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CONICITY INDEX AS A SCREENING TOOL FOR CARDIOVASCULAR RISK IN INDIANS

V. Anirudh Srinivas[1], G. Vijayalakshmi[2], S. Dhanraj[3]

[1]Senior Registrar, Department of Cardiology, KMC BR Ambedkar circle, Mangalore 575001, India.
Senior Assistant professor, Department of Medicine, Govt Stanley medical College, Chennai-600001, India.
[3]Assistant Professor, Department of Cardiology, Institute of Child Health and Hospital for Children Madras Medical College, Chennai, India.

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Corresponding Author: Dr. G. Vijayalakshmi, Senior Assistant Professor, Department of Medicine, Govt Stanley Medical College, Chennai-600001, India.
Email: dr.vijikarthik@gmail.com

Abstract

Background: Anthropometric indices and body measurements are used as indicators of measures of body fat distribution since axial computed tomography (the gold standard to assess body fat distribution) is expensive as well as time-consuming. The most appropriate anthropometric index to assess body fat distribution still remains unclear. Measures of centralized adiposity like Waist circumference (WC) Waist-To-Hip-Ratio (WHR), etc are superior to Body Mass Index (BMI) which is the most commonly used and available index, in detecting cardiovascular risk factors. Conicity Index (CI) is relatively unknown anthropometric index which allows for comparison of abdominal adiposity between individuals of varying height, weight, and populations, as the formula contains the height, weight and waist circumference. Waist circumference, Waist-to-hip ratio etc are good representatives of abdominal obesity, have shown variable results in predicting cardiovascular risk factors among different races and populations globally. In Western populations CI as a predictor of cardiovascular risk factors has been studied but there are very few studies on Indians on the use of CI for prediction of cardiovascular risk factors. A positive but weak correlation was found between CI and cardiovascular risk. The cut-off value of CI to enable an action level to prevent cardiovascular mortality was 1.23. A stronger correlation was found between WHtR and cardiovascular risk. WHtR was found to be a better screening tool in men and women. CI also correlated strongly with waist circumference PPBS, SBP.A better correlation was found between WHtR and cardiovascular risk in men and women, signifying that increasing waist circumference, and therefore abdominal obesity has a strong role in the causation of cardiovascular morbidity and mortality. These findings to inculcate the fact that measures of abdominal obesity are required to determine the metabolic risk factors of an individual to start on primary preventive strategies against cardiovascular diseases, hence enabling us physicians to reduce the global cardiometabolic risk.

Keywords: Obesity; abdominal obesity; cardiovascular risk factors.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

Introduction

India as well like all developing countries is getting engulfed in obesity which is now a worldwide pandemic. Obesity is due to an imbalance in energy intake and energy expenditure. Changes in diet and work from home lifestyle are other contributing factors towards increase in cases of obesity which is accompanied by changes in economy and the resultant globalisation. Recently increase in central adiposity or abdominal obesity is particularly implicated in the development of diabetes [1] , hypertension , and cardiovascular co-morbidities. Metabolic syndrome refers to the co-existence of several known cardiovascular risk factors, including hypertension, insulin resistance, atherogenic dyslipidemia and obesity. These conditions are interconnected and have common pathways, mediators and mechanisms. It is imperative to identify patients with metabolic syndrome as they are at high risk of developing cardiovascular disease and type 2 diabetes, both of which contribute significantly to morbidity and mortality. The value of metabolic syndrome as a scientific concept remains controversial. The presence of metabolic syndrome alone cannot predict global cardiovascular disease risk. Abdominal obesity, a marker of 'dysfunctional adipose tissue', is the most prevalent manifestation of metabolic syndrome – hence it is a very important in clinical diagnosis of metabolic syndrome. Better risk assessment algorithms are needed to quantify cardiovascular disease risk on a global scale. At every visit to a doctor , anthropometric measures can be used to assess central adiposity and to initiate a cardiovascular risk factor screening and by which we can introduce to the general public, a simple concept of modifiable risk factor reduction. Body Mass Index (BMI) is the most commonly used anthropometric index to assess the prevalence of overweight and obesity. There are several criticisms to using BMI as a sole marker for obesity as it does not enunciate the composition of body weight. The most prevalent form of this cluster of metabolic abnormalities linked to insulin resistance is found in patients with abdominal obesity, especially with an excess of intra-abdominal or visceral adipose tissue (VAT). Several anthropometric indices such as waist circumference (WC), waist – to hip ratio (WHR), waist to height ratio (WHtR) have been used as clinical measures of central obesity.[2] Obesity is defined by a state of chronic, low-grade inflammation which is associated with increased markers of inflammation and oxidative stress [3] and its well known that oxidative stress accelerates atherosclerotic disease process.

Visceral adiposity has been connected to Type 2 diabetes, and cardiovascular disease risk factors such as insulin resistance and dyslipidemia.[4] Nevertheless, the quest for best adiposity indices as markers of cardiovascular risk remain still unassailable and very few studies have been performed in Asian populations in this regard. Waist-to-hip ratio (WHR), waist circumference (WC) or sagittal abdominal diameter (SAD) - the height of the abdomen when the patient is in the supine position - are a few standard measures used in general practice to estimate the visceral adiposity. It is thought that WC represents visceral and subcutaneous fat while hip circumference (HC) reflects subcutaneous fat only.

Conicity Index (CI) is an anthropometric index, first described by Valdez [5] *et al.*, developed based on a model that suggests people who accumulate fat around the abdomen have a shape similar to a double cone with base at the waist, whereas those people who have less fat in the central region have the shape of a cylinder. CI includes the variables of weight, height and WC, hence weakening the correlation between WC and height, inferring that central obesity is associated with higher risk for cardiovascular disease than general obesity. Evidence has pointed out that Asian populations have different associations between BMI, percentage of body fat, and health risks as compared to European populations. Higher percentage of body fat at lower BMIs also reflects increased risk of disease (i.e., diabetes and heart disease), risk factors for chronic disease, and death in Asian populations.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

Use of anthropometric indices such as the CI during routine health check ups may provide a breakthrough for early initiation of primary preventive strategies. Various studies from WHO reveal that there are ethnic-specific cut-off values for different anthropometric parameters. Recent studies have identified ethnic specific cutoff values for BMI, WC, HC, WHR and WHtR for Asians, North Americans, South Americans, Africans, Hispanic, Middle-Eastern, Aboriginals and Pacific in landers. Minimal studies have been done to determine the cut off values of anthropometric indices for the risk of metabolic complications in Indian population.

Objectives

To study the utility of Conicity Index as a screening tool for cardiovascular risk factors in Indians and compare CI with other anthropometric measures like BMI, WHR, WC etc. as a correlate of cardiovascular risk factors.

Materials and Methods

The study was taken up from the month of July 2021 to January 2023. Subjects above the age of 18 years availing the Master Health Checkup facility at Government Stanley Medical College and Hospital were taken into the study. Anthropometric measurements like waist circumference, hip circumference, weight and height were taken. A brief medical history was taken and physical examination was done. Fasting blood glucose, post prandial blood glucose, fasting lipid profile, and serum TSH was tested. Statistical analysis of the data was done to arrive at a cut-off of CI as a screening tool for cardiovascular risk

A total of 185 subjects were included in this study after sample size calculation using N Master software. Informed consent was taken prior to enrolment into the study A brief medical history was taken with particular reference to diabetes, hypertension, history of smoking, family history of myocardial infarctions and medications which modify body weight. Anthropometric measurements like waist circumference, hip circumference, height, weight were measured using WHO- Stepwise approach to surveillance or NHANES[46] guidelines as appropriate.

Results

185 subjects were examined and blood investigations were taken. 62 percent of the sample population belonged to the age group of 31-50. Higher percentage of males (54%)was seen in the study group. 88.6 % of persons studied were overweight (i.e. having a BMI > 23 kg/m2 upto 30 kg/m2).35.1% were obese (BMI > 30 kg/m2).Only 10.3% of persons in this study belonged to the normal BMI category of 18.5 – 22.9 kg/m2.

There was a 10- year cardiovascular risk of >10% as calculated by PROCAM score in 23% of the subjects. 38.9% were diagnosed diabetics and 29.7 % of the subjects were diagnosed hypertensive.

The mean waist circumference was 91.42 cm with a SD of 11.71 cm, mean WHR was0.98 with a SD of 0.06, and mean WHtR was 0.573 with a SD of 0.07.Mean BMI was 28.13 with a SD of 4.56

Mean Conicity Index was 1.253 with a SD of 0.09 and a range of 1.03 to 1.52

Mean WC among men is 94.12 cm with a SD of 11.83, mean WC among women is 88.24 cm with a SD of 10.79. Mean CI among men is 1.281 with a SD of 0.09 and 1.22 with a SD of 0.09 among women.

As age increased, the mean WC, mean WHR, mean WHtR and mean CI increased (all achieving statistical significance of $p < 0.05$). A very strong correlation was obtained between CI and WC (r= 0.784).A strong correlation was obtained between CI and WHtR (r = 0.702). A moderately strong correlation was obtained between CI and WHR (r = 0.641). A

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

positive but weak correlation was obtained between CI and SBP (r= 0.356) and CI and CV risk score (r= 0.344).
AUC curve for CI as a screening tool for CV risk is 0.729, with a sensitivity of 70.7% and a specificity of 50%. (p = 0.04). Cut-off value is 1.23. 110 out of 185 participants (59.4%) had a CI higher than the calculated cut off A stronger correlation was found between WHtR and cardiovascular risk. WHtR was found to be a better screening tool in men and women. CI also correlated strongly with waist circumference, PPBS, SBP.

Table 1: Overall demographic features and means

Demographic parameter	**Mean**	**Standard Deviation**	**Range**
Age	45.98	12.74	20-80
Waist Circumference	91.42	11.71	63.75-117.5
Hip Circumference	93.18	10.07	70.25-125.75
BMI	28.13	4.56	16.4-44
Waist to Hip Ratio	0.98	0.06	0.80-1.10
Waist to Height Ratio	0.573	0.07	0.408-0.744
Conicity Index	1.253	0.09	1.03-1.52
SBP	127.64	17.3	100-180
DBP	81.28	11.87	60-120
Total Cholesterol	193.8	44.1	109-415
Triglycerides	158.65	75.03	54-638
HDL	45.91	8.75	20-85
LDL	116.55	36.61	39-298
FBS	123.19	62.29	66-375
PPBS	183.9	114.3	81-606
TSH	3.58	4.42	0.02-43.8

Table 2: Distribution of subjects according to Cardiovascular risk

CV risk	**Frequency**	**Percentage**
<10%	144	77.8%
10-20%	24	13%
20-40%	12	6.6%
>40%	5	2.7%

Table 3: AUC and cut off value of anthropometric indices by ROC curve analysis

Anthropometric Index	**Area under the curve**	**P value**	**Cut off**	**Sensitivity**	**Specificity**
Conicity index	0.729	0.042	1.23	70.7%	50%
Body Mass Index	0.642	0.051	27.61	73.2%	50.3%
Waist Circumference	0.730	0.043	90.02	73.2%	54.9%
Waist to Hip Ratio	0.695	0.047	0.978	80.5%	57.2%
Waist to Height Ratio	0.755	0.045	0.573	75.6%	59%

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

Table 4: Correlation of CI with other parameters

		CONICITY INDEX
WC	Pearson coeffcient	0.784**
	P value	<0.001
BMI	Pearson coeffcient	0.212*
	P value	0.004
WHR	Pearson coeffcient	0.641**
	P value	<0.001
WHtR	Pearson coeffcient	0.702**
	P value	<0.001
SBP	Pearson coeffcient	0.356**
	P value	<0.001
DBP	Pearson coeffcient	0.264**
	P value	<0.001
TGL	Pearson coeffcient	0.155*
	P value	0.04
FBS	Pearson coeffcient	0.114
	P value	0.12
PPBS	Pearson coeffcient	0.183*
	P value	0.012
CV RISK	Pearson coeffcient	0.344**
	P value	<0.001

*Moderately significant (P value: 0.01<P <=0.05)
** Strongly significant (P value: P<=0.01)

$$Conicity\ index = \frac{Waist\ circumference\ (cm)}{0.109\sqrt{\frac{Weight\ (kg)}{Height\ (m)}}}$$

Figure 1: Conicity Index formula

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

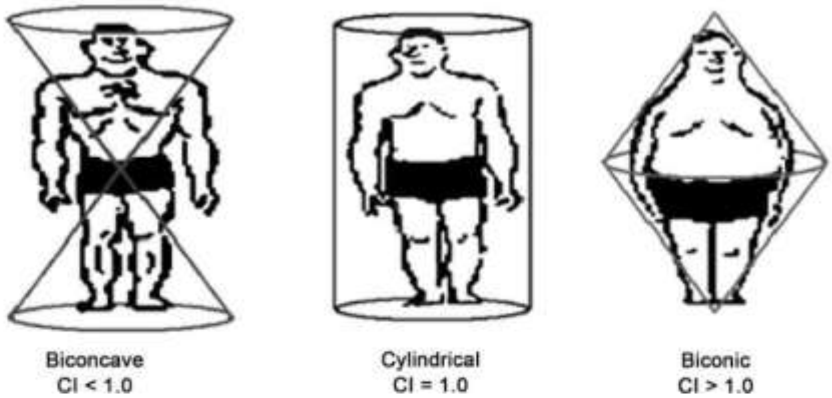

Figure 2: PROCAM Score and Cardiovascular risk

PROCAM score	Cardiovascular risk
≤20	<1%
21-28	1-2%
29-37	2-5%
38-44	5-10%
45-53	10-20%
54-61	20-40%
≥62	>40%

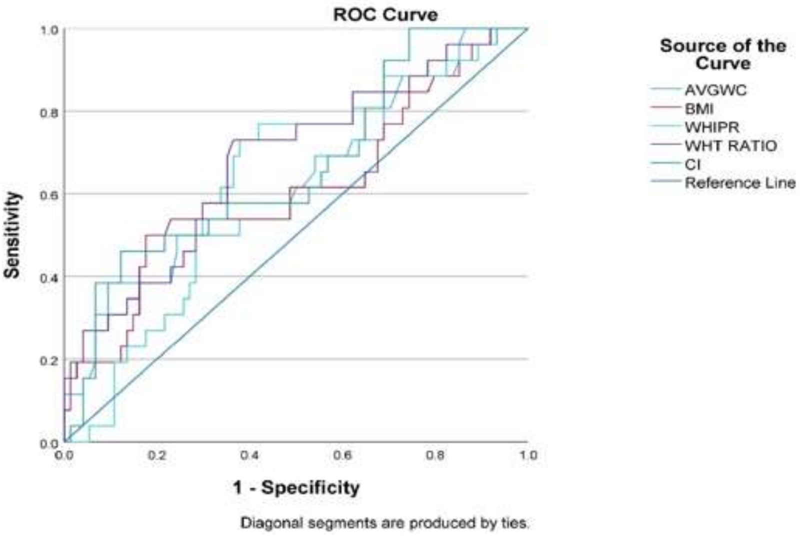

Figure 3 : ROC curve for CI, BMI,WC,WHR,WHtR for men

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

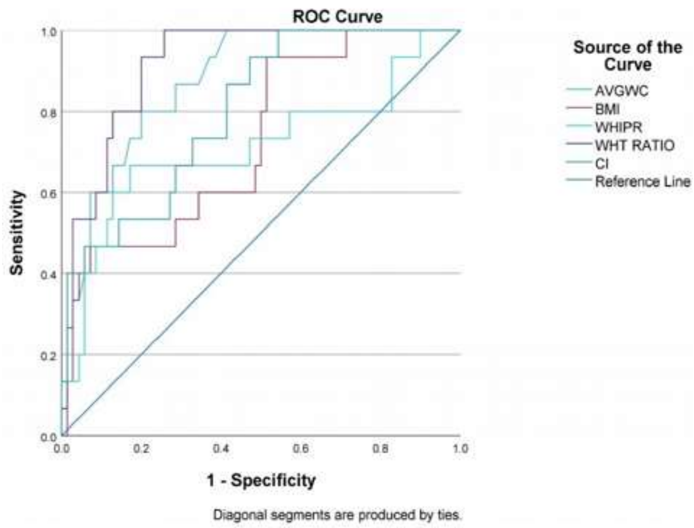

Figure 4: ROC Curve of CI

Discussion

Conicity Index is an anthropometric index examining the abdominal obesity of the subject Increasing waist obesity is associated with a higher cardiovascular risk and mortality.[45]The risk assessment tools cannot assess the abdominal obesity directly.

In this study, we studied the usage and importance of Conicity Index as a screening tool for the presence of Cardiovascular risk using a PROCAM score. We have also tried to establish the correlation of Conicity Index with other anthropometric indices such as BMI, WC, WHtR. We have arrived at a cut-off value of CI (1.23) (table 15) to enable action levels in Indian population to prevent cardiovascular mortality.

Mean age of the subject population was 45.98 years with a SD of 12.74 (table 9).as compared to another study done by Venkataramanan [47] *et al.*, in Andhra Pradesh where they compared association of obesity indices with CHD risk factors in urban vs rural Indian men where the mean age was 47.4 years with a SD of 9.1.

Males (54%) are higher than females (46%) in this study (table 4) comparable to another study done by Nadeem [48] *et al.* in Pakistan on anthropometric indices to determine insulin resistance where males constituted 65% and females 35% of the study population.

The mean BMI (table 9) calculated was 28.13 kg/m2, belonging in the overweight range as per the Asian population cut offs given by WHO The prevalence of overweight subjects was 53.6% and the prevalence of obesity was 35.1% (table 5) Only 11.4% of subject were of normal BMI category of 18.5 – 22.9 kg/m2. In urban north Indian study[49] the overall prevalence of generalized obesity was 50.1 per cent, where the criterion for generalised obesity was defined as a BMI > 25kg/m2. Almost all of the subjects in our study were from urban areas and this can explain the high prevalence of obesity as urban dwellers are more of sedentary lifestyle. These statistics suggests the dangerous prevalence of obesity and actually enhance the importance of such studies.

The 10-year cardio vascular risk calculated by PROCAM score was more than 10% in 23% of the subjects. PROCAM score was selected in our study as we did not exclude diabetics or elderly individuals.

The mean Conicity index was calculated to be 1.25 (table 9), which is slightly above the cut-off value calculated in this study (1.23). (table 15).Around 60% subjects had a CI higher than the calculated cut-off of 1.23 (table 17).The mean CI of men and women in our study was

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

1.281 with a SD of 0.09 and 1.22 with a SD of 0.09 respectively (table 10). These are similar to the results obtained by Adithi [61] *et al.* where the mean CI among women in was 1.22 ± 0.1 and similar to Venkatramana [48] *et al.* where the mean CI among men was 1.3±0.1.

Conicity index positively correlated with CV risk calculated by PROCAM (r = 0.344, p<0.001(table 14) however the strength of correlation was higher as compared to the study performed by Adithi [61] *et al.* Strong correlation was found between CI and some of modifiable risk factors like PPBS, SBP and DBP (table 14). CI also correlated strongly with WC and WHtR.

The cut-off value for CI as calculated in this study is 1.23 with AUC being 0.729 and a sensitivity of 70.7% and a specificity of 50% with no statistically significant difference in the discriminatory power of CI as a screening tool between men and women (table 16). This is similar to the study conducted in south India by Adithi [61] *et al.* which suggested similar sensitivity (73%) and statistically significant difference in Conicity Index.

A study conducted at Brazil, South America utility of Conicity Index as a coronary event where the best cut-off points to discriminate high coronary risk in men and women were, respectively, 1.25 (73.91% sensitivity and 74.92% specificity) and 1.18 (73.39% sensitivity and 61.15% specificity) by Pitanga [50] *et al.* In Pakistan, Nadeem[48]*et al.* study suggested 1.39 to be the best cut-off of CI for determining insulin resistance. This variance in the cut-off obtained between these studies across geographical regions can be explained by various factors like ethnicity and diversity in physical activity, eating patterns and standard of living.

In our study, CI had a weak correlation with SBP (r= 0.356) (table 14). But this correlation was stronger as compared various studies like Mantzoros[51] *et al.* on CI as a predictor of blood pressure levels where CI correlated with systolic blood pressure (r = 0.14, p = 0.02). Shidfar[52] *et al.* study of post-menopausal women showed that BMI and CI were significantly correlated with SBP. (r = 0.212, p = 0.009). This shows that BMI and CI could be an important determining factor of SBP.

CI was weakly but positively correlated with FBS (r = 0.114) and with PPBS (r = 0.183) (table 14). Our results shows a similar result to the study by Ghosh[53] *et al.* where CI was positively correlated with PPBS with r= 0.244.(table 14) Considering that insulin resistance is by itself a cardiovascular risk, these findings are appropriately similar in our study.

There was a very strong correlation between CI and WC with r = 0.784 and a good correlation between CI and WHtR with r = 0.702 (table 14), both of these achieving statistical significance. Hence this proves that CI can be used as an alternative index for assessing abdominal obesity.

Interestingly, it was found that overall, WHtR was a better screening tool for cardiovascular risk with an AUC of 0.755 with a p value of 0.045, a sensitivity of 75.6% and a specificity of 59% (table 15). The meta-analysis study[54] of 88000 individuals, suggested the statistical superiority of WHtR over other anthropometric indices in detecting the CV risk . The risk of atherosclerosis and its complications determined by ideal WHtR in ROC analysis was ≥0.53 with a prevalence of 55.8% in a Chinese study[55] done on elderly individuals.

In women, WC was found to be a better screening tool for cardiovascular risk than CI, WHR or BMI with an AUC of 0.873, p <0.042, and a sensitivity of 86.7% and a specificity of 71.4% (table 21). In an Iranian study [57], WC proved to be a better predictor of modifiable risk factor of CVD like diabetes and hypertension than BMI, in women. The cut-off value for WC for women (90.38cm) in our study was found to be higher than the WHO cut – off for Asians in women, i.e, less than 80cm. Further studies are required to ascertain region specific cut offs to provide an improved tool for screening. In men, the AUC for WC did not achieve statistical significance (table 18). Overall, WC had an AUC of 0.730, with p =0.043, sensitivity of 73.2% and specificity of 54.9%.(table 15).

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 06, 2023

BMI was not found to be related to any MACE (Major Adverse Cardiac Event and Waist circumference was inferred to be a very good predictor of the same in a study by Tarastchuk[56] reinforcing the emphasis on central adiposity and its effect on CV risk. In our study too, BMI did not prove to be good screening tools for cardiovascular risk (table 15). In a study done in China [58] with increasing BMI, the risk of hypertension increased substantially for both genders ($p<0.001$), which was inferred in our study as well.
Comparative analyses between all the anthropometric indices for men showed WHtR to be a better screening tool with an AUC of 0.682, sensitivity of 73.1% and specificity of 63.5%.
Abdominal obesity majorly increases the weight of the individual and in turn BMI was suggested in our study because Waist Circumference increased with BMI at a statistical significance of $p<0.001$. Increase in waist circumference seems to be the major contributor to weight as the BMI increases in our study the WHtR also correspondingly increases with a $p=0.001$ suggesting tracking waist circumference along with weight is of utmost importance for central obesity.
The fact that the pathogenic mechanisms of interplay between central adiposity and atherosclerosis are not fully understood yet is being proved by these findings. Further studies on Conicity Index and other anthropometric measures are the need of the hour due to the alarming rate this undervalued pandemic that is obesity so that an action level cut-off can be established to prevent further disease progression and mortality.

Conclusion

This was a cross-sectional study done on 185 subjects attending the general OPD in a teritiary care setup in a urban city in South India to study the utility of conicity index as a screening tool for cardiovascular risk factors in Indians. The study was done between April 2021 and June 2022.
Complete clinical profile with history and examination followed by anthropometric measures diabetic and lipid profile was assessed. Statistical analyses were done to arrive at a cut-off of CI as no standard values have yet been derived for Indian population.
The mean CI calculated in this study was 1.25 and the cut-off of CI calculated to identify an increased cardiovascular risk was 1.23. CI had a positive but weak correlation with cardiovascular risk. However, strong correlations were obtained between CI and individual cardiovascular risk factors like PPBS, SBP, DBP. Strong correlations were also found between CI and other anthropometric indices like WC and WHtR. WHtR can be used as a screening tool for cardiovascular risk in males as well as females
Along with traditional risk factors of cardiovascular risk like total cholesterol, triglycerides or blood pressure , the measures of abdominal obesity need to be considered as well in the risk analysis.
Primary prevention strategies should be initiated for preventing the cardiometabolic risk for individuals at early age using both cardiovascular risk factors and metabolic risk factors in order to give a comprehensive direction.
Anthropometric measures are the need of the hour in tackling this global epidemic that is obesity,hence it is important that frequent montioring is done and its imbibation in the regular clinical practice is imperative.

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Conflict of Interest

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The authors declare that there is no conflict of interest.

Authors' Contribution

All authors listed have made a substantial, direct and intellectual contribution to the work and approved it for publication.

Ethics Commitee Statement

The study is approved by the Insititutional Ethics Commitee ,Government Stanley Medical College, Chennai

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