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Predictors of metabolic syndrome in Asian north Indians with newly detected type 2 diabetes

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***Background & objectives*: The identification of metabolic syndrome (MS) among patients with type 2 diabetes (T2DM) is of great importance, since those with MS carry a cluster of cardiovascular risk factors. This study evaluates suitable criteria with high efficiency in diagnosing MS and to identify the strongest predictors of MS in newly detected type 2 diabetes individuals.**

***Methods*: Newly detected type 2 diabetes (<6 months) patients were assessed. The MS was assessed by WHO, National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), modified NCEP-ATP-III and International Diabetes Federation (IDF) criteria. Receiver operating characteristics (ROC) curves of serum triglycerides, HDL, and waist circumference were created for the prediction of MS and the area under the corresponding curves (AUC) were used to evaluate the predictive efficiency of each MS parameter. Different cut points in the selected variables and the corresponding sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were estimated.**

***Results*: Among the 563 newly detected T2DM individuals, the presence of MS ranged from 57 to 68 per cent according to the different criteria. The higher percentage of MS was observed in modified NCEP-ATP III criteria. In comparison to men, presence of MS was higher in women in all the four criteria [198 (67%) vs. 165 (62%); 209 (70%) vs. 111 (42%); 231 (78%) vs. 151 (57%); 222 (75%) vs. 129 (49%)] by modified WHO, NCEP-ATP III, modified NCEP-ATP III, and IDF, respectively. The predictive ability to diagnose MS was highest with modified NCEP-ATP III and lowest with IDF criteria. The optimal cut-off of waist circumference in men and women were 90 and 88 cm respectively. Serum triglyceride in men effectively indicated the presence of MS in newly detected T2DM individuals, whereas, in women the HDL-C was the stronger predictor of MS.**

***Interpretation & conclusions*: The study results show that modified NCEP-ATP III criteria predict highest occurrence of MS in newly detected T2DM patients. Elevated serum triglyceride for men and decreased serum HDL-C in women were the strongest single predictors, effectively indicating presence of MS in newly detected T2DM.**

Key words Hypertension - lipids - metabolic syndrome - newly detected T2DM

The metabolic syndrome (MS) is described as clusters of abnormalities including abdominal obesity, insulin resistance, hypertension, hyperglycaemia, increased triglycerides, and decreased high-density lipoprotein cholesterol (HDL-C)[1]. It is estimated that 13 per cent of adolescents in the United States[2] and 15 per cent nondiabetic European adults have metabolic syndrome[3]. The number of people with the metabolic syndrome also differs by sex, race, and ethnicity[2]. Most patients with diabetes have metabolic syndrome with estimated prevalence of 69.9 per cent for Whites, 64.8 per cent for Blacks, and 62.4 per cent for Mexican Americans[4]. Several studies indicate a rising prevalence of diabetes and insulin resistance in India[5-7] with varying prevalence of MS in Asian Indian immigrants (31.6 to 33.9%)[8,9], and in urban Asian Indian adults (41.1 to 49.2%)[10,11].

Type 2 diabetes mellitus (T2DM) is a significant risk factor for coronary heart disease (CHD) and stroke[1]. At least 65 per cent of people with T2DM die of some form of heart disease and stroke[12]. Patients with T2DM have an increased prevalence of lipid abnormalities, which contribute to higher rates of CHD. High triglyceride and low HDL cholesterol levels were significantly related to all coronary heart disease events and to coronary mortality in patients with T2DM[13]. Moreover, the prevalence of CHD in diabetes patients increases significantly with the addition of MS components[14]. According to Third National Health and Nutrition Examination Survey (NHANES III) data, people who did not have MS, had the lowest risk for cardiovascular disease (CVD) events, those with MS had an intermediate level of risk, and those with diabetes had the highest level of risk[15].

Asian Indian men and women have a higher incidence and mortality rate from CVD than Caucasian men and women[16]. Both MS and T2DM are heterogeneous and complex conditions due to interplay between environmental and genetic factors operating differentially in different populations. The International Diabetes Federation (IDF)[17], World Health Organization (WHO) and the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP-III) have proposed working definitions for the MS based on the traits like overall obesity, central obesity, dyslipidaemia as characterized by elevated levels of triglycerides and low levels of HDL cholesterol, hyperglycaemia, and hypertension. In this study an attempt was made to determine the parameters used for diagnosing MS according to modified WHO, NCEP-ATP III, modified NCEP-ATP III[18] and IDF classifications which could effectively predict the presence of the MS in newly detected T2DM. South Asians develop metabolic abnormalities at a lower body mass index and waist circumference than other groups[19]. Hence, to determine the prevalence of MS and formulating preventive strategies remains contentious. Therefore, the recognition of suitable criteria with high efficiency in diagnosing MS and to identify the strongest predictors of MS in newly detected T2DM individuals were the main objectives of this study.

Material & Methods

This study was carried out from January 2005 to December 2007 at the Nehru Hospital, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, north India. All consecutive patients with newly detected type 2 diabetes (<6 months) attending the Endocrinology Outpatient Clinic were included. Informed and written consent was obtained from all the participants after explaining the procedure. The study protocol was approved by the Institute's Ethics Committee. Initial evaluation included a detailed history and clinical examination to exclude any systemic disease.

Diagnosis of MS was based on modified WHO criteria (microalbuminuria was excluded)[17], NCEP ATP III criteria[20], modified NCEP ATP III criteria[18] and IDF criteria[17] (Table I).

Anthropometric assessment: Standing body height (to the nearest 0.5 cm) was measured with a commercial stadiometer. A digital scale, with an accuracy of ±100 g, was used to measure body weight (BW). The waist circumference (WC) was measured in a horizontal plane, midway between the inferior margin of the ribs and the superior border of the iliac crest. Hip circumference (HC) was measured at the fullest point around the buttocks with a metallic tape. The measurements were taken thrice and the mean was taken in all cases. WC (cm) was divided by HC (cm) to calculate waist to hip ratio (WHR). Body mass index (BMI) (kg/m^2) was calculated by dividing weight (in kilograms) by the square of height (in meters), as a measure of total adiposity.

Systolic and diastolic blood pressure (SBP & DBP) were measured twice at an interval of 3 min in the sitting position after a 15 min rest, and the mean was taken. Per cent body fat (%BF) was evaluated by impedance plethysmography (bioelectrical impedance meter (Omron BF 302, Tokyo). Blood samples

(3 ml) were drawn after 8-12 h overnight fasting for the measurement of lipid profile [total cholesterol, high density lipoprotein (HDL) cholesterol, and triglycerides] and fasting plasma glucose levels. Plasma glucose was measured using the glucose oxidase-peroxidase method[21], serum total cholesterol[22] and triglycerides[23] by standard enzymatic procedures and HDL cholesterol[24] by direct assay method. Diagnosis of diabetes was based on fasting plasma glucose (FPG) ≥126 mg/dl and/or a 2 h plasma glucose ≥200 mg/dl[25].

Statistical analysis: Differences in characteristics between T2DM with and without MS were tested with independent sample *t* tests for normal distributed variables, with the Wilcoxon rank sum test for skewed variables and with the chi-square test for categorical variables. The significance level was set at 5 per cent. All statistical analyses were carried out using sigma stat (Version 2.03) and Analyse-it software (Analyse - it Software Ltd., trial version 1.0.5.0). Receiver operating characteristics (ROC) curves of serum triglycerides, HDL, and waist circumference were created for the prediction of MS and area under the corresponding curves (AUC) were used to evaluate the predictive efficiency of each MS parameter. The AUCs derived from different samples were compared by the method described by Hanley and McNeil[26]. The critical level for the z statistic was set at 1.96. Different cut points in the selected variables and the corresponding sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were also estimated. Serum HDL and waist circumference were analyzed according to the gender. The optimal cut-off[27] was calculated as the minimum value of the square root of $[(1 - \text{sensitivity})^2 + (1 - \text{specificity})^2]$, and greater accuracy is reflected by a smaller distance to (0,1).

Results

Among the 563 patients (266 males and 297 females) metabolic syndrome was diagnosed in 363 (64.47%), 320 (56.83%), 382 (67.85%), 351 (62.34%) patients according to the modified WHO, NCEP ATP III, modified NCEP ATP III and IDF criteria, respectively. After stratification by gender, 165 men (62.03%) and 198 women (66.7%), 111 men (41.7%) and 209 women (70.4%), 151 men (56.8%) and 231 women (77.8%), 129 men (48.5%) and 222 women (74.7%), had MS according to the modified WHO, NCEP ATP III, modified NCEP ATP III and IDF criteria, respectively. Presence of components of metabolic syndrome was seen more in women in comparison to men (Table II). Baseline and demographic characteristics of the patients with MS versus those without MS according to the modified NCEP-ATP III criteria are summarized in Table III.

Of the four criteria assessed, serum triglycerides for men had shown highest predictive ability for MS in modified WHO criteria (AUC 0.859 with 95% CI 0.803 to 0.915). After stratification by gender, the AUC for triglycerides differed significantly (0.859 in men vs. 0.750 in women, $P<0.05$). However, in women HDL had shown

Table I. Diagnosis of metabolic syndrome as per different criteria

NCEP-ATP III	Modified NCEP-ATP III	Modified WHO (Microalbuminuria was excluded)	IDF
Presence of > 3 of the following:	Presence of ≥ 3 of the following:	Presence of diabetes and ≥2 of the following:	Presence of central obesity with waist circumference >90 cm (men) and >80 cm (women) plus any 2 of the following:
(*i*) Waist circumference (>102 cm in men, >88 cm in women)	(*i*) Waist circumference (>90 cm in men, >80 cm in women)	(*i*) BMI >30 kg/m^2 or WHR >0.9 for men >0.85 for women	(*i*) TG >150 mg/dl or specific treatment for this lipid abnormality
(*ii*) SBP >130 mmHg and/or DBP >85 mmHg or medical treatment of previously diagnosed hypertension	(*ii*) SBP ≥130 mmHg and/or DBP ≥85 mmHg or medical treatment of previously diagnosed hypertension	(*ii*) TG ≥ 150 mg/dl (1.7 mmol/l) or HDL-C <35 mg/dl (0.9 mmol/l) for men <39 mg/dl (1.0 mmol/l) for women	(*ii*) HDL-C <40 mg/dl (men), <50 mg/dl (women) or specific treatment for this lipid abnormality
(*iii*) TG >150 mg/dl (1.7 mmol/l)	(*iii*) TG≥150 mg/dl	(*iii*) BP ≥ 140/90 mmHg or medication	(*iii*) SBP >130 mmHg and/or DBP >85 mmHg or medical treatment for previously diagnosed hypertension
(*iv*) HDL-C <40 mg/dl (1.03 mmol/l) in men, <50 mg/dl (1.29 mmol/l) in women	(*iv*) HDL-C <40 mg/dl in men, <50 mg/dl in women		(*iv*) Fasting plasma glucose (>100 mg/dl) or previously diagnosed type 2 diabetes
(*v*) Fasting glucose >110 mg/dl	(*v*) Fasting glucose >110 mg/dl		

NCEP-ATP III, National Cholesterol Education Program Adult Treatment Panel III; WHO, World Health Organization; IDF, International Diabetes Federation; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure; WHR, Waist Hip ratio

highest predictive ability for MS in modified NCEP ATP III criteria. The displayed AUCs in all the four criteria were 0.669 with 95 per cent CI 0.588 to 0.749, 0.795 with 95 per cent CI 0.723 to 0.867, 0.846 with 95 per cent CI 0.778 to 0.914, and 0.668 with 95 per cent CI 0.577 to 0.760 in modified WHO, NCEP ATP III, modified NCEP ATP III, and IDF criteria respectively (Table IV). The AUC for HDL- C in women in comparison with men, differed significantly (0.846 by modified NCEP ATP III vs. 0.656 by IDF criteria, $P<0.05$).

The optimal cut point (calculated as the minimum value of the square root of [(1 - sensitivity) ^{2} + (1 - specificity)^2] for triglycerides in men was 153, 154, 170 mg/dl and it showed satisfactory sensitivity (%) and specificity (%) 78.9 and 92.9, 83.8 and 72.3, 78.2 and 82.1 in modified WHO, NCEP-ATP III, and modified ATP-III criteria respectively (Table V). For the IDF classification, a cut-off of 150 mg/dl for serum triglycerides in men showed 69.4 per cent sensitivity and 56 per cent specificity, while an optimal cut-off of 170 mg/dl showed 59.3 and 69.7 per cent values.

For women serum HDL-C cut-off of 50 mg/dl showed sensitivity (74%) and specificity (45%) of 80 and 77 per cent, 77 per cent and 86, 74 and 52 per cent by modified WHO, NCEP ATP III, modified NCEP ATP III and IDF criteria respectively. The optimal cut-off of 50 mg/dl was observed in NCEP ATP III and modified NCEP ATP III criteria. Whereas, in modified WHO the optimal cut-off of 47.6 mg/dl (sensitivity 65%, specificity 58%), and 47 mg/dl (sensitivity 66%, specificity 62%) in IDF criteria was observed. However, HDL cut-offs above the suggested 50 mg/dl exhibited specificity lower than 60 per cent (Table III). The optimal cut-off for HDL in men showed 44 mg/dl (sensitivity 58%, specificity 53%), 40 (sensitivity 55%, specificity 85%), 40 (sensitivity 46%, specificity 85%) and 47 mg/dl (sensitivity 72%, specificity 36%) in modified WHO, NCEP-ATP III, modified ATP-III and IDF criteria, respectively.

The optimal cut-off for waist circumference in men displayed 90.5 cm (sensitivity 67.1%, specificity 67%), 96.8 cm (sensitivity 55%, specificity 86%), and 90 cm (sensitivity 78%, specificity 76%) in modified WHO, NCEP-ATP III and modified ATP-III criteria respectively. The optimal cut point for waist circumference in women showed 88.7 cm (sensitivity 66%, specificity 55%), 88 cm (sensitivity 74%, specificity 71%) and 84 cm (sensitivity 83%, specificity 54%) in modified WHO, NCEP-ATP III and modified ATP-III criteria, respectively (Table V).

The metabolic components triglyceride and waist circumference for men and HDL-C for women had shown better predictive ability and observed AUC >0.800 in modified NCEP ATP III classification (Figs 1-3). However, the serum triglyceride and HDL did

Table II. Presence of components of metabolic syndrome in newly detected T2DM

Variable	Men (n=266)	Women (n=297)
Waist circumference		
(Men >102 cm; Women >88 cm)	49 (18.42)	179 (60.26)
(Men >90 cm; Women >80 cm)	145 (54.51)	250 (84.17)
Hypertension	154 (57.89)	191 (64.30)
Elevated triglyceride (>150 mg/dl)	127 (47.74)	129 (43.43)
Low HDL cholesterol		
(Men <40 mg/dl; Women <50 mg/dl)	72 (27.06)	159 (53.53)

Values in parentheses are percentages

Table III. Baseline characteristics in newly detected type 2 diabetes individuals with MS and without MS by modified NCEP-ATP criteria

Variable	DM with MS (n=382)	DM without MS (n=181)
Age (Yr)	49.94±10.85	49.14±10.73
Weight (kg)	71.57±13.80*	61.99±12.52
Height (cm)	159.25±8.97	160.65±9.24
BMI (kg/m^2)	28.26±5.05*	24.01±4.43
Waist (cm)	95.27±11.39*	85.02±10.94
Hip (cm)	100.02±10.07*	92.16±8.59
WHR	0.95±0.08*	0.92±0.07
SBP (mm Hg)	132.69±17.66*	119.29±13.51
DBP (mm Hg)	85.89±11.33*	78.63±7.66
%BF	35.07±7.94*	27.78±7.23
FPG	199.29±72.63	211.67±82.26
PPG	277.42±87.08	281.15±103.15
HbA_{1c}	8.62±1.95	8.34±1.87
TCh (mg/dl)	198.16±45.21*	181.80±35.25
HDL-C (mg/dl)	43.03±9.28*	48.36±9.11
LDL-C (mg/dl)	113.10±37.98	103.57±30.58
TG (mg/dl)	200.18±97.95*	129.44±49.47

*$P<0.001$ compared to T2DM patients without MS.

DM, Diabetes mellitus; MS, metabolic syndrome; NCEP-ATP III, National Cholesterol Education Program Adult Treatment Panel III; BMI, body mass Index; WHR: Waist Hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; %BF, per cent body fat; FPG, fasting plasma glucose; PPG, postprandial plasma glucose; HbA_{1c}, glycated haemoglobin C; Tch, total cholesterol; HDL-C, high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol; TG, triglyceride

Table IV. Area under the ROC curve of TG, HDL-C, and waist circumference

Variable	NCEP ATP-III ROC curve area (95% CI)	Modified NCEP ATP-III ROC curve area (95% CI)	Modified WHO ROC curve area (95% CI)	IDF ROC curve area (95% CI)
TG:				
Overall	0.737 (0.688-0.785)	0.776 (0.728-0.824)	0.806 (0.761-0.852)	0.638 (0.583-0.692)
Men	0.805 (0.746-0.864)	0.824 (0.768-0.881)	0.859 (0.803-0.915)	0.666 (0.594-0.738)
Women	0.715 (0.634-0.795)	0.760 (0.676-0.843)	0.750 (0.677-0.823)	0.639 (0.545-0.734)
HDL-C:				
Men	0.700 (0.628-0.773)	0.656 (0.584-0.728)	0.591 (0.514-0.668)	0.530 (0.452-0.608)
Women	0.795 (0.723-0.867)	0.846 (0.778-0.914)	0.669 (0.588-0.749)	0.668 (0.577-0.760)
Waist:				
Men	0.724 (0.659-0.790)	0.807 (0.754-0.860)	0.735 (0.673-0.797)	-----
Women	0.757 (0.697-0.817)	0.722 (0.647-0.797)	0.650 (0.580-0.719)	-----

ROC, Receiver operating characteristic; TG, triglyceride; HDL-C, high density lipoprotein cholesterol; NCEP-ATP III, National Cholesterol Education Program Adult Treatment Panel III; WHO, World Health Organization; IDF, International Diabetes Federation; TG, triglyceride; HDL-C, high density lipoprotein cholesterol

Table V. TG cut-off with sensitivity, specificity, PPV, NPV of MS diagnosis according to different criteria

Optimal cut point	NCEP-ATP III				Modified NCEP-ATP III				Modified WHO				IDF			
	SEN	SPE	PPV	NPV	SEN	SPE	PPV	NPV	SEN	SPE	PPV	NPV	SEN	SPE	PPV	NPV
TG-all (mg/dl)																
147	72.1	69.8	81.5	57.5	69.7	69.7	90.3	47.1	73.0	82.7	91.5	54.4				
155													59.7	61.8	74.7	44.7
TG-men (mg/dl)																
153									78.9	92.9	95.8	67.7				
154	83.8	72.3	73.9	82.6	78.2	82.1	87.3	70.4								
170													59.3	69.7	65.9	63.3
TG-women (mg/dl)																
136					65.9	75.0	94.8	30.0					71.6	56.5	87.1	32.5
140	70.9	70.2	90.5	37.5												
149									65.9	78.9	90.7	42.4				
HDL-C men (mg/dl)																
40	54.9	85.5	77.7	67.1	46.5	85.5	83.3	50.7								
44									57.6	52.9	72.1	37.1				
47													72.4	36.4	52.7	57.3
HDL-C women (mg/dl)																
47.6									65.3	58.5	83.9	33.7				
47													65.8	61.9	88.4	28.8
50	80.1	76.7	93.7	47.1	77.1	85.7	97.4	34.2								
Waist-men (Cm)																
90					78.0	76.5	81.2	72.7								
96.8	55.5	85.8	73.4	73.0												
Waist-women (Cm)																
84					83.5	53.8	86.4	47.9								
88	73.6	71.3	85.9	52.9												

SEN, Sensitivity; SPE, specificity; PPV, positive predictive value; NPV, negative predictive value

not show AUC >0.700 in IDF classification. Serum triglycerides for men AUC (0.824 vs. 0.666, $P<0.05$) and HDL-C for women (0.846 vs. 0.668, $P<0.05$) in modified NCEP ATP III classification differed significantly with the IDF criteria. The cut-off of 150 mg/dl for serum triglycerides in men showed the specificity and PPV of 90 and 94 per cent in modified WHO criteria, 70 and 72 per cent in NCEP ATP III criteria, 79 and 85 per cent in modified NCEP ATP III criteria whereas, in IDF criteria the observed values were 56 and 61 per cent, respectively. The cut-off of 50 mg/dl for serum HDL-C in women showed the

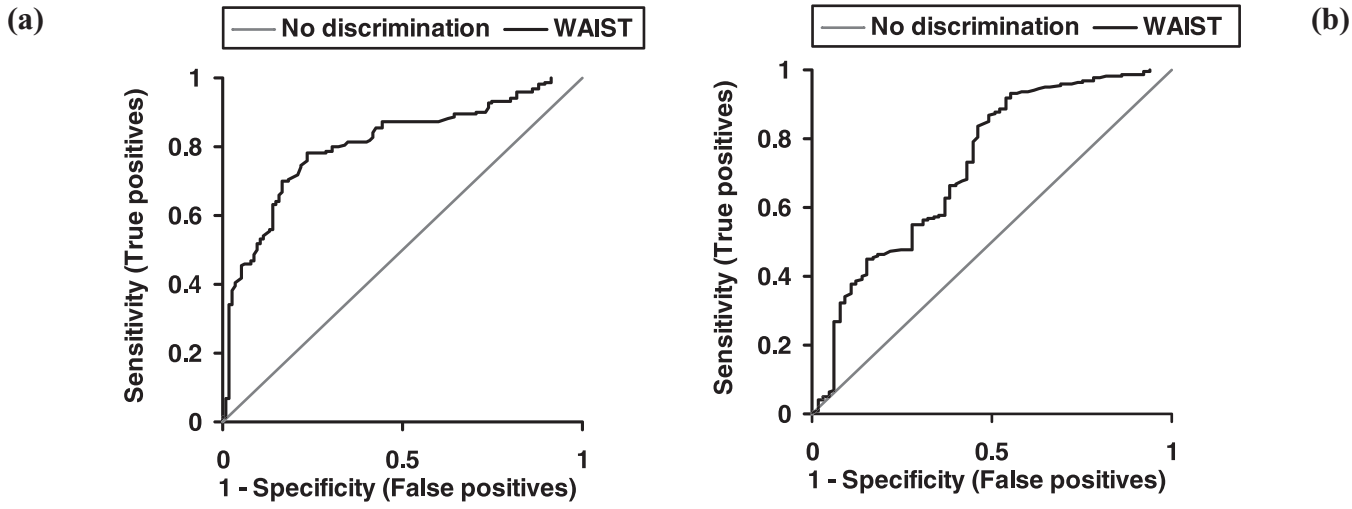

Fig.1. ROC curve to assess discrimination of waist circumference as a predictor of MS in men **(a)** and women **(b)** defined by modified NCEP-ATP III criteria.

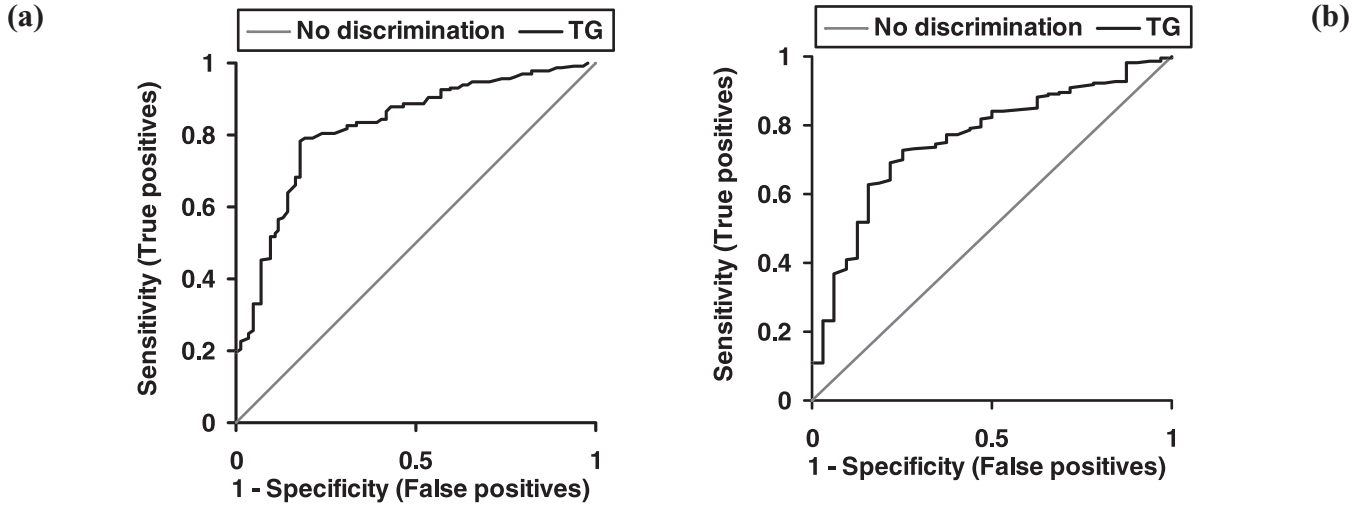

Fig. 2. ROC curve to assess discrimination of triglyceride as a predictor of MS in men **(a)** and women **(b)** defined by modified NCEP-ATP III criteria.

specificity and PPV of 86 and 97 per cent in modified NCEP ATP III criteria whereas in IDF criteria the observed values were 52 and 87 per cent, respectively. However, cut-off of 40 mg/dl for HDL-C in men showed the specificity and PPV of 85 and 83 per cent in modified NCEP ATP-III criteria (Fig. 3) and showed 69 and 54 per cent, respectively in IDF criteria.

Discussion

The present study shows the prevalence of MS varying from 57 per cent (NCEP-ATP III) to 68 per cent (Modified NCEP-ATP III) by different criteria in newly detected T2DM individuals. In comparison to men, prevalence of MS was higher in women in all the criteria. The predictive ability to diagnose MS was highest with modified NCEP-ATP III and least with IDF criteria. Among the various components of MS hypertriglyceridemia showed highest predictive ability to diagnose MS in men and low HDL-C in women.

The prevalence of MS was highest with modified NCEP ATP III and least with NCEP ATP III. This difference in prevalence may be attributed to waist circumference cut-offs of 102 and 88 cm for men and women respectively in NCEP ATP III, while 90 and 80 cm for men and women respectively in modified NCEP ATP III. The prevalence of MS was higher in our study as compared to a similar study from South India[10] (68% vs 41%). This may be attributed to the different criteria

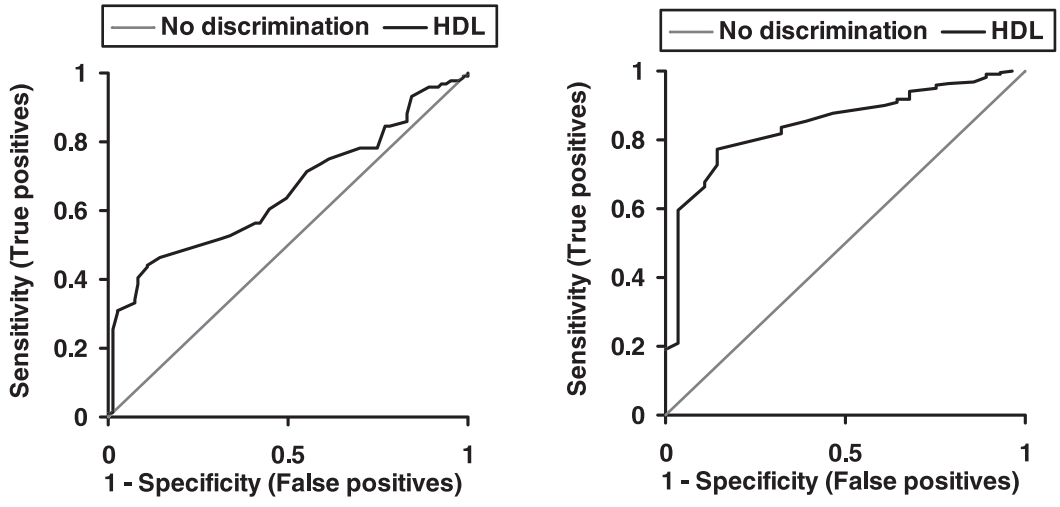

Fig. 3. ROC curve to assess discrimination of high density lipoprotein as a predictor of MS in men **(a)** and women **(b)** defined by modified NCEP-ATP III criteria.

used to define MS particularly the waist circumference of ≥85 cm in women as standard of 80 cm. The higher prevalence of MS in women with diabetes as compared to men is not a surprising observation. Eighty four per cent of women were centrally obese (waist circumference ≥ 80 cm) with a significantly higher mean BMI than men and had higher prevalence of low HDL-C and hypertension. Excess weight has been shown to be the main underlying contributors to the development of MS in women[11]. This further substantiates that women in general otherwise have higher prevalence of MS.

In a study by Hsieh *et al*[28] the most common combination of component of MS in patients with MS were obesity, hypertension and low HDL-C by modified NCEP ATP-III. We also had a similar observation however, hypertriglyceridemia dominated over low HDL-C. It was interesting to observe that patients with diabetes who fulfilled the criteria of MS had higher BMI, waist circumference, %BF, BP and dyslipidemia, than those who did not have MS, even though their blood glucose profile and HbA_{1c} were comparable. This further explicit that diabetes with MS have clustering of more CV risk factors as compared to those without MS. This is further supported by NHANES survey[15]. It will be interesting to observe in long term follow up the CV outcome in patients of diabetes with or without MS, as diabetes *per se* is considered as equivalent to one episode of myocardial infarction[29]. This will also help in understanding the contribution of associated comorbidities for the CV outcome in patients with diabetes.

The modified NCEP-ATP III showed highest predictive ability to diagnose MS and it was least with IDF criteria. The difference could be attributed to the waist circumference as the primary inclusion criteria for diagnosis of MS by IDF classification. Therefore those subjects with DM who did not have central obesity were excluded for the diagnosis of MS. Among the various components of MS hypertriglyceridemia had the highest predictive ability for MS in men and low HDL-C in women. Literature is scarce in defining the predictive ability of different metabolic parameters to diagnose MS. A study by Kompoti *et al*[30] in patients with established diabetes showed increased serum triglyceride level was the strongest single predictor for MS in both men and women according to NCEP ATP-III classification. This is not surprising as hypertriglyceridemia is the most common and earliest lipid abnormalities in patients with DM. Ethnic differences have also been observed with hypertriglyceridemia in predicting insulin resistance in whites but not in blacks[31]. Observation of a low HDL-C in women as a single most predictor to diagnose MS may be attributed to higher BMI, %BF and sedentary life style. These factors overshadowed the beneficial effects of estrogen as most of the women were perimenopausal.

The cut-off of 153 mg/dl for serum triglyceride in men had an optimal sensitivity and specificity which is marginally higher than the standard cut-off of 150 mg/dl. This may possibly be related to more preponderance of central obesity in Asian Indians as compared to Caucasians[19]. The cut-off of 150 mg/dl for serum triglyceride in women had an optimal sensitivity and specificity, and it is in accordance with the standard

levels. The cut-off for HDL-C in women of 50 mg/dl had an optimal sensitivity and specificity which is in accordance with the standard cut-off required to define MS. However, serum HDL-C level of 40 mg/dl in men had poor sensitivity to diagnose MS. Therefore, HDL-C in men as a single most predictor for diagnosing metabolic syndrome was weaker. The cut-off of 90 cm for the waist circumference in men displayed optimal sensitivity and specificity which is in accordance with the modified cut-off for Asian Indians. However, in women, the cut-off of 88 cm showed the optimal sensitivity and specificity of more than 70 per cent which is appreciably higher than the standard cut off of 80 cm. The mean waist circumference for women in this study group was 92 cm, which differ from the Caucasians and African American counterparts. A study from Iran has shown the waist cut-off of 91.5 cm in men and 85.5 cm in women had the highest sensitivity and specificity in predicting MS[32]. Even a study from South India[10], a cut-off for waist circumference of 85 cm was considered rather than standard cut-off of 80 cm. We suggest that the commonly used definition to predict MS at least in present form requires modifications. As Asian Indians have higher truncal and abdominal fat mass compared with Caucasians and African American and abdominal obesity has been postulated as the leading modifiable cause of cardiovascular disease in Asia[33].

Despite various limitations including small sample size, inclusion of only native Punjabis and surrounding population of Chandigarh, this study shows that modified NCEP ATP-III criteria had a highest predictive ability to diagnose MS and increased triglyceride for men and low HDL-C in women was the strongest single predictor to recognize MS in newly detected T2DM. Larger studies are required to redefine the waist cut point for women to establish the risk of CV outcome.

In conclusion, the study results provide evidence that modified NCEP ATP III criteria was better than the other three criteria in identifying MS. The elevated serum triglyceride for men and serum HDL in women was the strongest single predictor, which effectively indicated the presence of MS in newly detected type 2 diabetes. The currently recommended cut points for waist circumference for the MS required some modifications for the better prediction.

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