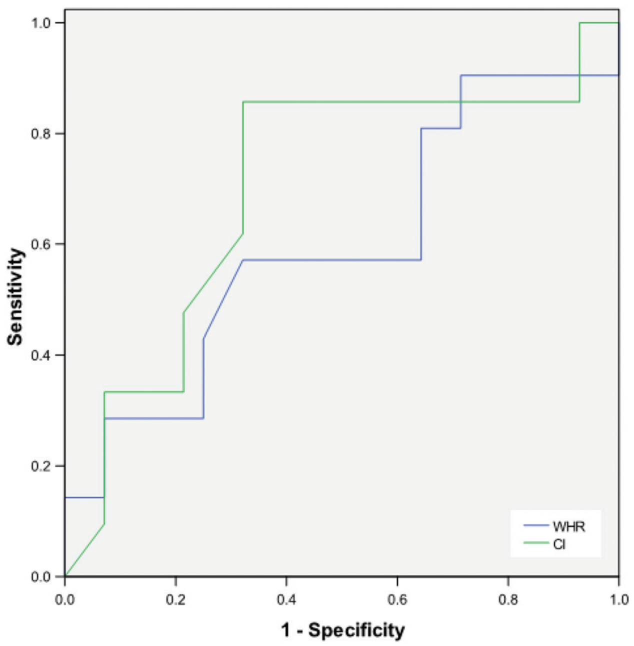

Figure 2: ROC for WHR and CI.

the sample of population. Twenty-nine subjects with metabolic abnormalities in our study did not reveal all the anthropometric measurements suggesting positive correlation. However, we observed BMI as a lone indicator that strongly correlates with all the metabolic abnormalities in our study, followed by WC, AVI, CI, and SST. The other anthropometric parameters showing correlation with metabolic abnormalities were either any one metabolic condition such as diabetes mellitus (DM), hypertension, or hypertriglyceridemia.

In an elderly British population with no history of DM or cardiovascular disease, BMI and WC were strongly correlated and the simple adiposity measures most strongly associated with the metabolic syndrome and insulin resistance after adjustment for other lifestyle characteristics. Another report from the British Regional Heart study showed that BMI is strongly associated with morbidity and cardiovascular disease risk factors in these elderly men.[9] This study extends the findings and indicates that BMI is indicator in presence of the clustering of metabolic abnormalities.

BMI has been conventionally used to define and classify overweight and obesity but does not account for wide variation in distribution of fat in body mainly in prediction of intraabdominal fat accumulation. Hence, we investigated the role of AVI and CI, which are surrogates of WC and abdominal fat in predicting metabolic abnormalities. There is considerable debate in the literature as to whether anthropometric measures may perform differently for the prediction of metabolic abnormalities in diverse ethnic and geographic populations. Few studies in populations of Asian origin have reported WHR to have superior predictive capacity than WC only, while similar studies in North American population have reported WC to be superior to WHR.[10]

Although in our study, we found BMI and sum of skin fold thickness as the only two parameters suggesting an indicator of risk in prehypertensive subjects. The other parameters were not statistically significant; these values were similar to the study results of Neufeld et al.[10] In the risk factor of hypertriglyceridemia, only BMI was the lone anthropometric indicator suggesting an correlating risk factor, and no other parameter suggested any relation, which is in conjunction to study predicted by Neufeld et al.[10]

Recent studies have produced differing conclusions about which anthropometric measure has the best predictive capacity for detecting disease risk. We are reporting that BMI has a significantly better predictive capacity for detecting cases of DM and hypertension. We found no statistically significant difference in the predictive ability of other anthropometric parameters, estimated using area under the ROC curve. In fact, the AUCs in our analysis for BMI with all other anthropometric parameters were not with statistically significant difference although WC, AVI, and CI with SST values were close to the values observed in BMI.

The limitations of our study are that small sample size in each group of socioeconomic class might be not true indicators to demonstrate the actual strength of association between anthropometric parameters and metabolic abnormalities, and the study was limited to local place with no previous standard values of anthropometric measurements set.

Conclusion

In conclusion, we specify that obesity is prevalent in all the classes of society and not limited to upper socioeconomic class of society. Among anthropometric markers, BMI is one of the best parameter in detecting metabolic abnormalities such as DM, hypertension, and hypertriglyceridemia as early as possible. AVI, CI, and WC also stand equal chance in predicting the metabolic abnormalities and more superior on comparison to WHR or SST. Hence, AVI and CI along with BMI and WC can be utilized as an investigative tool in the field to detect problems associated with obesity. Thus, in the population detected, we can take precautions to prevent further progress in the condition and delay the onset of metabolic abnormalities by regular exercise or diet management or if needed by pharmacological support.

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