(RESEARCH ARTICLE)

Optimal waist circumference cut-off points and prediabetic state as predictors of metabolic syndrome prevalence among Saudi adults in Jeddah city

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Abstract

With increasing prevalence of metabolic syndrome and absence of local waist circumference cut-off point, it is important to determine the local cut-off point of waist circumference to predict metabolic syndrome.

The aim of this study is to estimate the prevalence of metabolic syndrome among Saudi adults who attend primary health care centers (PHC) in Jeddah city in 2017, and to determine the appropriate waist circumference cut-off value for identifying a person at risk for the metabolic syndrome.

A cross-sectional analytic study was conducted. Results shows; mean age of participants was 30.94±9.70 and waist circumference was 96.87±17.40 in males and 86.51±15.30 in females. The prevalence (CI: 95%) of pre-diabetes was 16.3% (12.9%; 20.1%), while the prevalence of metabolic syndrome was {(95% CI = 10.6%) (7.80%; 13.8%)}. Abdominal obesity was the most frequent component of MetS, detected in 60.6%, and followed by high blood pressure in 25.0%. In males, a waist circumference≥93.5 cm is likely to indicate MetS with 100% sensitivity and 47.2% specificity; whereas, in females, optimal waist circumference cut-off was determined as ≥83.5 cm, showing 92.3% sensitivity and 46.4% specificity. In multivariate logistic regression, extended waist circumference was the strongest predictor of MetS {OR (95%CI) =3.75 (1.30; 10.81); p=0.014}, followed by the presence pre-diabetes {OR (95%CI) =2.31 (1.06; 5.04); p=0.035}. Further, high educational level was a significant predictor for MetS {OR (95%CI) = 0.34 (0.12; 0.99); p=0.047}; while age and marital status were not significant predictors.

Keywords: Prevalence; Metabolic syndrome; Waist circumference; Saudi adults

1. Introduction

A metabolic syndrome (MetS) is a group of several metabolic problems that increase the risk of type 2 diabetes mellitus and cardiovascular diseases [1]. Metabolic syndrome is prevalent all over the world [2], and also among the middle east population [3,4]. Extended waist circumference (WC) is not an obligatory component of MetS while using treatment of dyslipidemia, high BP and high glucose level are considered as risk predictors of MetS [5]. In Saudi Arabia, according to consensus definition, the overall prevalence of MetS was 21,9% in 2013, and abdominal obesity is the commonest component of MetS, with prevalence 45,9% [6]. Moreover, a recent study showed that abdominal obesity is a major

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factor in the prediction of prediabetes [7]. Using waist circumference measurement is an applicable and inexpensive way for measuring abdominal obesity and predicting MetS [8].

Furthermore, most of the studies conducted in Saudi Arabia regarding MetS risk does not determine the optimal waist circumference cut-off point for prediction of more than two components of MetS [9,10]. This study aims to improve the early detection of MetS among Saudi adult population.

1.1. Study design

A cross-sectional analytic study was conducted on the period from January to September 2017 in government primary health care centers in Jeddah city. Jeddah city located in Makkah region in the western part of Saudi Arabia. The population of Jeddah city was about 4,336,145 in 2016, and the number of government primary health care centers in Jeddah city was about 47 centers, distributed in five health sectors in public health administration. This study included adult (aged ≥18 years) men and women who attended primary health care centers in Jeddah. The participants must be fasting for at least 12 hours.

1.2. Sample size

The following formula was used to determine the sample size:

$$N = Z_{1-a\backslash2}{}^2 \text{ x P x (1-P) } \backslash d^2$$

Where N=sample size;

$Z_{1-a\backslash2}$ =point corresponding to significant level of 5%=1.96;

p=prevalence of abdominal obesity among adults with metabolic syndrome in Jeddah city = 45.9% [6];

q= 1-p = 54.1%

d=maximum likely error (5%)

By setting the level of significance as 95% (p≤0.05), and study power as 80%, the estimated population was N=381.

Adults (men and women) visiting PHCs aged 18 years or above were considered for the study. The patents were approached for recruitment into the project as an initial selection step and asked about their current diagnosed condition. Those stating to be non-diabetic, and free of cancer, a hereditary disorder, heart failure and other cardiovascular diseases, and for women if not pregnant were considered to be legible candidates.

The study was explained to patients in a simple lay language, and once agreed, they were requested to sign an informed consent form. After selection, they were asked for non-fasting condition and were given a later appointment for blood testing.

A blood sample is drawn using butterfly needle into one ethylene diamine tetra acetic acid (EDTA) tube (2.0 mL), and one plain tube (4.0 mL). The blood samples were collected by PHCs laboratory technician.

Anthropometric measurements (weight, height, waist, and hip circumference), and blood pressure measured. Also, the pre-designed structured questionnaire was be filled by face-to-face interview. The questionnaire was aimed to collect data regarding medical history, medication history, and socio- demographic characteristics.

Numbers of all approached individuals and those who completed the study to determine response rate was noted.

The following tests were carried out in the fasting serum sample (obtained after clotting and centrifugation): Glucose, HbA1c, Triglycerides, and levels HDL- C. Collected samples were placed on ice immediately, and transferred to King Fahd Medical Research Center at the end of each collection session for processing and storage at - 80 ̊ C. The processing and storage were handled by a well-trained laboratory technician. All biochemical tests were performed in one batch at the completion of sample collection.

The study questionnaire contained three parts:

- Personal data, demographic information, and medical history (including personal history of chronic disease, and a current medication used)
- Anthropometric measurements;
- Blood tests results.

Data were coded, entered and managed using Statistical Package for Social Sciences (SPSS) v.22.

Approval of the study protocol and the data collection was obtained from health authority and Ethical Committee in Jeddah.

2. Results

2.1. Demographic characteristics

Among 451 recruited patients 436 were included in the study; 15 were diagnosed as diabetics based on FBG or HbA1c. Demographic characteristics showed 64.9% of males; mean (SD) age was 30.94 (9.70) years, with the male group being relatively younger than female one {mean (SD) age=30.02 (8.93) versus 32.66 (10.80) years; p=0.006}. Majority of the participants achieved university or post-graduate degree, which was almost equal in males (59.2%) and females (58.8%), (p=0.408). Regarding economic status, 28.9% had moderate income (>5,000 – 10,000 SR), and 38.4% had high or very high income (>10,000 SR), without significant difference between males and females (p=0.221). A statistically significant difference was found in the amount of physical activity at work, where males were more likely to have moderate or considerable activity, by comparison to females (p=0.000). Ethnically, 78.9% of the participants descended from Arabian tribes, more of males (86.6%) than females (64.7%), (p=0.000).

2.2. Clinical characteristics by gender

Table 1 Anthropomorphic and clinical characteristics by gender

Parameter	Total (N=436)	Men (N=283)	Women (N=153)	p-value
Medical history				
Hypertension	34 (7.8)	15 (5.3)	19 (12.4)	0.008*
Treatment for hypertension				
No	415 (95.2)	275 (97.2)	140 (91.5)	**0.002***
Yes	15 (3.4)	8 (2.8)	7 94.6)	
Previously	6 (1.4)	0 (0.0)	6 (3.9)	
Anthropomorphic measurements				
Weight (kg)	77.87 (19.31)	83.05 (18.98)	68.29 (16.01)	0.000*
Height (cm)	167.35 (9.16)	171.87 (6.91)	158.99 (6.58)	0.000*
Body mass index (kg/m2)	27.70 (6.05)	28.09 (6.03)	26.97 (6.05)	0.065
BMI (classification)				
Underweight	14 (3.2)	8 (2.8)	6 (3.9)	
Normal	136 (31.2)	82 (29.0)	54 (35.3)	
Overweight	158 (36.2)	105 (37.1)	53 (34.6)	
Class I obesity	75 (17.2)	54 (19.1)	21 (13.7)	0.398
Class II obesity	36 (8.3)	21 (7.4)	15 (9.8)	
Extreme obesity	17 (3.9)	13 (4.6)	4 (2.6)	
Waist circumference (cm)	93.24 (17.39)	96.87 (17.40)	86.51 (15.30)	0.000*

Hip circumference (cm)	106.08 (15.37)	106.96 (16.54)	104.46 (12.82)	0.104
Waist-to-hip ratio	0.88 (0.10)	0.91 (0.09)	0.83 (0.10)	0.000*
Clinical examination				
Systolic BP (mm Hg)	119.12 (11.52)	121.59 (9.46)	114.56 (13.47)	0.000*
Diastolic BP (mm Hg)	73.95 (10.93)	75.31 (9.65)	71.42 (12.62)	0.000*
High systolic BP, n (%)	81 (18.6)	56 (19.8)	25 (16.3)	0.377
High diastolic BP, n (%)	62 (14.2)	41 (14.5)	21 (13.7)	0.828

Values are mean (standard deviation) unless indicated otherwise. The *t* test was used for continuous variables and the chi-square test for categorical variables; * statistically significant result (p-value<0.05);

Anthropomorphic and clinical characteristics of the total population as well as by gender are presented in Table 1. The reported mean (SD) BMI= 28.09 (6.03) versus 26.97 (6.05) kg/m^2, (p=0.065); waist circumference=96.87 (17.40) versus 86.51 (15.30) cm, (p=0.000); waist-to-hip ratio=0.91 (0.09) versus 0.83 (0.10), (p=0.000) among males versus females, respectively. There were statistically significant differences in both systolic (p=0.000) and diastolic (p=0.000) BP measurement between males and females; however, the percentages of high systolic and diastolic BP were equal in both genders.

2.3. Laboratory results

Mean (SD) HbA$_{1c}$ level was 5.30 (0.41) % without statistically significant difference between males and females (independent t-test; p=0.773). On the other hand, a statistically significant difference was observed in mean (SD) FBG between males {3.80 (1.18)} and females {4.01 (0.90)}, (independent *t*-test; p=0.006). Considering HbA$_{1c}$ level, the prevalence of prediabetes was 14.9%, identically in males (14.9%) and females (14.9%), (Chi-square test; p=0.998); whereas, according to FBG, prediabetes, indicated by IFG, was diagnosed in 2.3% of the participants (1.4% in males and 3.9% in females; p=0.103). Thus, the prevalence (95%) of prediabetes was 16.3% (12.9%; 20.1%).

Table 2 Result of laboratory tests by gender

Parameter	Total (N=436)	Men (N=283)	Women (N=153)	p-value
Glucose metabolism				
HbA1c (%)	5.30 (0.41)	5.30 (0.42)	5.31 (0.39)	0.773
HbA1c (category), n (%)				
Normal (<	361 (85.1)	235 (85.1)	126 (85.1)	**0.998**
High ()	63 (14.9)	41 (14.9)	22 (14.9)	
FBG (mmol/L)	3.80 (1.18)	3.69 (1.30)	4.01 (0.90)	0.006*
FBG (category), n (%)				
Normal	420 (97.7)	273 (98.6)	147 (96.1)	**0.103**
IFG	10 (2.3)	4 (1.4)	6 (3.9)	
Prediabetes, n (%)	71 (16.3)	43 (15.2)	28 (18.3)	0.402
Lipid metabolism				
Triglyceride (mmol/L)	1.20 (0.84)	1.35 (0.93)	0.93 (0.53)	0.000*
HDL (mmol/L)	1.39 (0.31)	1.31 (0.27)	1.53 (0.32)	0.000*

Values are mean (standard deviation) unless indicated otherwise. The *t* test was used for continuous variables and the chi-square test for categorical variables. HDL: high-density lipoprotein cholesterol; HbA1c: glycated hemoglobin A1c; FBG: fasting blood glucose; IFG: impaired fasting blood glucose; * statistically significant result (p-value<0.05).

Lipid metabolism profile showed that males had higher levels of triglyceride {mean (SD)=1.35 (0.93) versus 0.93 (0.53) mmol/L; p=0.000} and lower levels of HDL {1.31 (0.27) versus 1.53(0.32) mmol/L; p=0.000}, as compared to females,

respectively. Males were more likely to have hypertriglyceridemia (23.7% versus 5.1%; p=0.000) and less likely to have reduced HDL cholesterol (16.6% versus 25.0%; p=0.032), as compared to females, respectively (Table 2).

2.4. Diagnosis and prevalence of metabolic syndrome

According to diagnostic criteria, MetS was diagnosed in 46 among the 436 participants {prevalence (95%CI)= 10.6% (7.80%; 13.8%)}; 35 (8.0%) had 3 abnormalities and 11 (2.5%) had 4 abnormalities. The prevalence of MetS was relatively higher among males (11.7%) than females (8.5%); however, the difference was not statistically significant (p=0.305). Abdominal obesity was the most frequent abnormality, detected in 60.6%, followed by high BP in 25.0%. Hypertriglyceridemia was more prevalent among males (22.6%) as compared to females (5.9%), p=0.000. While reduced HDL was more prevalent among females (26.1%) as compared to male (17.9%), p=0.044 (Table 3).

Table 3 Diagnosis of metabolic syndrome by gender

Parameter	Total (N=436)	Men (N=283)	Women (N=153)	p-value
High BP	109 (25.0)	76 (26.9)	33 (21.6)	0.224
Abdominal obesity	264 (60.6)	165 (58.3)	99 (64.7)	0.192
Elevated triglyceride	72 (16.7)	63 (22.6)	9 (5.9)	0.000*
Reduced HDL cholesterol	90 (20.8)	50 (17.9)	40 (26.1)	0.044*
Number of abnormalities in one patient				
0	108 (24.8)	69 (24.4)	39 (25.5)	
1	167 (38.3)	108 (38.2)	59 (38.6)	
2	115 (26.4)	73 (25.8)	42 (27.5)	0.562
3	35 (8.0)	27 (9.5)	8 (5.2)	
4	11 (2.5)	6 (2.1)	5 (3.3)	
Metabolic syndrome	46 (10.6)	33(11.7)	13 (8.5)	0.305

Values are frequency (percentage), and percentages are calculated on columns. BP: blood pressure; HDL: high-density lipoprotein; * statistically significant result (p-value<0.05); test used chi-square test

## 2.5. Diagnostic significance of waist circumference, waist-to-hip ratio and body mass index in metabolic syndrome

In ROC curve analysis, waist circumference showed fair accuracy to detect MetS in total population {AUC (95%CI)=0.746 (0.678; 0.814); p=0.000}, males {AUC (95%CI)=0.756 (0.686; 0.827); p=0.000} and females {AUC (95%CI)=0.720 (0.587; 0.854); p=0.009} (Figure 1). Comparatively, waist-to-hip ratio showed lower diagnostic accuracy in detecting MetS, with AUC ranging from 0.655 (poor) in males to 0.713 (fair) in females (Figure 2). Likewise, BMI (Figure 3) was reported to be a poor diagnostic test for MetS in females (AUC=0.679), although it was fair in males (AUC=0.716).
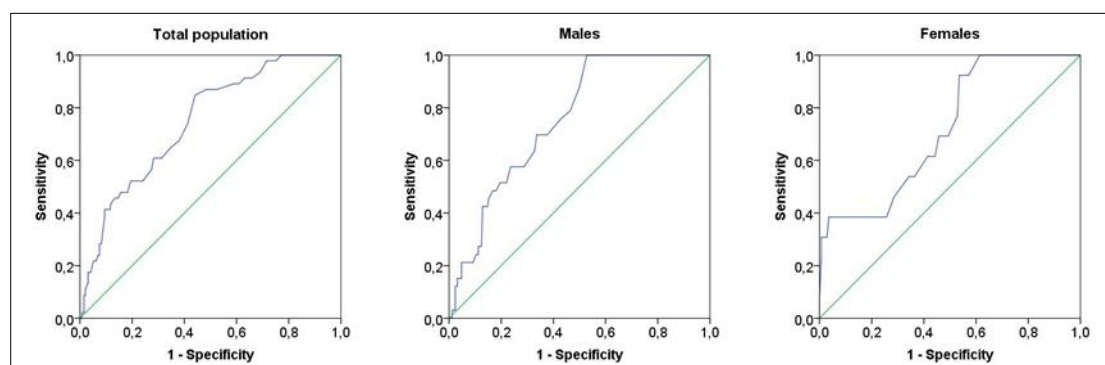
Population	AUC	95%CI		p-value
Total population	0.746	0.678	0.814	0.000*
Males	0.756	0.686	0.827	0.000*
Females	0.720	0.587	0.854	0.009*

AUC: Area under the curve; CI: confidence interval; * statistically significant result (p<0.05)
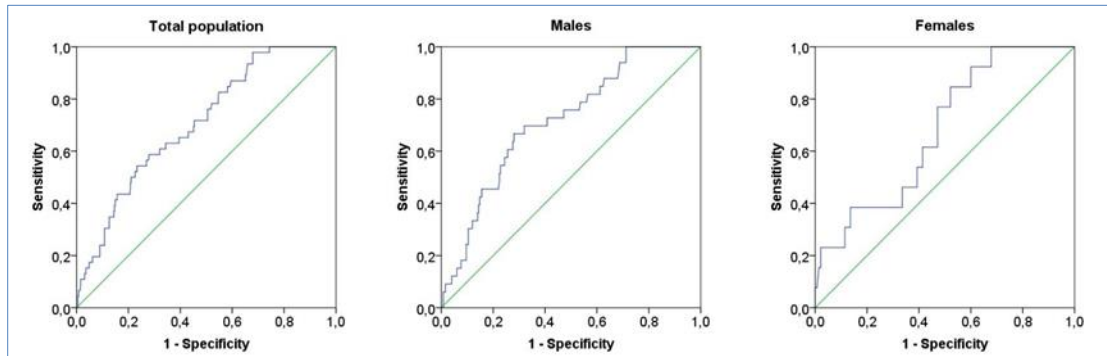
Figure 1 Diagnostic value of waist circumference in metabolic syndrome (ROC curve analysis)
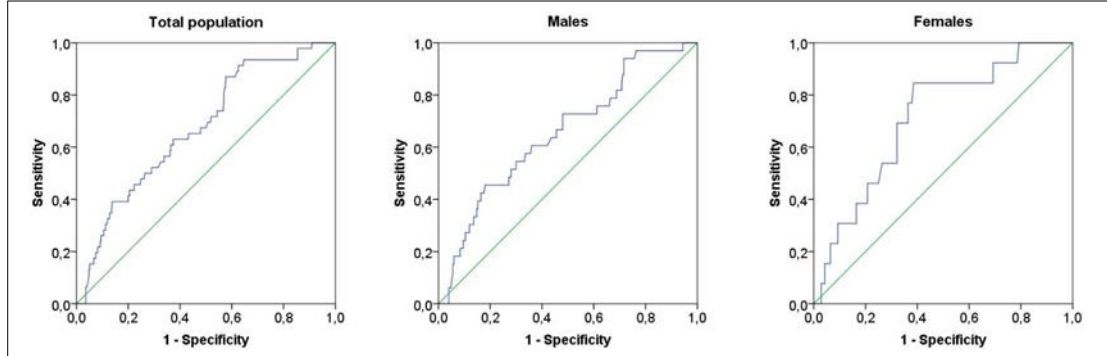
Population	AUC	95%CI		p-value
Total population	0.673	0.596	0.750	.000*
Males	0.655	0.557	0.753	.004*
Females	0.713	0.580	0.946	.011*

AUC: Area under the curve; CI: confidence interval; * statistically significant result ($p<0.05$).

Figure 2 Diagnostic value of waist-to-hip ratio in metabolic syndrome (ROC curve analysis)

Population	AUC	95%CI		p-value
Total population	0.707	0.635	0.779	0.000*
Males	0.716	0.630	0.802	0.000*
Females	0.679	0.546	0.813	0.033*

AUC: Area under the curve; CI: confidence interval; * statistically significant result ($p<0.05$).

Figure 3 Diagnostic value of body mass index in metabolic syndrome (ROC curve analysis)

3. Determining the optimal cut-off values for identifying metabolic syndrome

Waist circumference, waist-to-hip ratio, and BMI were analyzed as screening tests for MetS in total population, as well as in men and women separately. Thus, the highest sensitivity possible was regarded to determine the respective optimal cut-off values, using the best value of Youden J index value ±0.050. Results of this analysis including cut-off values of the three tests with their respective sensitivity, specificity, and Youden J index are presented in Table 4. Also, OR (95% CI) of the prevalence of metabolic syndrome in exposed versus non-exposed population were calculated and presented in the same table. In males, a waist circumference≥93.5 cm is likely to be detecting MetS with 100% sensitivity and 47.2% specificity; whereas, optimal waist-to-hip (≥0.91) ratio and BMI (≥28.7 kg/m^2) cut-offs had lower diagnostic values; with 72.7% and 69.7% sensitivity and 52.0% and 66.8% specificity, respectively. In females, optimal waist circumference cut-off was determined as ≥83.5 cm, showing 92.3% sensitivity and 46.4% specificity. Whereas, the optimal waist-to-hip ratio (≥0.84) and BMI (≥26.0 kg/m^2) cut-offs had lower diagnostic values, with 84.6% each sensitivity and 61.4% and 47.9% specificity, respectively. Additionally, by reference to cut-offs, increased waist circumference was associated with the highest OR of metabolic syndrome both in males (OR=59.9) and females (10.4); by comparison to waist-to-hip ratio and BMI.

3.1. Factors and predictors of metabolic syndrome

Individuals with MetS had relatively older age {mean (SD)= 35.91 (12.53) versus 30.36 (9.15); p=0.000} by reference to those without metabolic syndrome. Other sociodemographic factors associated with MetS included marital status (p=0.003) and educational attainment (p=0.004); that is the prevalence of MetS was higher among married individuals as well as those with low educational attainment when compared to their counterparts (Table 5). Metabolic syndrome was also associated with prediabetes, showing 19.7% versus 8.8% of prevalence among people with prediabetes versus those without, respectively (p=0.006) (Figure 4).
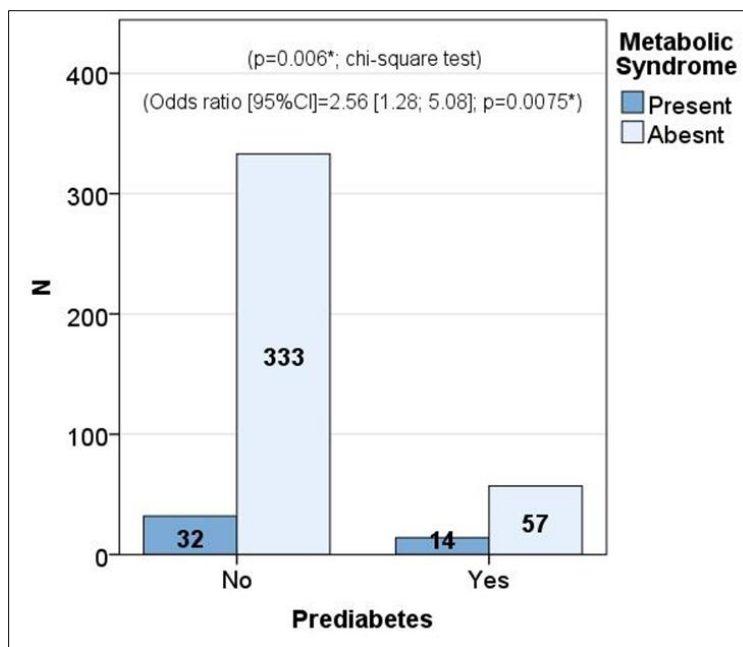
Figure 4 Correlation of metabolic syndrome with prediabetes

Caption: Bars represent the number of patients with (dark blue) and without (light blue) metabolic syndrome among those who have versus those who do not have prediabetes. There is higher prevalence of metabolic syndrome among people with prediabetes as compared to those without prediabetes (OR [95%CI=2.56 [1.28; 5.08]; p=0.0075).

In multivariate logistic regression (Table 6), extended waist circumference was the strongest predictor of MetS {OR (95%CI)=3.75 (1.30; 10.81); p=0.014}, followed by the presence prediabetes {OR (95%CI)=2.31 (1.06; 5.04); p=0.035}. However, waist-to-hip ration and BMI were not significant predictors of metabolic syndrome. Further, the high educational level was a significant predictor for metabolic syndrome {OR (95%CI)=0.34 (0.12; 0.99); p=0.047}; while age and marital status were not significant.

Table 4 Optimal cutoff values for identifying metabolic syndrome by the presence of at least one of the three risk factors among adult men and women

Group	Total population			Males			Females		
Risk factor	WC	W:H	BMI	WC	W:H	BMI	WC	W:H	BMI
Cutoff value	93.5	0.86	26.0	93.5	0.91	28.7	83.5	0.84	26.0
Sensitivity	84.8%	87.0%	82.6%	100.0%	72.7%	69.7%	92.3%	84.6%	84.6%
Specificity	55.9%	42.3%	44.9%	47.2%	52.0%	66.8%	46.4%	61.4%	47.9%
Youden J index	0.407	0.293	0.275	0.472	0.247	0.365	0.387	0.460	0.325
Odds-ratio (95%CI)	7.06 (3.08; 16.18)	4.21 (1.74; 10.17)	3.91 (1.78; 8.59)	59.9[‡] (3.63; 988.8)	2.80 (1.25; 6.26)	4.55 (2.07; 9.99)	10.4 (1.32; 82.16)	7.78 (1.66; 36.41)	5.05 (1.08; 23.6)
p-value	<0.0001*	0.0014*	0.0007*	0.0042*	0.0123*	0.0002*	0.0264*	0.0092*	0.0397*

WC: Waist circumference (cm); W:H: waist-to-hip ratio; BMI: body mass index (kg/m^2); cut-off values were selected considering the highest sensitivity for the best Youden J index ±0.050; ‡ odd ratio was computed by adding 0.5 to all contingency table cells to correct the presence of null values in denominator (Pagano & Gauvreau, 2000; Deeks & Higgins, 2010)

Table 5 Demographic factors of metabolic syndrome

Factor / category	Metabolic syndrome		p-value
	Absent (N=390)	Present (N=46)	
Sociodemographic factors			
Age (years); mean (SD)	30.36 (9.15)	35.91 (12.53)	0.000*
Gender			
Male	250 (88.3)	33 (11.7)	0.305
Female	140 (91.5)	13 (8.5)	
Marital status			
Single	202 (94.0)	13 (6.0)	0.003*
Married	188 (85.1)	33 (14.9)	
Educational attainment			
Up to primary	21 (70.0)	9 (30.0)	
Intermediate school	17 (89.5)	2 (10.5)	
Secondary & diplomas	114 (88.4)	15 (11.6)	0.004*
Basic university degree	221 (91.7)	20 (8.3)	
Post-graduate degree	17 (100.0)	0 (0.0)	
Family Income per month			
≤3000 SR	54 (91.5)	5 (8.5)	
>3000–5000 SR	72 (85.7)	12 (14.3)	
>5000–10000 SR	109 (86.5)	17 (13.5)	0.320
>10000–20000 SR	112 (92.6)	9 (7.4)	
>20000 SR	43 (93.5)	3 (6.5)	
Physical activity at work			
Office work	78 (91.8)	7 (8.2)	
Moderate	106 (87.6)	15 (12.4)	0.547
Considerable	34 (85.0)	6 (15.0)	
Other	172 (90.5)	18 (9.5)	
Home ownership			
Rented	15 (83.3)	3 (16.7)	
Owned	165 (90.7)	17 (9.3)	0.592
Other	210 (89.0)	26 (11.0)	
Ethnicity			
Arabian tribes	309 (89.8)	35 (10.2)	
Sub-Saharan African	18 (94.7)	1 (5.3)	
Mediterranean Arab	35 (85.4)	6 (14.6)	
Indian subcontinent	12 (85.7)	2 (14.3)	0.496
South-east Asia	3 (75.0)	1 (25.0)	
Central Asia	2 (66.7)	1 (33.3)	
Other	11 (100.0)	0 (0.0)	

Values are frequency (percentage) unless otherwise specified;

* Statistically significant result ($p<0.05$); percentages are calculated on row variables.

Table 6 Predictors of metabolic syndrome

Predictor	Odds-ratio	95%CI		p-value
Age (years)	1.01	0.97	1.05	0.722
Marital status				
Single (*ref*)	-	-	-	-
Married	1.63	0.69	3.82	0.263
Educational attainment				
Up to primary (*ref*)	-	-	-	0.364
Intermediate school	0.31	0.05	1.78	0.190
Secondary & diplomas	0.48	0.16	1.42	0.185
Basic university degree	0.34	0.12	0.99	0.047*
Post-graduate degree	0.00	0.00	0.00	-
Prediabetes				
Absence (*ref*)	-	-	-	-
Presence	2.31	1.06	5.04	0.035*
Waist circumference				
Normal (*ref*)	-	-	-	-
Increased	3.75	1.30	10.81	0.014*
Waist-to-hip ratio				
Normal (*ref*)	-	-	-	-
Increased	2.00	0.74	5.42	0.171
BMI				
Normal (*ref*)	-	-	-	-
Increased	1.29	0.48	3.50	0.618

Test used: multivariate binary logistic regression, with presence of metabolic syndrome being the dependent variable. * Statistically significant result ($p<0.05$); CI: confidence interval; *ref*: reference category; BMI: body mass index.

4. Discussion

Screening all the eligible adults (n=436), the majority (83.7%) (n=365) were normal glycemic, and (16.3%) (n=71) were prediabetics. Whereas, 10.6% of all eligible adult had MetS (n=53). This was expected since most of the participants were young, with a mean age of years is 30.94±(SD 9.70) and highly educated. Advanced age and low education level were independently associated with increased likelihood of metabolic syndrome [17]. In addition to advanced age, it is a strong predictor of prediabetes [7].

However, on screen for the presence of MetS among prediabetes, 19.7% (n=14) of prediabetic person (n=71) were found to meet the MetS definition. This is expecting once a prediabetic state is associated with metabolic abnormalities. The study results showed that 36.2% of the screened population was overweight and almost one-third (29.4%) were obese and about two-thirds (60.6%) had abdominal obesity.

This study demonstrated that the prevalence of MetS among the overall studied population is less than the prevalence MetS among prediabetic individuals. However, MetS prevalence among prediabetic individual was almost same as of the previous study conducted in Jeddah [6]. These results suggest that the most of the screened population in the study had T2DM or prediabetes. Regarding the current study findings in comparison with the prevalence in other countries,

MetS prevalence among all individuals was relevant to a study conducted in Asia. Although the impaired glucose metabolism is not common [15], the MetS prevalence among prediabetic person is almost similar to a study conducted to demonstrate that impaired glucose metabolism is one of the first two common component of MetS [16]. This suggests that impaired glucose metabolism play an important role in MetS prevalence.

In this study, the prevalence of prediabetes was more than the previous study conducted in Jeddah city [7]. This can support by the fact that the previous study used IFG alone in determining a prediabetic state; however, the current study used IFG, HbA$_{1c}$, and both in the definition of prediabetes. [18,19].

When the prevalence of MetS was considered among prediabetic patients, the prevalence was higher than MetS alone or prediabetes alone among the population studied. This can be expected because the component of MetS is more obvious in prediabetic state [20].

The prevalence of metabolic syndrome was relatively higher among males (11.7%) than females (8.5%); however, the difference was not statistically significant (p=0.305) in this study. Some studies have shown that Mets is common in male as compared to females [12]. However, most of the studies have demonstrated that MetS is common among women as compared to men [11,13,16,21].

In this study, after adjustment of IFG, abdominal obesity was the most frequent abnormality detected in 60.6%, followed by high BP in 25.0%. Hypertriglyceridemia was more prevalent among males (22.6% versus 5.9%; p=0.000) as compared to females, while reduced HDL was more prevalent among females (26.1% versus 17.9%; p=0.044) as compared to males [15].

In multivariate logistic regression, extended waist circumference was the strongest predictor of MetS (OR [95%CI] =3.75 [1.30; 10.81]; p=0.014), followed by the presence prediabetes (OR [95%CI]=2.31 [1.06; 5.04]; p=0.035). Further, high educational level was a significant protective predictor for MetS (OR [95%CI]=0.34 [0.12; 0.99]; p=0.047); while age and marital status were not significant. Most of the other studies reflect the same fact of that age and low education were associated with MetS[11,12]. Other study showed that MetS prevalence is affected by older age, but not by education level [14].

The second objective of the present study was to determine the appropriate waist circumference cutoff value for identifying a person's risk for the MetS.

The present study reported a waist circumference≥93.5 cm is likely to be detecting MetS in males with 100% sensitivity and 47.2% specificity. Whereas, in females, optimal waist circumference cut-off was determined as ≥83.5 cm, showing 92.3% sensitivity and 46.4% specificity.

The waist circumference showed fair accuracy to detect MetS in total population (AUC [95%CI]=0.746 [0.678; 0.814]; p=0.000), males (AUC [95%CI]=0.756 [0.686; 0.827]; p=0.000) and females (AUC [95%CI]=0.720 [0.587; 0.854]; p=0.009). This point is close to estimated cut-off point in recent study conducted in Saudi Arabia for men, but is slightly less than estimated cut-off point demonstrated for women [22]. However, it is different from other studies in other countries [14,15,21].

Strength of the study: It gave figure of the prevalence of MetS and some important health related characteristics. The study results will help definine the local cut-off point for prediction of MetS and improve early detection of MetS. Further, this study assessed the motives for screening for a high risk of T2DM and CVD, with simple tool.

Limitations of the study: It is the study conducted in one city and as any cross-sectional study, it measures prevalence rather than incidence and it is susceptible to bias due to few responses.

5. Conclusion

Metabolic syndrome was reported in approximately in one out of nine patients attending PHC in Jeddah. The rate was almost equal among males and females. Waist circumference is a strong predictor for MetS, showing good associations and fair diagnostic utility. People with extended waist circumference (≥ 93.5 cm in males and ≥83.5 cm in females) are exposed to more than 10-fold odds risk of developing MetS. These cut-off values can be used as a screening test with

93% to 100% sensitivity. Further, given the simplicity of the test, auto-measurement of waist circumference should be encouraged to increase the chances of early detection and management of MetS.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflicts of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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