The First Nationwide Study of the Prevalence of the Metabolic Syndrome and Optimal Cut-off Points of Waist Circumference in the Middle East: The National Survey of Risk Factors for Non-Communicable Diseases of Iran

Alireza Delavari MD¹; Mohammad Hossein Forouzanfar MD, MPH, PhD¹,²; Siamak Alikhani MD, MPH³; Afsaneh Sharifian MD⁴; Roya Kelishadi MD⁵

1. Assistant Professor, Endocrine & Metabolism Research Center, Tehran University of Medical Sciences, Tehran, Iran
2. Assistant Professor, Department of Epidemiology and Biostatistics, Tehran University of Medical Sciences, Tehran, Iran
3. Technical Officer, Ministry of Health and Medical Education, Tehran, Iran
4. Assistant Professor, Kordestan Digestive Research Center, Kordestan University of Medical Sciences, Sanandaj, Iran
5. Associate Professor, Isfahan Cardiovascular Research Center, Isfahan University of Medical Sciences, Isfahan, Iran

Correspondence to:
Roya Kelishadi MD,
E-mail: Kelishadi@med.mui.ac.ir, kroya@aap.net

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Objective: To provide the first national estimate on the prevalence of the metabolic syndrome (MetS) and its components, as well as the first ethnic-specific cut-off point for waist circumference (WC) in the Eastern Mediterranean Region.

Research Design and Methods: This national survey was conducted in 2007 on 3024 Iranians aged 25-64 years living in urban and rural areas of all 30 provinces in Iran. The MetS was defined by different criteria, namely the definition of the National Cholesterol Education Program-Adult Treatment Panel III (ATP III), the International Diabetes Federation (IDF) criteria, and the modified definition of the NCEP/ATP III (ATPIII /AHA/NHLBI).

Results: The age-standardised prevalence of the MetS was about 34.7% (95% CI 33.1, 36.2) based on the ATP III criteria, 37.4% (35.9-39.0%) based on the IDF definition, and 41.6% (40.1-43.2%) based on the ATPIII/AHA/NHLBI criteria. By all definitions, the prevalence of the MetS was higher in women, in urban areas, and in the 55-64-year age group compared to men, rural areas and other age groups, respectively. The burden of the MetS was estimated to affect more than 11 million Iranians. The optimal cut-off point of WC for predicting at least two other components of the MetS as defined by IDF was 89 cm for men and 91 cm for women.

Conclusions: The high prevalence of the MetS with considerable burden on the middle-aged population mandates the implementation of national policies for its prevention, notably by tackling obesity. The obtained WC cut-off points can be used in the region.
Despite the rapidly growing prevalence of chronic non-communicable diseases in developing countries, notably in Asians with an ethnic predisposition to the insulin resistance and adverse body fat patterning seen in the metabolic syndrome (MetS) (1), very limited data exists on national estimates of such disorders. In this context, rapid epidemiological transition in the Middle East is a cause of concern. These nations have the highest dietary energy surplus of all developing countries (2) and one of the highest prevalence rates of overweight (3); the region is expected to bear one of the world's greatest increases in the absolute burden of diabetes in the next two decades (4). Meanwhile there is no national data either on the distribution of the MetS and its components, or the ethnic-specific optimal thresholds for waist circumference (WC) in this region.

We aimed to estimate the national prevalence of the MetS based on three sets of criteria, and to determine the optimal cut-off point of WC based on matching with other components of the MetS in the Middle East.

METHODS

Study population: The third National Survey of Risk Factors of Non-Communicable Diseases SURFNCDD 2007 was a population-based nationwide health survey conducted in Iran using guidelines of the STEPwise approach to non-communicable disease risk factor surveillance of the World Health Organization (WHO) (5) with some modifications (6). The sample size was calculated as 384 in each age and sex group, and was increased to 500 because the cluster sampling method was used; 250 clusters, each with 20 individuals were selected in each sex and age group. We recruited individuals from the households in a cluster using a quota approach, but we avoided recruiting subjects from the same age group in a single household.

The population aged above 25 years was eligible for blood sampling and consisted of 4000 individuals. Using a probability proportional to size multistage cluster random sampling method, a stratified representative sample of the population in the urban and rural areas of all 30 provinces of the country were studied. The Centre for Disease Control and Management approved the study, and informed written consent was obtained from participants.

Data collection: Strict training modules were designed and used to train interviewers and other staff. A vigorous quality assurance program was implemented to ensure the quality of data collection and laboratory examinations. After selecting the eligible individuals, all steps were done at door. A team consisting of healthcare professionals recorded demographic and health information in a checklist and carried out the field examinations by standardized and calibrated instruments. Weight, height and WC were measured according to standard protocol (5) and body mass index (BMI) was computed. Blood pressure was measured three times by using a M7 Omron digital sphygmomanometer. The mean of second and third measurements was used in the analysis.

Trained laboratory technicians obtained fasting (10-12 hours) venous blood samples and transferred them in cold boxes to a referral laboratory in each province that was at most 4 hours away from the sampling site. In addition, for protecting blood glucose concentrations from glycolysis, the anticoagulant sodium floride was added to the collection vial. The blood samples were centrifuged and sera were kept frozen at -20 C° before being transferred to the National Reference Laboratory, a WHO-collaborating centre in Tehran. We measured glucose with glucose oxidase/peroxidase-4-
aminophenazone-phenol (GOD-PAP) method and triglycerides were measured using GPO-PAP (glycerolphosphate oxidase-peroxidase aminophenazone, Randox). High-density lipoprotein cholesterol (HDL-C) was determined after dextran sulphate-magnesium chloride precipitation of non-HDL-C (7). Uniform testing kits from the same batch number (Pars Azmoun Company) were used to test the samples. Of all samples, 10% were re-checked by the National Reference Laboratory as a quality assurance measure. The coefficient of variation was less than 5% for all laboratory measurements.

Definitions and criteria for MetS: We used the criteria of the National Cholesterol Education Program-Adult Treatment Panel III (NCEP/ATP III) in 2001 (8), the International Diabetes Federation (IDF) criteria in 2005 (9) and the definition of the NCEP/ATP III modified in 2005 by the American Heart Association and the National Heart, Lung and Blood Institute (AHA/NHLBI) (10).

Statistical methods: STATA statistical software (Release 9.1, College Station, TX) was used for analysis with complex sample survey modules and commands. Variables of provinces were the indicators of strata, and in each province there were a few clusters that participants were recruited. Since the sampling was based on studying two persons in each sex and ten-year-width within every randomly selected cluster, we used age and sex strata for post-stratification and standardization for the Iranian population. Standardization was achieved by determining community size in the provinces and rural/urban areas represented by each participant in the study. These weights made the standardized results that can be generalized to the Iranian population aged 25 to 64 years according to the 2007 National Census. Continuous variables are described by mean ± standard error of mean. For categorical data and abnormal levels of variables studied, the prevalence of abnormal cases with confidence intervals is reported.

The receiver operator characteristic (ROC) curve for WC to present at least two other components of the MetS as defined by the IDF criteria (9) was plotted. The optimal cut-off values of WC were calculated by plotting the true positive rate (sensitivity) against the false-positive rate (1-specificity), where maximum accuracy (sensitivity plus specificity) was achieved.

To be able to compare our results with those from other countries in the Eastern Mediterranean Region (EMR), the findings were also directly standardized with the WHO world standard population (11).

RESULTS

Of 4000 target samples, 3864 responded to interviews and 3455 agreed to give blood samples. On the whole, data obtained from interviews and laboratory tests of 3024 participants (i.e. 75% of the desired number, and 79% of the recruited population) were complete and were included in the analysis. The 20% of participants who had dropped out in the laboratory phase were from different age and sex groups; the majority were young males and the minority were old females. Estimation of prevalence was performed on non-missing cases and standardized to the Iran population. In each stratum, the missing pattern seems random and is not confined to special places or attributes. Although some differences existed in various age and sex groups, as post-stratification was done with real weights, the final estimates are not biased by the imbalance of groups. Losing cases in the laboratory stage was mainly because some standard transportation and sampling procedures were not followed; also codes assigned to some patients were lost and the cases could not be matched to their corresponding results.
We studied 3024 individuals with a mean age of 41.3 (0.07) years, living in urban and rural areas of all 30 provinces of Iran. About two-thirds of the population were urban residents. Mean systolic and diastolic blood pressure (SBP, DBP) and FPG in urban residents were higher than in rural residents (Table 1).

Overweight was documented in 34.2% of the population with a higher prevalence in women than in men (36.1% vs. 32.1%, respectively, \( P=0.001 \)). Overall, 25.1% of the population studied was obese, with a higher prevalence in women than in men (33.3% vs. 17.2%, respectively, \( P<0.0001 \)). In both genders, overweight and obesity in urban areas were more prevalent than in rural areas (data not shown).

The age-standardized prevalence of the MetS was 35.6% based on the ATP III criteria (8), 37.4% by the IDF definition (9), and 42.3% according to the ATPIII/AHA/NHLBI criteria (10). By all definitions, the prevalence of the MetS in women and the 55-64-year age group was higher than in men and other age groups, respectively. The increase in the prevalence of MetS with age had a higher slope in women than in men, with the 20% difference between men and women in the 25-34-year age group by the ATPIII criteria (8), increasing to more than 75% in the 55-64-year age group. The estimated prevalence of the MetS was consistently higher based on the IDF definition (9), compared to the ATPIII (8) and ATPIII/AHA/NHLBI (10) criteria (Table 2).

Regardless of the definition used (8-10), the prevalence of the MetS in the urban population was 30-100% higher than in the rural population. The prevalence of the MetS in the urban vs. rural population by the ATP III definition, the IDF criteria (9), and the ATPIII/AHA/NHLBI criteria (10) was 42.1% (39.6-44.5) vs. 28.1% (26.4-29.7), 43.1% (40.7-45.5) vs. 30.9 (29.1-32.7)% and 49.5% (47.0-51.9) vs. 33.8% (32.1-35.6), respectively (\( P<0.0001 \) for all differences).

By all sets of criteria used (8-10), the commonest component of the MetS was low serum HDL-C, found in 80% of the population. Half of population had increased WC and more than one-third had high serum triglyceride levels and high BP. FPG levels higher than 110 mg/dL were found in 12% and levels higher than 100 mg/dL in 16% of individuals (Table 3).

We estimated the burden of the MetS for the Iranian population aged 25-64 years. According to the national census, in 2007 this population consisted of 15,900,331 males and 15,479,406 females. Based on the ATPIII criteria (8), the MetS affected 4,574,352 men (95% CI, 4,301,254-4,847,450) and 6,621,786 women (6,260,567-6,983,008). The estimates based on the IDF definition (9) were 4,375,044 (4,301,254-4,847,450) for men and 7,412,998 (7,060,598-7,765,397) for women, and based on the ATPIII/AHA/NHLBI criteria (10) they were 5,766,897 (5,477,624-6,056,171) for men and 7,514,809 (7,151,077-7,878,541) for women. The optimal cut-off point of WC for predicting at least two other components of the MetS as defined by IDF (9) was 88 cm for men and 91 cm for women (Figure 1).

When standardized with the WHO world standard population (11), the estimates of MetS in the EMR were 36.2% (95% CI 34.6, 37.8) based on the ATPIII criteria (8), 39.2% (37.6, 40.9) based on the IDF criteria (9), and 44.6% (42.9, 46.3) based on the ATPIII/AHA/NHLBI criteria (10). By the same calculation, the regional estimates were 36.5% (34.7, 38.2) for overweight, 24.3% (22.8, 25.8) for generalised obesity, and 36.9% (35.4, 38.4) for abdominal obesity based on the ATP III criteria (8), and 57.2% (55.6, 58.8) based on the IDF (9) and ATPIII/AHA/NHLBI criteria (10). As the cluster effect was not considered in
standardization, these confidence intervals are slightly underestimated.

**DISCUSSION**

In this first nationally representative study of the burden of the MetS in the Middle East, we found alarming prevalence rates of the syndrome and its components as defined by different sets of criteria. This may be accounted for by the rapid epidemiological, demographic and nutritional transition in the Iranian community. In addition, while the optimal cut-off points of WC for predicting other components of the MetS in the Iranian population were similar in both sexes, in men they were lower and in women higher than the Europids cut-off points currently recommended for use with the Middle Eastern populations (9). Our study of the burden of the MetS which in turn influences the risk of chronic diseases provides up-to-date evidence-based data that can be sued to orient the health systems of Middle Eastern countries towards prevention and early control of modifiable factors related to clustering of risk factors in this region.

Limited experience exists about the prevalence of the MetS in the EMR. In a study in Tunisia, this prevalence was 45.5% based on the IDF criteria (9) and 24.3% according to the ATPIII definition (8), with significantly higher prevalence in women than in men. The two most common components were increased WC and low HDL-C (12). A survey in Turkey reported a prevalence of 33.9% for MetS (8), with a higher prevalence in women (39.6%) than in men (28%) (13). Another study in Turkey reported a prevalence of 10.09% and 27.33% for the MetS in men and women, respectively (14).

It is well documented that Asians have ethnic predisposition to adverse body fat distribution and MetS (1), hence optimal cut-off points for WC have been established for South Asians (9); by using this cut-off, the prevalence of the MetS in this populations is estimated to be 10-30% (15). None of the Middle-Eastern studies have been conducted at the national level and many target specific populations, hence their findings cannot be generalized to the region. A study of female Saudi subjects found the prevalence of MetS to be 16.1% and 13.6% according to IDF (9) and ATPIII (8) definitions, respectively (16). In a population in Northern Jordan, the prevalence of the MetS (8) was reported at 36.3%, with a significantly higher prevalence in women than in men. The most common abnormality was low HDL-C in men (62.7%) and increased WC in women (69.1%) (17). The prevalence of the MetS (8) was reported at 21.0% in one city in Oman, with low HDL-C (75.4%) and increased WC as the two most common components (18).

The gender-difference in the prevalence of the MetS in this study is in line with previous studies in the EMR (12-15, 18), as well as local studies in Iran (19-20). The prevalence of the MetS (8) in one of the studies in Iran is reported to be 33.7%, with a higher prevalence in women (42%) than in men (24%) (19), the corresponding figure in the other study was 23.3%, with a higher prevalence in women (35.1%) than in men (10.7%), respectively (20). The MetS was documented in about 75% of women aged 55-64 years; this finding is alarming, and confirms that more attention should be paid to prevention and control of this disorder which poses serious health threats.

In all aforementioned population-based studies in the Middle-East (17-20) as well as the present one, low HDL-C followed by abdominal obesity has been the commonest component of the MetS. The high prevalence of low HDL-C, even in many cases without obesity and hypertriglyceridemia support an ethnic predisposition to this type of dyslipidemia. The findings of a recent study of the strong association between migration of Iranians to Sweden and the prevalence of hypertension
and smoking but not dyslipidemia (21) provide further confirmatory evidence on the ethnic predisposition to low HDL-C. This ethnic predisposition should be examined by future genetic studies.

The IDF consensus strongly recommends that ethnic-group-specific cut-points for WC should be used; for the Eastern Mediterranean and Middle Eastern populations, it is recommended to use the European cut-off points of WC until more specific data become available (9). In a survey in Tunisia, a cut-off point of 85 cm was documented for WC in both genders (22). A study in a city of Iraq found WC cut-off points of 97 cm in men and 99 cm in women (23). In a study in Tehran the cut-off points for WC were 80-93 cm for men and 79-96 cm for women (24). The optimal cut-off points obtained from the current study (i.e. 89 cm for men and 91 cm for women) are different from the Europid cut-off points that are currently recommended for use with Middle Eastern populations (9-10).

Our finding of greater WC values in Iranian compared to Western populations may be partly due to ethnic differences in body fat patterning and the genetic tendency of Asians to abdominal obesity (1), in addition, high carbohydrate intake and sedentary lifestyle in the Iranian community might be a contributing factor (20,25). However, a recent study comparing elderly Iranians inside Iran with those settled as migrants in Sweden found the prevalence of general obesity to be higher in Iranian women in Sweden (42%) compared to those in Iran (34%); however, abdominal obesity was found in nearly 80% of women in both groups (21). This finding suggests that the role of ethnicity on increased WC might be more important than lifestyle factors. This concept needs confirming by birth cohorts and other longitudinal studies.

**Study limitations and strengths:**
The main limitation of this study in determining the optimal cut-off point for WC is its cross-sectional nature; longitudinal studies are required to confirm our findings. Furthermore, the sensitivity and specificity of this cut-off point was not high, however it would be useful as a screening tool. The strength of this study is its nationally-representative sample with valid weights for standardization that enable us to infer with some confidence the distribution and epidemiology of the MetS and its components in Iran and even in the region.

**CONCLUSIONS**

The high prevalence of the MetS and its considerable burden on the middle-aged population mandate the implementation of national policies for its prevention and control in the Middle Eastern countries which face the world's greatest increment in the absolute burden of diabetes in the next two decades. The cut-off points provided by this survey can be used as optimal cut-off points in the region.

**ACKNOWLEDGMENTS**

The survey was funded by the Iranian Ministry of Health and Medical Education. The authors would like to offer their sincere thanks to all members of the large team working in this project especially colleagues in the NCD risk factor surveillance system and in the Center for Disease Control (CDC), Ministry of Health. We are grateful to Dr Mohammad Mehdi Gouya, the CDC Director for his support.

**Conflict of interests:** None.
REFERENCES


Table 1. Characteristics of participants by sex and living area

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Urban</td>
<td>Rural</td>
</tr>
<tr>
<td></td>
<td>(^n=1431)</td>
<td>(n=942)</td>
<td>(n=489)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>41.5(0.07)</td>
<td>41.5(0.1)</td>
<td>41.6(0.1)</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>124.7(0.3)</td>
<td>126.6(0.4)¶</td>
<td>122.4(0.5)¶</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>80.0(0.4)*</td>
<td>82.2(0.7)*</td>
<td>77.3(0.4)*</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>74.3(0.3)</td>
<td>79.9(0.4)</td>
<td>71.1(0.6)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.6(0.2)</td>
<td>171.0(0.2)¶</td>
<td>167.9(0.3)</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>25.6(0.1)</td>
<td>26.3(0.1)¶</td>
<td>24.9(0.2)¶</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>89.8(0.3)</td>
<td>91.5(0.4)</td>
<td>87.7(0.4)</td>
</tr>
<tr>
<td>Total cholesterol (mmol/L)</td>
<td>4.99(5.2)</td>
<td>5.05(0.04)</td>
<td>4.93(0.03)</td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/L)</td>
<td>3.27(0.02)</td>
<td>3.28(0.03)</td>
<td>3.25(0.02)</td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/L)</td>
<td>0.89(0.01)</td>
<td>0.85(0.01)</td>
<td>0.97(0.01)</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>1.84(0.03)</td>
<td>2.00(0.05)</td>
<td>1.64(0.03)</td>
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<tr>
<td>Fasting blood glucose (mmol/L)</td>
<td>5.22(0.05)*</td>
<td>5.42(0.08)*</td>
<td>4.99(0.03)</td>
</tr>
</tbody>
</table>

Data are mean (SE)
SBP=systolic blood pressure, DBP=diastolic blood pressure, BMI=body mass index
*: number of participant that has non-missing values for all variable, number of valid cases for each variable may slightly differ.
*=p<0.05 for men versus women
¶: p<0.05 for urban versus rural area
Table 2. Prevalence of metabolic syndrome based on different sets of criteria by age group and sex

<table>
<thead>
<tr>
<th>Age(yrs)</th>
<th>ATPIII 8</th>
<th>IDF 9</th>
<th>ATPII/AHA/NHLBI 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Men</td>
<td>Women</td>
<td>Total Men</td>
</tr>
<tr>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
</tr>
<tr>
<td>25-34</td>
<td>19.0 (16.4-21.7)</td>
<td>17.5 (14.6-20.4)</td>
<td>20.5 (19.3-23.8)</td>
</tr>
<tr>
<td>35-44</td>
<td>35.8 (33.2-38.3)</td>
<td>31.0 (27.9-34.0)</td>
<td>41.2 (37.1-45.3)</td>
</tr>
<tr>
<td>45-54</td>
<td>50.1 (48.2-53.8)</td>
<td>37.0 (33.3-40.8)</td>
<td>66.6 (62.0-71.2)</td>
</tr>
<tr>
<td>55-64</td>
<td>57.6 (53.8-61.4)</td>
<td>41.5 (35.7-47.2)</td>
<td>72.9 (68.2-77.7)</td>
</tr>
<tr>
<td>Total</td>
<td>35.6 (34.1-37.1)</td>
<td>28.8 (27.0-30.5)</td>
<td>42.8 (40.4-45.1)</td>
</tr>
</tbody>
</table>

Table 3. Prevalence of the metabolic syndrome components based on different sets of criteria

<table>
<thead>
<tr>
<th>Components</th>
<th>High FPG</th>
<th>High TG</th>
<th>Low HDL-C</th>
<th>High BP</th>
<th>Increased WC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
</tr>
<tr>
<td><strong>ATPIII 8</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12.4 (11.4-13.4)</td>
<td>37.8 (36.0-39.5)</td>
<td>79.9 (78.2-81.6)</td>
<td>41.9 (40.1-43.5)</td>
<td>36.0 (34.7-37.4)</td>
</tr>
<tr>
<td>Men</td>
<td>13.3 (12.0-14.7)</td>
<td>40.1 (37.9-42.2)</td>
<td>75.9 (73.9-77.9)</td>
<td>39.6 (37.4-41.9)</td>
<td>16.5 (14.9-18.0)</td>
</tr>
<tr>
<td>Women</td>
<td>11.4 (9.9-12.9)</td>
<td>35.4 (33.0-37.7)</td>
<td>84.1 (81.8-86.3)</td>
<td>44.1 (41.9-46.3)</td>
<td>56.5 (54.3-58.6)</td>
</tr>
<tr>
<td><strong>IDF 9</strong>- <strong>ATPII/AHA/NHLBI 10</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15.7 (14.5-16.9)</td>
<td>37.8 (36.0-39.5)</td>
<td>79.9 (78.2-81.6)</td>
<td>41.9 (40.1-43.5)</td>
<td>54.9 (53.5-56.3)</td>
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<tr>
<td>Men</td>
<td>17.2 (15.7-18.6)</td>
<td>40.1 (37.9-42.2)</td>
<td>75.9 (73.9-77.9)</td>
<td>39.6 (37.4-41.9)</td>
<td>38.6 (36.6-40.7)</td>
</tr>
<tr>
<td>Women</td>
<td>14.2 (12.5-15.9)</td>
<td>35.4 (33.0-37.7)</td>
<td>84.1 (81.8-86.3)</td>
<td>44.1 (41.9-46.3)</td>
<td>71.9 (69.9-73.9)</td>
</tr>
</tbody>
</table>

*: all components are similar in the IDF 9 and ATPII/AHA/NHLBI 10 definitions except than the increased waist circumference that is the core component of the IDF criteria
FPG: fasting plasma glucose; TG: triglycerides; HDL-C: high density lipoprotein-cholesterol; BP: blood pressure; WC: waist circumference
Figure 1A. The receiver operator characteristic (ROC) curves for waist circumference to predict the presence of at least two risk factors of the metabolic syndrome, as defined by the International Diabetes Federation for men.

Figure 1B. The receiver operator characteristic (ROC) curves for waist circumference to predict the presence of at least two risk factors of the metabolic syndrome, as defined by the International Diabetes Federation for women.