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Original Article

The Discriminatory Performance of Body Mass Index, Waist Circumference, Waist-To-Hip Ratio and Waist-To-Height Ratio for Detection of Metabolic Syndrome and Their Optimal Cutoffs among Iranian Adults

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ABSTRACT

Background: The superiority of either of body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) for prediction of metabolic syndrome (MetS) is remained controversial in Asian population. The objective of this study was to compare the discriminative capacity of either of these measures in prediction of non-adipose components of MetS.

Methods: In this population-based cross sectional study, 1000 representative samples of adults were recruited in Babol, northern Iran. The demographic, anthropometric measures and blood pressure were determined by standard method. Fasting plasma glucose (FPG), triglycerides (TG), total cholesterol (CHL), high density lipoprotein (HDL) cholesterol levels were measured with enzymatic methods by an auto analyzer. The presence of two or more any of four non-obese components were considered as MetS.

Results: The diagnostic accuracies (AUC= Area under the Curve) of four different measures were rather similar. While AUC for BMI (AUC=0.684; 95% CI: 0.633, 0.736) slightly tended to be higher than that of WC (AUC=0.640; 95% CI: 0.587, 0.693) and WHtR (AUC=0.649; 95% CI: 0.596, 0.701) in men but the accuracy of WC (equivalently WHtR (AUC=0.708; 95% CI: 0.664, 0.751) is tended to be greater than that of BMI in women. The optimal cut-off value for WC was higher in men compared with women.

Conclusions: Overall, BMI, WC and WHtR were significant predictors of MetS equally but WC (equivalently WHtR) was a better predictor than BMI and WHR in women. The optimal cut-offs of WC are lower compared with western population for men but not for women.

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Introduction

Metabolic syndrome (MetS) is referred as X syndrome that is a clustering of cardio metabolic risk factors including adiposity (obesity or abdominal obesity), diabetes mellitus, hypertension and dyslipidaemia[1]. It was clearly established that MetS has several consequences on the risk of cardio vascular diseases and its serious outcomes[2-4]. For the component of adiposity, several definitions have been proposed. The original WHO definition included a measure of obesity as defined either by body mass index (BMI) or waist- to- hip ratio (WHR)[5] while Adult Treatment Panel III (ATP III) criteria suggested waist circumference (WC) as a measure of abdominal fat in the definition of MetS but not as a compulsory component[6]. The presence of three or more of five components of metabolic risk factors would confirm as MetS[6]. The latest definition proposed by International Diabetes Federation (IDF), i.e., the abdominal obesity is measured by WC, was introduced as compulsory component of MetS[7].

However, different measures of adiposity such as BMI, WC, WHR and waist -to- height ratio (WHtR) have been proposed. The superiority of either of these measures in the literature in particular in Asian population is controversial[8-12]. Although the measure of abdominal obesity is associated with metabolic risk factors that generally recommended by WC as a primary screening tool for measuring abdominal fat distribution[1,6] but the cutoff values of abdominal adiposity cannot be used universally and it is strongly depending on sex, ethnic groups. For example, Asian with shorter height may be more predisposed to visceral fat than Caucasian and thus they have a greater chance of cardio metabolic risk factor at lower BMI[13,14]. Therefore, WHtR as an alternative measure of abdominal obesity adjusted by height rather a single measure, in particular is of greater interest in healthy individuals with normal BMI or WC[15]. Since most Asians are not sever obese but having metabolic risk factors, thus WHtR may be an alternative measures of central adiposity in Asian population compared to WC in western counterparts. In a study of Iranian adults, WC had the higher discriminating value in prediction of MetS compared to other indexes in different age groups[16]. However, they included high WC as a component of MetS using ATP III criteria. In other study in Tehranian adult men, WHtR was a better screening measure of cardio vascular risk factors than WC or BMI[17] but WC was a stronger predictor in women in another report[18]. Thus, the best measure of abdominal obesity and also the appropriate cut- off values were remained controversial.

In spite of emerging high prevalence of metabolic syndrome because of high abdominal obesity rate in recent decades in the north of Iran[19,20], there is a paucity of information of useful of BMI, WC, WHtR and WHR in assessing metabolic syndrome and there are no regional optimal cut-off values. Thus, the objective of this study was to compare the discriminative capacity of BMI, WC, WHR, and WHtR in prediction of non-adipose components and to determine their relevant optimal cut-offs in Iranian adults.

Methods

We analyzed the data of a population based cross-sectional study of metabolic syndrome that was conducted in urban area of Babol, northern of Iran, in 2011. A total of 1000 representative samples of urban resident aged 20 to 70 years were enrolled in the study using two stage cluster sampling technique. The description of sampling procedure and eligibility for inclusion and exclusion criteria were described in details elsewhere[20]. In the first stage of sampling, 25 clusters were selected randomly based on cumulative frequency of population size under coverage of urban health centers. In the second stage, around the center of each cluster about 50 subjects who met our inclusion criteria were recruited in the study. Subjects who were not residence of Babol urban area, suffered from severe physical abnormality, diagnosis of severe cardiovascular atherosclerosis (CVA), diagnosis of cancer under radio-chemotherapy, end stage of kidney disease, pregnant women and those who had less than 10 hours overnight fasting at a time attending to lab center for taking blood sample were excluded.

Study project was approved by Ethical Committee of Research Council of Babol University of Medical Sciences and all study subjects assented a written consent prior their participation in the study.

In a household survey, the demographic data and the clinical history of diabetes and hypertension and hyperlipidemia and the drug treatment used for each of these clinical conditions were collected by trained nurses at home visit with a designed questionnaire. All anthropometric indexes (weight, height, waist circumference (WC), hip circumference (HC) and blood pressure were measured with standard methods. All measurements were collected by trained nurses with similar instructions and guidelines. The reliability of measurements was calculated by Intraclass Correlation Coefficient (ICC) and was estimated as ≥95%. Weight was measured to the nearest 0.1 kg with light clothes without shoes using a digital scale. The height was measured to nearest 0.1 cm using a portable stadiometer. The waist circumference were determined the nearest 0.1 cm at level of midpoint between iliac crest and lower border of tenth rib. The body mass index was calculated as weight in kg divided by height in m^2. Then BMI was categorized as <18.5 (underweight), 18.5-24.9 (normal), 25-29.9 (overweight) and ≥30 as obese. The waist- to -hip ratio (WHR) was determine as the ratio of WC in cm to HC in cm. Waist-to- height ratio calculated by waist in cm divided by height in cm. The systolic and diastolic blood pressure was measured consecutively two times with a resting period of 10 minutes using a digital spylygmnometer by trained nurses at home visit while the participant was in the sitting position after 10 minutes rest and the cuff was placed on the right arm at head level. The average of two measurements with interval of 10 minutes was used in analysis**.** All participants were asked to go on overnight fasting for 10-12 hours and to attend at central lab of Ayatollah Rohani Hospital for taking blood samples in the next morning after clinical examination. Fasting plasma glucose (FPG), triglycerides (TG), total cholesterol (CHL), high density lipoprotein (HDL) cholesterol, and low density lipoprotein (LDL) cholesterol levels were measured with enzymatic methods by an auto analyzer.

In definition of metabolic syndrome, we used ATP III criteria[6] but our study objective was to compare the obesity and abdominal obesity measures in prediction of non-adiposity components of MetS. We omitted the central obesity requirement as defined by WC from our definition. Thus, we used the four non-adiposity components of ATP III criteria. The presence of two or more any of non-obese components criteria were considered as metabolic syndrome in order to determine equivalently the diagnostic accuracy of different anthropometric measures in prediction of metabolic syndrome.

Statistical analysis

We used SPSS software version 18.0 (Chicago, IL, USA) in data analysis. In bivariate analysis, we applied the *t*-test for normality distributed continuous measurements to compare the mean of two groups and the Chi-square test for categorical data whatever was appropriate. In order to explore which of BMI, WC, WHR and WHtR has better discriminant ability for detection of non-adipose components of MetS and to estimate the optimal cutoff values, we used receiver operating characteristic (ROC) analysis[21]. As already mentioned, we defined MetS as presence of at least two of any non-adiposity component criteria in order to establish which of adiposity measure is more appropriate in discrimination with and without MetS. The overall accuracy index as defined by area under the curve (AUC) and its 95% confidence interval (CI) was estimated for each index. The optimal cut-offs and the corresponding sensitivity and specificity for each anthropometric measure was estimated in the threshold that maximizes the sum of sensitivity and specificity or equivalently maximizes the Youden index as defined by sensitivity+specificity-1 in ROC curve operating points. Additionally, we categorized the age of participants as 20-39, 40-59 and 60-70 years, and we performed stratified ROC analysis to calculate the AUC (with 95%CI) across age groups and sexes. Further ROC analysis was used for each individual component risk factors of MetS and for MetS as well based on ATP III criteria. The *P*-values less than 0.05 were considered as significant level.

Results

The respective mean age of participants in men and women was rather similar (43.5 ±14.4 years vs. 41.8 ±12.6 years, *P*=0.062) and 450 (45%) subjects were male and 550 (55%) were female. As Table 1 shows the mean of WC, WHR, systolic BP, and TG were significantly higher in men than women (*P*=0.001). While the men of BMI, HC, WHR, HDL, LDL, and CHL were significantly lower in men compared with women (*P*=0.001 for all cardio vascular risk factors and for CHL, *P*=0.030). There was no significant difference was observed in diastolic BP and FPG between two sexes.

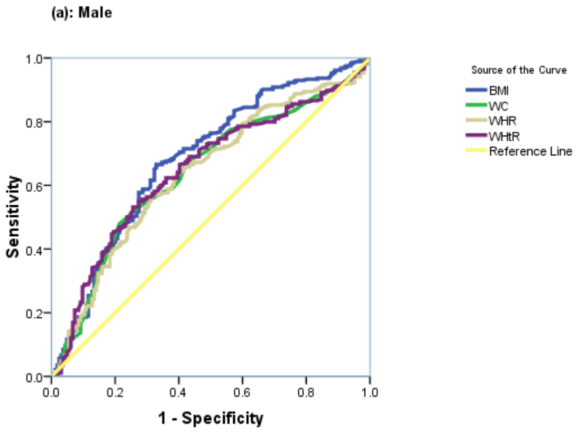
Table 1: The mean and standard deviation (SD) of anthropometric and biomedical measures with respect to gender using *t*-test

	Men (n=450)		Women (n=550)		
Characteristics	**Mean**	**SD**	**Mean**	**SD**	***P* value**
Age (yr)	43.5	14.4	41.8	12.6	0.062
Body mass index (kg/m^2)	26.4	4.6	28.7	5.7	0.001
Waist circumference (cm)	93.5	14.5	91.5	14.9	0.037
Hip circumference (cm)	102.2	12.5	109.3	13.5	0.001
Waist-to-hip ratio	0.91	0.09	0.84	0.09	0.001
Waist-to-height ratio	0.54	0.09	0.58	0.09	0.001
Systolic blood pressure (mmHg)	128.3	15.6	124.2	19.1	0.001
Diastolic blood pressure (mmHg)	82.6	12.9	81.3	15.1	0.170
Triglycerides (mg/dl)	189.6	139.3	156.0	115.2	0.001
High density lipoprotein (mg/dl)	35.9	9.7	38.7	12.1	0.001
Low density lipoprotein (mg/dl)	117.9	43.3	129.5	39.2	0.001
Cholesterol (mg/dl)	191.6	56.7	198.6	43.6	0.030
Fasting plasma glucose (mg/dl)	108.4	34.5	109.2	43.1	0.750

All cardio metabolic risk factors were significantly more prevalent with higher level of BMI except for HDL. The highest prevalence rate was observed in obese subjects (BMI ≥30 kg/m^2) in both sexes (*P*=0.001). The results in Table 2 indicate that all four anthropometric measures have significant predictive ability for discriminating non-obese components of MetS and the diagnostic accuracies as estimated by AUCs for four different anthropometric measures were rather similar (see ROC curves in Figure 1). While AUC for BMI (AUC=0.684; 95% CI: 0.632, 0.736) slightly tended to be higher than WC (AUC=0.640; 95% CI 0.587, 0.693) and WHtR (AUC=0.649; 95% CI: 0.596, 0.701) in men but the accuracy of WC (equivalently WHtR (AUC=0.649; 95% CI: 0.596, 0.701) is tended to be greater than that of BMI in women and the least discriminative ability was observed for WHR in both genders. The estimated optimal cut-off values of BMI were identical between two sexes (25.3 kg/m^2 men vs. 25.4 kg/m^2 women). However, the optimal cut-off value of WC was higher in men compared with women (97.5 cm vs. 93.5 cm). In addition, the optimal cut-off values of WHR (0.86 in men and 0.85 in women) and WHtR (0.51 in both sexes) were identical between sexes. The higher sensitivity was corresponded with lower specificity (Table2).

Table 2: The area under the curve (AUC) of anthropometric indexes and the optimal cutoffs in prediction of metabolic syndrome

Anthropometric indexes	**AUC (95% CI)**	**Cut-off**	**Sensitivity**	**Specificity**
Men				
Body mass index	0.685 (0.632, 0.736)	25.3	0.67	0.65
Waist circumference	0.640 (0.587, 0.693)	97.5	0.48	0.79
Waist-to-hip ratio	0.637 (0.584, 0.690)	0.86	0.85	0.33
Waist-to-height ratio	0.649 (0.596, 0.701)	0.51	0.73	0.51
Women				
Body mass index	0.681 (0.636, 0.726)	25.4	0.80	0.43
Waist circumference	0.708 (0.664, 0.752)	93.5	0.56	0.73
Waist-to-hip ratio	0.623 (0.576, 0.621)	0.85	0.54	0.65
Waist-to-height ratio	0.708 (0.664, 0.751)	0.51	0.88	0.38



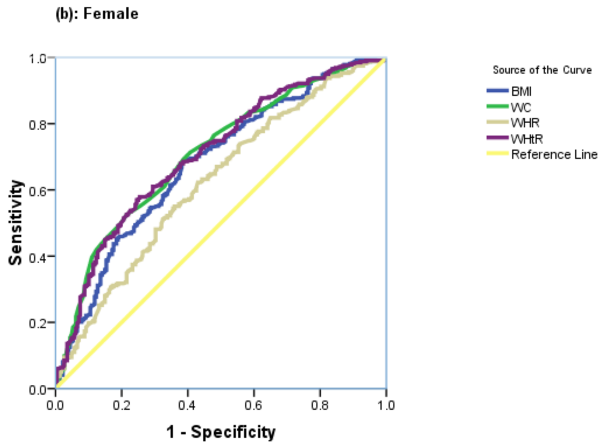


Figure 1: Receiver operator characteristic curves of body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) for detection of metabolic syndrome in males (a) and females (b)

Table 3 shows that the estimated accuracy index varied a little in relation to age groups and gender for all anthropometric measures. However, because of paucity of data in age group of 60-70 years, the diagnostic accuracies of all measures were not appeared to be significant. All measures were roughly equivalent significant predictors of MetS in age group of 20-39 and 40-59 years in both sexes (*P*=0.001). In table 4, WHtR index had higher accuracy in detection of high WC (or abdominal obesity) compared to BMI and WHR. For detection of each component non-obese criteria, high BP, high TG, high FPG, all four indexes produced roughly a similar AUCs ranged from 0.59 to 0.65 in both genders. In addition, there was no discriminative ability observed by either of four anthropometric measures in detection of low HDL. Even, surprisingly, a reverse discrimination was observed by either of four indexes in women. When we shifted the definition of MetS to ATP III criteria (including abdominal obesity), as one expects by definition of MetS in ATP III criteria, our results showed that WC (equivalently WHtR) had higher diagnostic accuracy than BMI and WHR in particular among women. In this case, the accuracy indexes for all measures were higher than those in detection of non-adiposity components of MetS.

Table 3: The area under the curve (AUC) anthropometric indexes in prediction of metabolic syndrome with respect to age group and gender

Anthropometric indexes	20-39 year AUC (95% CI)	40-59 yeas AUC (95% CI)	60-70 year AUC (95% CI)
Men			
Body mass index	0.725 (0.650, 0.800)	0.643 (0.561, 0.726)	0.644 (0.481, 0.807)
Waist circumference	0.660 (0.580, 0.700)	0.630 (0.548, 0.713)	0.583 (0.438, 0.732)
Waist-to-hip ratio	0.626 (0.545, 0.708)	0.644 (0.561, 0.728)	0.533 (0.374, 0.692)
Waist-to-height ratio	0.659 (0.579, 0.738)	0.638 (0.566, 0.719)	0.582 (0.431, 0.732)
Women			
Body mass index	0.638 (0.569, 0.708)	0.672 (0.598, 0.747)	0.611 (0.414, 0.807)
Waist circumference	0.677 (0.609, 0.745)	0.656 (0.582, 0.731)	0.658 (0.461, 0.855)
Waist-to-hip ratio	0.602 (0.531, 0.674)	0.543 (0.469, 0.623)	0.642 (0.437, 0.846)
Waist-to-height ratio	0.666 (0.598, 0.735)	0.642 (0.566, 0.717)	0.662 (0.459, 0.866)

Table 4: The area under the curve (AUC) anthropometric indexes in prediction of individual cardio metabolic risk factors and MetS

	Body mass index		Waist circumference		Waist-to-hip ratio		Waist-to-height ratio	
Cardio metabolic risk factors	**AUC (95%CI)**	***P* value**	**AUC (95% CI)**	***P* value**	**AUC (95% CI)**	***P* value**	**AUC (95% CI)**	***P* value**
Men								
High waist circumference (>102cm)	0.862 (0.821, 0.903)	0.001	Not relevant	-	0.834 (0.792, 0.845)	0.001	0.971 (0.956, 0.984)	0.001
High blood pressure (≥130/85 mmHg)	0.620 (0.565, 0.676)	0.001	0.627 (0.571, 0.685)	0.001	0.645 (0.590, 0.700)	0.001	0.642 (0.586, 0.697)	0.001
High Triglycerides (≥150 mg/dl)	0.687 (0.638, 0.737)	0.001	0.638 (0.586, 0.689)	0.001	0.631 (0.579, 0.673)	0.001	0.645 (0.594, 0.697)	0.001
Low High density lipoprotein (<40 mg/dl)	0.505 (0.440, 0.570)	0.878	0.488 (0.425, 0.553)	0.707	0.520 0.458, 0.582)	0.534	0.480 (0.415, 0.544)	0.518
High Fasting plasma glucose (≥110 mg/dl)	0.593 (0.557, 0.644)	0.002	0.607 (0.547, 0.668)	0.001	0.597 (0.541, 0.654)	0.001	0.592 (0.532, 0.652)	0.002
Metabolic syndrome (ATP III)	0.725 (0.677, 0.775)	0.001	0.768 0.719, 0.817)	0.001	0.723 (0.674, 0.773)	0.001	0.762 0.713, 0.811	0.001
Women								
High waist circumference (>88 cm)	0.875 (0.846, 0.904)	0.001	Not relevant	-	0.822 (0.786, 0.869)	0.001	0.979 (0.790, 0.988)	0.001
High blood pressure (≥130/85 mmHg)	0.644 (0.592, 0.695)	0.001	0.693 (0.643, 0.749)	0.001	0.631 (0.578, 0.685)	0.001	0.690 (0.641, 0.740)	0.001
High Triglycerides (≥150 mg/dl)	0.651 (0.665, 0.697)	0.001	0.677 (0.632, 0.722)	0.001	0.634 (0.587, 0.681)	0.001	0.674 (0.629, 0.722)	0.001
Low High density lipoprotein (<50 mg/dl)	0.466 (0.396, 0.536)	0.358	0.430 (0.356, 0.504)	0.057	0.398 (0.324, 0.472)	0.006	0.411 (0.338, 0.485)	0.016
High Fasting plasma glucose (≥110 mg/dl)	0.642 (0.590, 0.693)	0.001	0.641 (0.583, 0.645)	0.001	0.594 (0.542, 0.647)	0.001	0.652 (0.599, 0.704)	0.001
Metabolic syndrome (ATP III)	0.773 (0.734, 0.811)	0.001	0.829 (0.795, 0.864)	0.001	0.709 (0.667, 0.752)	0.001	0.822 (0.787, 0.857)	0.001

Discussion

Our findings showed the highest prevalence rates of cardio vascular risk factors and metabolic syndrome in obese subjects in both sexes. The obesity (BMI>30) and the central obesity (WC>102 cm men, >88 cm women) were significantly more prevalent in women than men. All four anthropometric measures were significant predictors for discriminating non-obese components of MetS. The predictive ability of BMI was slightly tended to be higher than WC or WHtR in men while the WC (equivalently WHtR) has a greater discriminative ability than BMI (or WHR) in women. Overall BMI, WC and WHtR produced roughly a similar AUC ranging from 0.64 to 0.68 in men and from 0.62 to 0.71 in women. Our results are rather similar with a study in our neighborhood country among adult Omani Arab that all three indexes BMI, WC and WHR predicted prevalence CVD risk factors equally[10]. While, recent published study among adult Chinese population reported that BMI had a better discrimination than WC for non-adipose components of Mets in males but both had equivalently predictive ability in females[9]. In contrast, among Korean adult with normal BMI and WC, WHR had the best predictive ability for evaluating metabolic risk factors compared with BMI and WC alone[11]. While among Taiwanese adults, the superiority of WHtR than that of BMI or WC in prediction of all cardio vascular risk factors has been reported in both sexes[12]. In Chilean adults, the predictive ability of BMI and WC for any cardiovascular risk factors was similar[22]. However, BMI alone may have some limitations and it does not show the distribution of fat on the body in some individual well[15]. On the other hand, WC is primary interesting as screening tool to measure abdominal fat and is a significant predictor of serious CVD outcomes[1,6]. The visceral fat, which is more linked to WC than subcutaneous fat, plays an important role with greater lipolyctic activity and increasing the level of free fatty acids and decreasing insulin resistance [22].

In compared with other studies in Iranian adult population in Esfahan, the central part of Iran, WC had higher discriminative accuracy for detection of metabolic syndrome than other indexes[16]. For all indexes, a higher level of accuracy has been reported than ours[16]. A possible explanation for such a high accuracy in the later study is obvious by their definition of metabolic syndrome based on ATP III criteria. One expects a higher accuracy for WC if high WC included as a criterion of cardiovascular risk factors while we used the non-adipose components of metabolic syndrome in our predictive models for comparability of WC with other measures. In our finding, the estimates of diagnostic accuracy and the superiority of WC over other measures in particular among women were rather close to other study in Tehranian population in prediction of non-adipose components of CVD risk factors[23]. While the recent Iranian prospective study, there was no difference between abdominal obesity measures in prediction of CVD risk in males, whereas in females, WHtR and WHR were stronger predictors than WC[24] but in our findings, WHtR (equivalently WC) had the highest predictive ability of cardio vascular risk factors in women. The differences partially can be explained by assessment of different outcomes in the predictive model across different studies.

We found the estimated optimal cut-off values for BMI was identical between men and women (25.3 kg/m^2 vs. 25.4 kg/m^2). Our results agree very close with those reported in Japanese study[25] and to those defined by WHO as cut-off point (25 kg/m^2) for diagnosis overweight in both sexes. However, Chinese study suggested lower cut-off (24 kg/m^2) than ours in predicting cardiovascular risk factors[9]. In contrast, a higher BMI cut-off values has been suggested in Iranian studies in predicting of type 2 diabetes (26 kg/m^2 in men and 30 kg/m^2 in women)[24] and also CVD risk[26].This high value of cut-off may be related to a higher criterion of FPG >126 mg/dl used in definition of type 2 diabetes while our criterion was >110 for high FPG as ATP III criteria.

Based on our findings, the optimal cut-off value of WC was higher in men versus women (97.5 cm vs. 93.5 cm). Our estimated optimal cut- off of WC was higher than that of reported for Asian population about 85-90 in men and 75-80 in women[27] but it is lower than that of ATP criteria of western counterparts[6] for men but not for women. In contrast to study among Tehranian adults, the optimal cutoff values of WC for cardio vascular risk factors were 91.5 cm in men and 85.5 cm in women[23]. In another study of Tehranian population, the cut-off value of WC in prediction of CVD risk was reported as 94.5 cm for both sexes[24]. Thus, based on this result the cut-off value of 95 cm for both sexes was recognized as regional measure of high WC by Iranian National Committee of Obesity (INCO)[28]. The estimated overall cut-off values of WC in both gender in our study was near to sex specific INCO recommended cut-off values, however the higher cut-off values in men and its lower in women than that of INCO cut-offs may be explained by difference in life styles in terms of food habit and exercise level between our study population and Tehranian population and also the differences in outcomes that were assessed in the two proposed predictive model.

Our optimal cutoff values for WHR and WHtR were rather similar between two sexes. A similar boundary cut-point that we estimated as 0.51 for WHtR has been reported in a systematic review of waist-to-hip ratio as a screening tools for prediction of cardio vascular risk factors as a global boundary[29]. The boundary value of 0.51 for WHtR in our study supports the public health message “keep your waist circumference to less than half of your height”. As one expects, for each index at optimal threshold, the higher sensitivity was corresponded with lower specificity. Furthermore, we found no difference of cut-off value in WHR between two sexes and it is close to WHO recommended WHR cut-off. In this regards, while our recommended cut-off was identical with those reported in Chinese study for men but it was slightly lower in women. Overall, our estimate WHR cut-off in women lies within the range of female Asian (0.79-0.85) for diagnosis of type 2 diabetes in different studies[30].

In addition, our findings revealed that WHtR index has higher accuracy in detection of high WC (or abdominal obesity) compared to BMI and WHR. For prediction of each component non-obese criteria including high BP, high TG, high FPG, all four indexes produced a similar AUCs that were ranged from 0.59 to 0.65 in both genders. Furthermore, there was no discriminative ability observed by either of four anthropometric measures in detection of low HDL. Even, surprisingly, a reverse discrimination was observed by either of four indexes in women. When we shifted the definition of MetS to ATP III criteria (including abdominal obesity), as one expects, our results showed that WC (equivalently WHtR) had higher diagnostic accuracy than BMI and WHR in particular among women. The accuracy indexes for all measures were higher than those in detection of non-adiposity components of MetS. In this condition, our results were similar to those reported in Esfahan population[16].

Our study had some limitations. The cross-sectional nature of this study does not allow any interpretation of the incidence of CVD risk factors. It only permits us to judge the prevalence of CVD risk factor in our predictive models. Although our samples were representative of urban adult population, we should be caution in generalizability of the results to rural population since the foot habit and other life style related factors may be rather different. Thus, more prospective cohort studies with a larger sample size of rural and urban area are required to establish the useful of anthropometric measures and the appropriate relevant cut-offs in predicting the incidence of CVD risk and related morbidity and mortality.

Conclusions

Although, WC (equivalently WHtR) is a better predictor of non- adiposity components of cardio vascular risk factors than BMI and WHR in women. Overall BMI, WC and WHtR predicted prevalence CVD risk factors equally. The optimal cut-offs of WC are lower compared with ATP III criteria of western population for men but not for women and it is higher than that of other Asian population in both sexes.

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Conflict of interest statement

There is no conflict of interest to be disclosed.

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