Original Article

Obesity and Associated Cardiometabolic Risk among Women from Tripura - A Northeastern State of India

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ABSTRACT

Introduction: Cardiometabolic health status of women is a serious public health concern. Markers of body fat content and their distribution are important indicators of cardiometabolic health risk in participants. In addition, socio-demographic status plays a determinant role. The aim of the study was to evaluate the influence of adiposity markers and socio-demographic determinants on various cardiovascular and metabolic risk factors in Indian women. **Materials and Methods:** The study was conducted on 388 women (age 25–65 years) from Tripura, a Northeastern state of India. Various obesity and atherogenic markers such as body mass index (BMI), waist circumference (WC), waist-hip ratio, waist - height ratio, high density lipoprotein-cholesterol (HDL-C)/total cholesterol, HDL-C/low density lipoprotein cholesterol, triglyceride/HDL-C ratio and traditional cardiometabolic risk factors such as high blood pressure, dyslipidemia, and glucose intolerance were evaluated in participant. The socio-demographic status included the level of education and monthly family income. **Results:** The cardiometabolic risk in postmenopausal women were higher than premenopausal women. The risk increases with age in both groups. Women with lower educational level and higher income group were found to be prone to higher cardiometabolic risk. Receiver operating characteristics analysis revealed central obesity marked by increased WC was a better predictor of cardiometabolic risk than general obesity marked by increased BMI. **Conclusion:** The cardiometabolic risk among both premenopausal and postmenopausal women are associated with central obesity which can be predicted by increased WC in the subject. Socio-demographic status of the participant plays a definitive role in determining cardiometabolic risk in women.

Keywords: *Cardiometabolic risk, obesity, premenopausal women, postmenopausal women*

Introduction

Epidemic obesity has emerged as a major public health challenge in both developed and developing countries. Obesity, a multifactorial disease developed from the interaction between genetic, environmental, and physiological factors, is associated with various comorbidities including cardiometabolic disorders.[1] Evidence suggested that distribution of body fat rather than the total fat content is the major contributing factor for cardiometabolic risk in individuals. Thus, indicators of body fat distribution such as waist circumference (WC), waist-hip ratio (WHR), waist - height ratio (WHtR) has emerged as important indicators of cardiometabolic risk than body mass index (BMI) that represents general obesity of the subject.[2]

Women are particularly found to be prone to obesity and associated disorders. Central obesity contributes to the development of various cardiometabolic risk in women, including insulin resistance and

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atherosclerosis.[3,4] Anthropometric indicators such as WC, WHR, and WHtR used as markers of central obesity are found to be negatively correlated with cardiometabolic risk parameters such as increased blood pressure (BP), dyslipidemia, and glucose intolerance.[5] Menopause in women leads to several changes in hormonal and other physiological parameters. It is found to be negatively associated with all the cardiometabolic risk parameters in women.[6] The biological possibility of this association ship is explained by the fact that with menopause, women experience changes characteristic of metabolic syndrome, including increased abdominal adiposity, hyperglycemia, hyperinsulinemia, and dyslipidemic changes.[7]

Both body adiposity pattern and associated cardiometabolic risk show racial and ethnic differences.[8] The South Asians are found to have greater accumulation of abdominal fat at lower BMI in comparison to their Western counterparts.[9] The prevalence of cardiometabolic risk also varies considerably between Asians and Europeans and Americans. Various socioeconomic characteristics are also found to be associated with obesity and cardiometabolic risk in subject.[10]

The relationship between various body adiposity markers and cardiometabolic risk indicators is not fully established in Indian women, especially involving women from Northeastern region of India. We, therefore, in the present study analyzed the influence of different adiposity markers on components of cardiometabolic risk and also assessed the association between various socio-demographic characteristics and cardiometabolic risk component in a representative sample of women from Tripura, a Northeastern state of India.

Materials and Methods

Study design

This cross-sectional study was carried out during the health camp organized by Brahma Kumaries Ishwariya Vishwavidyalay between February 2014 and February 2015 in Agartala city, Tripura. A total of 388 women were included randomly for the study after estimation of minimum sample size, which was 323, taking 30% prevalence with 95% confidence interval (CI) and 0.05% absolute precision.[11] Totally, 216 individuals were premenopausal (age 25–45 years), and 172 were postmenopausal (age 45–65 years) women.

Only apparently healthy women with no sign of pregnancy, hypertension, Type 2 diabetes or other endocrine disorders were included in the study. The marital status, history of menstrual cycle, and number of children of each subject were recorded. Women who had at least 1 year of cessation of menses were considered as postmenopausal. All willing volunteers signed an informed consent form before taking part in the study. The study was approved by Human Ethical Committee of Tripura University.

Anthropometric measures

All anthropometric measures such as standing height, body weight, waist and hip circumferences were recorded following standard protocol.[12] Basal metabolic rate (BMI), WHR, and WHtR were calculated.

Recording of blood pressure

BP was recorded by a standard method in supine position using an aneroid sphygmomanometer. Both systolic BP (SBP) and diastolic BP (DBP) were recorded. Mean and pulse pressure were calculated.

Laboratory tests

Venous blood samples were collected in the morning after fasting for at least 8 hr. Blood glucose level was estimated using Digilab auto colorimeter (Model No. ET-114, Eduterk Instumentation, India). Serum total cholesterol (TC), high density lipoprotein-cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), and triglyceride (TG) were estimated in a full auto analyzer (Erba - EM 200) using commercial kits (CHOL 576 XL-1000, HDL-C 360 XL-1000, LDL-C 80, TG 576 XL-1000).

Socioeconomic characteristics

Socioeconomic status and dietary history of the individuals were recorded through questioner prepared for the purpose.[13] The socioeconomic status of the individual was evaluated on the basis of level of education and monthly family income of the individual.

Cardiometabolic risk analysis

Cardiometabolic risk of the individuals was evaluated according to consensus statement for diagnosis of general obesity, abdominal obesity, and metabolic syndrome for Asian Indians.[14] As per the statement, women having three or more out of following five factors were identified as having cardiometabolic risk:

- Increased WC ≥80 cm
- Hypertriglyceredimia ≥150 mg/dl (1.7 mmol/L)
- Low HDL-C <50 mg/dl (1.3 mmol/L)
- Elevated BP ≥130/85 mmHg
- Elevated blood sugar ≥100 mg/dl (6.1 mmol/L).

Statistical analysis

The statistical analyses were performed using the PC version of SPSS statistical software (SPSS 20, IBM, Armonk, New York, USA). A *P* value (significance) of <0.05 is deemed statistically significant. A significance of 0.000 should be read as $P < 0.0001$ (very highly significant) as the software can detect significance up to 3 decimal points only. Parameters were expressed as

mean ± standard deviation and percentage. Difference between groups were examined by unpaired *t*-test. Pearson's correlation analysis was performed to establish relation between various obesity, atherogenic markers, and metabolic risk factors. Simple logistic regression analysis was selected as the dependent variable has the binary outcome. The independent variables are a mix of continuous and categorical variables. The dependent variable were metabolic syndrome and without metabolic syndrome. Simple logistic regression analysis was performed on all the independent variables and the outcome was tabulated. It was used as a screening in selection of variables for further analysis. The statistical method of receiver operating characteristic (ROC) curves were plotted to determine WC and BMI discriminatory capacity of cardiometabolic risk of the subject using both harmonized and National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III).

Results

Figure 1 represents age specific prevalence of cardiometabolic risk factors in the study population. From the table, it can be observed that highest number of individuals with cardiometabolic risk are in 51–55 years of age group with 51.85%. The total prevalence rate of 35.56% (n = 388) of cardiometabolic risk factors is observed in our study. The study shows a significantly higher prevalence rate of metabolic risk factors among postmenopausal women with 46.51% (n = 172) than premenopausal women at 26.85% (n = 216).

The baseline characteristics of the individuals revealed that marker of general obesity like BMI and also markers of body adiposity like WHtR were significantly high in postmenopausal women in comparison to the premenopausal women. Similarly, cardiovascular risk indicators such as SBP and DBP showed higher values in postmenopausal women than in premenopausal women except HDL-C. The atherogenic indices such as HDL-C/TC ratio and HDL-C/LDL-C ratio were found to be significantly high in postmenopausal women. However, the difference in WC and WHR remains insignificant in pre- and post-menopausal women. The details are depicted in Table 1.

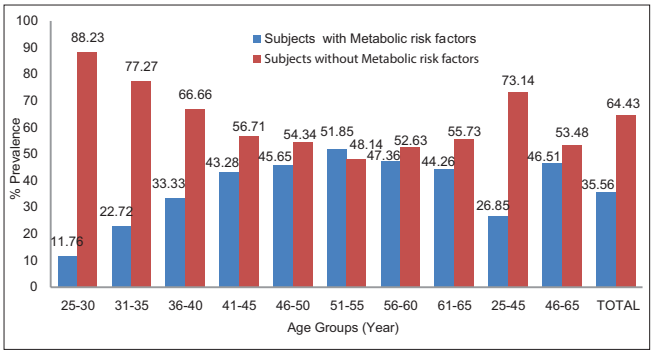

Figure 1: Age-specific prevalence of cardiometabolic risk factors in the study population

Table 2 represents the analysis of correlations between various obesity and atherogenic markers with traditional cardiometabolic risk indicators showed markers of central obesity such as WC, WHR, and WHtR correlates with most of the traditional cardiometabolic risk factors. While, BMI, the marker of general adiposity correlates negatively with all the traditional risk factors except fasting blood sugar (FBS). Among atherogenic markers, HDL-C/TC and HDL-C/LDL-C ratio showed correlation negatively while TG/HDL-C ratio correlated positively with all the traditional cardiometabolic risk indicators except HDL-C.

Sociodemographic characteristics of the individuals

Our study reveals significantly higher rates of metabolic risk factors among urban population including both pre- and post-menopausal women, respectively. Most of them are highly educated and having the monthly income of >30,000/-. The study also reported that majority of the individuals having metabolic risk factors are sedentary workers. Table 3 depicts the above fact.

Table 4 represents the odds ratio and 95% CI of cardiometabolic risk and its components according to socioeconomic status and traditional risk factors. In unadjusted model the prevalence of cardiometabolic risk was 2.36 times more likely (CI: 1.5492–3.6220) in postmenopausal women than premenopausal women (P < 0.0001). According to socioeconomic strata urbanity, sedentary working, high education, and high-income groups have been considered to susceptible into metabolic risk factors. The prevalence of elevated fasting blood glucose, high BPs, low HDL-C and high TGs were also significantly higher in postmenopausal women than premenopausal women.

Prevalence of individual components of metabolic risk factor

Figure 2 represents the prevalence of single component of metabolic risk factor in the study population. Overall in our study, central obesity was the most prevalent component in individuals having metabolic risk factors in both pre and postmenopausal groups, respectively, which is followed by elevated BP, altered lipid profile and hyperglycemia.

Figure 3a and b respectively illustrated the ROC of obesity markers including BMI and WC based on FBS values, showed central obesity was the significant predictor of cardiometabolic risk rather than BMI

Table 1: The baseline characteristics evaluated in the subject

Parameters	Total subject (388)	Premenopausal subject (216)	Postmenopausal subject (172)	*P*
Age (years)	44.91±13.25	34.96±7.65	57.40±6.47	0.0001***
BMI (kg/m^2)	22.76±2.51	22.39±2.40	23.23±2.57	0.001**
WC (cm)	81.00±4.61	80.58±4.38	81.52±4.84	0.05$^{\#}$
WHR	0.79±0.06	0.78±0.06	0.79±0.07	0.35$^{\#}$
WHtR	0.53±0.03	0.52±0.03	0.53±0.03	0.0001***
SBP (mmHg)	125.10±7.59	123.98±7.70	126.51±7.21	0.001**
DBP (mmHg)	84.16±7.79	83.00±7.62	85.61±7.78	0.001**
FBS (mg/dL)	98.90±33.28	91.99±28.67	107.58±36.57	0.0001***
TG (mg/dL)	145.18±56.67	134.10±53.31	159.10±57.83	0.0001***
TC (mg/dL)	193.31±62.44	186.97±55.92	201.27±69.12	0.02*
HDL-C (mg/dL)	50.45±22.03	55.16±22.35	44.54±20.19	0.0001***
LDL-C (mg/dL)	94.71±45.26	87.75±45.96	103.46±42.93	0.001**
VLDL-C (mg/dL)	33.47±19.52	31.56±19.49	35.88±19.35	0.03*
HDL-C/TC ratio	0.27±0.11	0.30±0.10	0.23±0.10	0.0001***
HDL-C/LDL-C ratio	0.63±0.55	0.76±0.69	0.47±0.23	0.0001***
TG/HDL-C ratio	3.61±2.48	2.91±1.90	4.49±2.82	0.0001***

Values are in mean±SD, *P<0.05, **P<0.01, ***P<0.001, $^{\#}$Not significant. BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio, WHtR: Waist-height ratio, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBS: Fasting blood sugar, TG: Triglyceride, TC: Total cholesterol, HDL-C: High-density lipoprotein-cholesterol, LDL-C: Low-density lipoprotein-cholesterol, VLDL-C: Very low-density lipoprotein-cholesterol, SD: Standard deviation

Table 2: Correlation between metabolic risk factors and obesity/atherogenic markers in total study population

Metabolic risk factors	Obesity/atherogenic markers													
	BMI		WC		WHR		WHtR		TG/HDL-C ratio		HDL-C/TC ratio		HDL-C/LDL-C ratio	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Central obesity (WC)	−0.019	0.707	1		0.549**	0.001	0.832**	0.001	0.123*	0.016	−0.137**	0.007	−0.096	0.058
SBP (mmHg)	−0.061	0.232	0.159**	0.002	0.090	0.075	0.086	0.090	0.039	0.444	−0.064	0.211	−0.076	0.135
DBP (mmHg)	−0.039	0.445	0.168**	0.001	0.097	0.057	0.108*	0.033	0.044	0.387	−0.055	0.277	−0.050	0.324
TG (mg/dL)	−0.001	0.985	0.099	0.052	0.033	0.521	0.116*	0.022	0.627**	0.001	−0.442**	0.001	−0.219**	0.001
HDL-C (mg/dL)	−0.055	0.276	−0.071	0.164	−0.040	0.437	−0.056	0.274	−0.683**	0.001	0.707**	0.001	0.463**	0.001
FBS (mg/dL)	0.027	0.594	0.184**	0.001	0.109*	0.032	0.174**	0.001	0.183**	0.001	−0.124*	0.014	−0.104*	0.040

*Correlation is significant at the 0.05 level (two-tailed), **Correlation is significant at the 0.01 level (two-tailed). BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio, WHtR: Waist-height ratio, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBS: Fasting blood sugar, TG: Triglyceride, HDL-C: High-density lipoprotein-cholesterol, TC: Total cholesterol, LDL-C: Low-density lipoprotein cholesterol

according to both harmonized and modified NCEP ATP III criteria.

Discussion

The present study conducted on a representative female cohort from Tripura, a North Eastern state of India, revealed a substantial prevalence (35.56%) of cardiometabolic risk among women (age 25–65 years). The results of our study is in agreement with different studies of metabolic syndrome, conducted worldwide.[15,16] The overall prevalence of metabolic syndrome in women reported in these studies ranges from 13.8% in premenopausal to over 60% in postmenopausal women, which is comparable with our observation of 26.85% (n = 216) in premenopausal and 46.51% (n = 172) in postmenopausal women from Tripura. In our previous study, we have observed 28.46% (n = 137) cardiometabolic risk in premenopausal women.[16] A study by Ramachandran *et al*. among 475 individuals aged 20–75 years in South India using modified ATP III criteria, the prevalence of metabolic syndrome was found to be 41.1%, where the prevalence rate was more in women (46.5%) than in men (36.4%).[17] Gupta *et al*. found 22.9% prevalence of metabolic syndrome in Indian urban men and 39.9% in women.[18]

Consistent with previous studies, a strong association of cardiometabolic risk with increasing age and menopausal status in women is observed in our study. However, a large percentage of premenopausal individuals in our

Table 3: Sociodemographic characteristics of metabolic risk factors in study population

Variables	Individuals with MetS (*n*=138)	Individuals without MetS (*n*=250)	Total (*n*=388)
Age, years (mean±SD)	49.55±11.10	42.35±13.66	44.91±13.25
Locality			
Urban	102 (73.91)	97 (38.8)	199 (51.28)
Rural	36 (26.08)	153 (61.2)	189 (48.71)
Education			
Illiterate	10 (7.24)	75 (30)	85 (21.90)
Elementary	20 (14.49)	65 (26)	85 (21.90)
High school	47 (34.05)	60 (24)	107 (27.57)
College	61 (44.20)	50 (20)	111 (28.60)
Socioeconomic class			
<10,000	10 (7.24)	22 (8.8)	32 (8.24)
<20,000	12 (8.69)	45 (18)	57 (14.69)
<30,000	56 (40.57)	90 (36)	146 (37.62)
>30,000	60 (43.47)	93 (37.2)	153 (39.43)
Occupation			
Sedentary	86 (62.31)	170 (68)	256 (65.97)
Moderate	52 (37.68)	80 (32)	132 (34.02)
Heavy	0	0	0
General obesity BMI ≥23 kg/m^2	91 (65.94)	98 (39.2)	189 (48.71)
Central obesity (WC females ≥80 cm)	109 (78.98)	92 (36.8)	207 (53.35)
Increased blood pressure			
SBP (≥130 mmHg)	106 (76.81)	95 (38)	201 (51.80)
DBP (≥85 mmHg)	107 (77.53)	89 (35.6)	196 (50.51)
Increased FBS (≥100 mg/dL)	86 (62.31)	61 (24.4)	147 (37.88)
Increased TG (≥150 mg/dL)	100 (72.46)	69 (27.6)	169 (43.55)
Decreased HDL-C (<50 mg/dL)	94 (68.11)	95 (38)	189 (48.71)

Numbers in parenthesis indicate percentages. MetS: Metabolic syndrome; BMI: Body mass index, WC: Waist circumference, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBS: Fasting blood sugar, TG: Triglyceride, HDL-C: High density lipoprotein-cholesterol, SD: Standard deviation

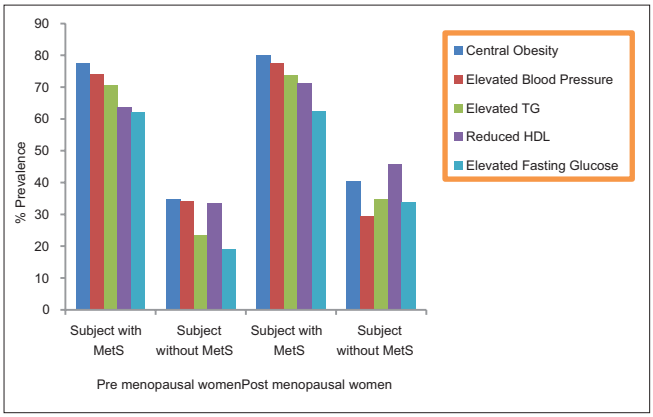

Figure 2: Prevalence of individual component of metabolic risk factors among women population

study, specially within the age group 41–45 years were observed to have profound cardiometabolic risk. Although many cardiometabolic risk features are associated with estrogen deficiency in postmenopausal women. In premenopausal women, particularly with the 41–45 years of age group, this may be attributed to obesity which might have diluted the protective effect of estrogen in premenopausal individuals.[19] The most common individual component of metabolic risk factor identified was the central obesity both in premenopausal (45%) and postmenopausal (63.36%) women having cardiometabolic risk. This is in agreement with different earlier findings. It is suggested that central obesity increases hepatic and adipose tissue insulin resistance and results in glucose intolerance, low HDL-C, increased TG and BP.[20] To explain the relationship between intra-abdominal fat accumulation and insulin resistance two hypotheses have been constituted.[21] It has been considered that intra-abdominal adiposities are biologically active and located near portal vein. Substances like free fatty acids released by intra-abdominal fat directly enter into the portal circulation and to the liver, eventually influence glucose metabolism and lipid production as well.[22] Second, visceral adipose tissue and it's neighbor macrophages intensify the production of inflammatory cytokines like tumour necrosis factor alpha and interleukin-6 and less amount of adiponectin.[23] This results in insulin resistance by inhibiting the synthesis of glucose transport protein GLUT4.

Table 4: Univariate analysis of correlates of metabolic syndrome

Variables	Individuals with MetS, *n* (%)	Metabolic syndrome OR (95% CI)	*P*
Age (years)			
25-45 (*n*=216)	58 (26.85)	2.36 (1.5492-3.6220)	<0.0001
46-65 (*n*=172)	80 (46.51)	Reference	
Locality			
Urban (*n*=199)	102 (51.25)	4.46 (2.8290-7.0600)	<0.0001
Rural (*n*=189)	36 (19.04)	Reference	
Education			
Illiterate (*n*=85)	10 (11.76)	Reference	
Elementary (*n*=85)	20 (23.52)	2.30 (1.0077-5.2848)	0.0479
High school (*n*=107)	47 (43.92)	5.87 (2.7412-12.5917)	<0.0001
College (*n*=111)	61 (54.95)	9.15 (4.2859-19.5342)	<0.0001
Socioeconomic class			
<10,000 (*n*=32)	10 (31.25)	Reference	
<20,000 (*n*=57)	12 (21.05)	1.70 (0.6385-4.5507)	0.2871
<30,000 (*n*=146)	56 (38.35)	2.33 (1.1370-4.7883)	0.0209
>30,000 (*n*=153)	60 (39.21)	2.41 (1.1839-4.9443)	0.0154
Occupation			
Sedentary (*n*=256)	86 (33.59)	0.77 (0.5038-1.2023)	0.2586
Moderate (*n*=132)	52 (39.39)	Reference	
General obesity BMI ≥23 kg/m^2			
Premenopausal (*n*=93)	20 (21.50)	10.36 (5.2903-20.3116)	<0.0001
Postmenopausal (*n*=96)	71 (73.95)	Reference	
Central obesity (WC females ≥80 cm)			
Premenopausal (*n*=100)	45 (45)	2.11 (1.2017-3.7192)	0.0094
Postmenopausal (*n*=101)	64 (63.36)	Reference	
Elevated blood pressure			
Premenopausal (*n*=97)	43 (44.32)	2.88 (1.5764-5.2751)	0.0006
Postmenopausal (*n*=89)	62 (69.66)	Reference	
Increased FBS (≥100 mg/dL)			
Premenopausal (*n*=66)	36 (54.54)	1.34 (0.6947-2.6004)	0.3798
Postmenopausal (*n*=81)	50 (61.72)	Reference	
Increased TG (≥150 mg/dL)			
Premenopausal (*n*=78)	41 (52.56)	1.66 (0.8963-3.0887)	0.1067
Postmenopausal (*n*=91)	59 (64.83)	Reference	
Decreased HDL-C (<50 mg/dL)			
Premenopausal (*n*=90)	37 (41.11)	1.94 (1.0896-3.4684)	0.0244
Postmenopausal (*n*=99)	57 (57.57)	Reference	

Numbers in parenthesis indicate percentages. MetS: Metabolic syndrome, BMI: Body mass index, WC: Waist circumference, FBS: Fasting blood sugar, TG: Triglyceride, HDL-C: High density lipoprotein-cholesterol, OR: Odds ratio, CI: Confidence interval

Univariate analysis of socioeconomic characteristics of our subject revealed high prevalence of cardiometabolic risk in urban individuals (73.91%) in comparison to rural individuals (26.08%). The prevalence of metabolic syndrome in urban and rural India figured out by several workers ranges from 11% to 41%.[24] Furthermore, the prevalence was more in individuals with higher education and monthly family income. It may be explained by the fact that this group of people consume high energy food, and are sedentary in lifestyle and thus prone to obese and associated cardiometabolic risk.[25] A significant increase in DBP has been observed in postmenopausal women in our study. This may suggest that DBP is one of the risk factor for the development of cardiovascular disease among postmenopausal women. Our study shows that TG was significantly higher among postmenopausal women. Different studies also showed the elevation of TG levels after menopause.[26] We have also observed a low level of HDL-C among postmenopausal women which is in agreement with different studies around the world.[27] Kreisberg and Kasim showed that reduction in the HDL-C level after menopause could be one of the coronary artery disease risk factor among postmenopausal women.[28] Consistent with other studies FBS in our study also showed a higher value in postmenopausal women.[29]

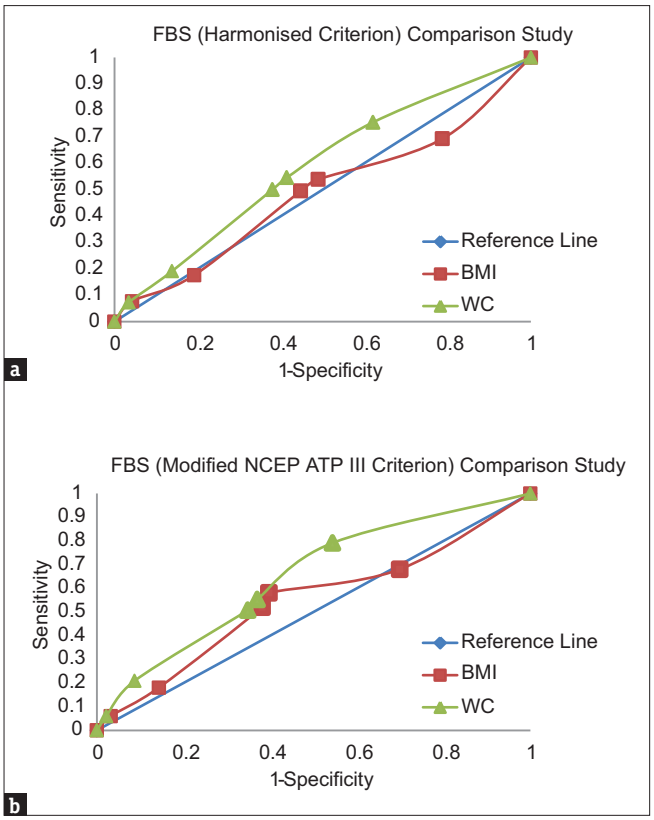

Figure 3: (a) The receiver operating characteristic curve for fasting blood sugar to determine waist circumference and body mass index discriminatory capacity of metabolic syndrome (Harmonized criteria). (b) The receiver operating characteristic curve for fasting blood sugar to determine waist circumference and body mass index discriminatory capacity of metabolic syndrome (modified National Cholesterol Education Programme Adult Treatment Panel III criteria)

In our study, measures of abdominal obesity including WC, WHR, and WHtR were found to be more correlated with cardiometabolic risk parameters in women. Several researchers have concluded that abdominal obesity, usually evaluated by WC, is more strongly associated with cardiometabolic risk factor levels than BMI.[30] We have also evaluated the predictability of adiposity markers BMI and WC on cardiometabolic risk using both harmonized and modified NCEP ATP III criteria. The ROC curve for metabolic syndrome using both the criteria, it is observed that WC presented a higher discriminatory capacity than BMI in our individuals in predicting cardiometabolic risk (area under curve).

Conclusion

Our study revealed that overall prevalence of cardiometabolic risk in women of Tripura is about 35.56%. Although postmenopausal women are having higher risk than the premenopausal women, the premenopausal women specially within 41–45 years age group are having profound cardiometabolic risk. Central obesity marked by increased WC has the better predictive power for cardiometabolic risk than BMI, the marker of general obesity. Sociodemographic characteristics such as level of education, family income, urban and rural dwelling plays determinant role in determining the prevalence of both obesity and associated cardiometabolic risk.

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Conflicts of interest

There are no conflicts of interest.

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