Research Article

The Cut-Off Values of Anthropometric Indices for Identifying Subjects at Risk for Metabolic Syndrome in Iranian Elderly Men

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Aim. This study aimed to investigate which anthropometric indices could be a better predictor of metabolic syndrome (MetS) and the cut-off points for these surrogates to appropriately differentiate MetS in the Iranian elderly. Method. The present cross-sectional study was conducted on a sample of Isfahan Healthy Heart Program (IHHP). MetS was defined according to Third Adult Treatment Panel (ATPIII). In total, 206 elderly subjects with MetS criteria were selected. Anthropometric indices were measured and plotted using receiver operating characteristic (ROC) curves. Results. WC followed by WHtR yielded the highest area under the curve (AUC) (0.683; 95% CI 0.606–0.761 and 0.680; 95% CI 0.602–0.758, resp.) for MetS. WC at a cut of 94.5 cm resulted in the highest Youden index with sensitivity 64% and 68% specificity to predict the presence of ≥2 metabolic risk factors. BMI had the lowest sensitivity and specificity for MetS and MetS components. WC has the best ability to detect MetS which followed by WHtR and BMI had a lower discriminating value comparatively. Conclusion. WC is the best predictor for predicting the presence of ≥2 metabolic risk factors among Iranian elderly population and the best value of WC is 94.5 cm. This cut-off values of WC should be advocated and used in Iranian men until larger cross-sectional studies show different results.

1. Introduction

Obesity increases the risk of cardiovascular disease in adults, has been strongly associated with insulin resistance in non-diabetic persons and in individuals with type 2 diabetes [1, 2], and is considered as prerequisite for the diagnosis of metabolic syndrome (MetS). Central obesity is defined using ethnicity-specific cut-off point of waist circumference (WC) [3]. In this regard, previous studies recommended the best cut-off points of WC values for prevention and control of cardiovascular disease in adults and children [4, 5]. Definition of obesity differs among various ethnics; therefore, many regional studies are conducted to find the best cut-off points for obesity [6]. The values of anthropometric indices are varied in different age groups with respect to race; for instance, the cut-off points of WC in studies in Oman, Iraq, and Korea were 80 cm, 97 cm, and 90 cm, respectively, in men and 84.5 cm, 99 cm, and 85 cm, respectively, in women [7]. Numerous national studies determined cut-off points for WC, WHR, and BMI among Iranian adolescents and adults [8–10]. For example, Iranian Multi-Centric Osteoporosis Studies (IMOS) [8] determined of WC in five major cities...
of Iran. Considering the dramatic changes in fat distribution and its function throughout life [11] and according to this fact these changes can have important consequences on the profile of risk factors for developing MetS [12]. Our previous study which was done to determine the prevalence of different phenotypes in various age groups demonstrated that current cut-off points for WC are not appropriate for distinguishing subjects at risk of developing MetS specially among Iranian elderly men [13]. We found that the prevalence of MetS decreased sharply in men above 65 years old, which is related to low prevalence of central obesity in this group. So this study is designed to determine appropriate cut-off points for anthropometric indices in the Iranian elderly especially in men.

2. Material and Methods

2.1. Study Population. Isfahan Healthy Heart Program is a comprehensive integrated community-based action-oriented study with a reference community which has been conducted by the Isfahan Cardiovascular Research Institute since 2000 and completed in 2007 [14, 15]. A random independent sample of adults was selected by multistage cluster sampling. The effect of confounding has been addressed by using random, stratified household sampling based on age and sex groups. The participants were more than 19 years old. The samples underwent a 30-minute interview by well-trained examiners to complete validated questionnaires containing questions on demography, socioeconomic status, smoking behavior, physical activity, nutritional habits, and other risk profiles. Informed consent was obtained from all subjects prior to their participation in this study, which was approved by the Ethical Committee of Isfahan University of Medical sciences. IHHP was covered under IRB protocol FW A00008578. In this substudy we consider only elder population (over 65) with MetS.

2.2. Data Collection. Information on sociodemographic factors and self-reported medical history were obtained by interview. Anthropometric measurements, including height, weight, and waist and hip circumferences, were taken with subjects wearing light clothing by well-trained examiners. Waist circumference was measured to the nearest 0.1 cm in the horizontal plane at the high point of the iliac crest during minimal respiration [15]. Blood pressure was measured with a mercury sphygmomanometer using right arms, in a sitting position, after a 5 min rest. Systolic and diastolic blood pressure were recorded twice and averages were used for the data analysis. Blood samples were drawn from an antecubital vein after an 8–12 hr overnight fast. Samples were stored at −20 until required for biochemical assays. Fasting venous blood samples were obtained from the antecubital vein between 08:00 and 09:30. Blood samples were centrifuged for 10 min at 906 g within 30 min of collection. Sera were analyzed for total cholesterol, high-density lipoprotein (HDL), triglycerides (TG), and fasting blood glucose (FBG). Low-density lipoprotein cholesterol (LDL) was calculated by the Friedewald equation when TG was less than 400 mg/dL [16]. TC was measured using enzymatic colorimetric methods. HDL was determined after dextran sulphate-magnesium chloride precipitation of HDL. All the tests were performed in the Central Laboratory of the Isfahan Cardiovascular Research Center and using autoanalyzer ELAN (Ependorf 2000). For quality control measures, this laboratory meets the criteria of the National Standard Laboratory (a WHO collaborating centre in Tehran).

2.3. MetS Definition. The ATPIII definition of MetS was met when three or more of the following criteria were present: waist circumference ≥ 102 cm; HDL < 40 mg/dL or specific treatment for this lipid abnormality; triglycerides ≥ 150 mg/dL or specific treatment for this lipid abnormality; systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg or treatment of previously diagnosed hypertension; fasting glucose ≥ 100 mg/dL [14].

2.4. Statistical Analysis. Data entry was carried out using EPI Info. Data were analyzed using STATA software (Stata/IC11.0, StataCorp LP, College Station, TX, USA). For all analyses, statistical significance was assessed at the level of 0.05 (2-tailed) and P value < 0.05 was considered as the borderline significance (marginal significance).

Receiver operating characteristic (ROC) analysis and the area under curve (AUC) were used to identify the sensitivity and specificity of anthropometric indices cut-off points for the detection of MetS without WC. The optimal cut-off values were defined as the point at which the value of “sensitivity + specificity − 1” was maximum (Youden’s index). The Akaike information criterion (AIC) considered for comparing nonnested models and goodness of fit. Lower values of the index indicate the preferred model, that is, the one with the fewest parameters that still provides an adequate fit to the data.

3. Results

3.1. Baseline Characteristics. In total, 206 elderly subjects with metabolic syndrome were evaluated for this study. The mean age of participants was 71.85 ± 5.44. The mean of WC, BMI, WHR, and WHtR in the presence of MetS was 97.39 ± 10.63, 26.32 ± 3.96, 0.96 ± 0.05, 0.96 ± 0.05, and 58.55 ± 6.11. Subjects with MetS had both higher systolic and diastolic blood pressure than subjects without MetS (140.79 ± 19.70 and 81.84 ± 4.39 (P < 0.001) versus 124.12 ± 20.10 and 77.41 ± 10.78 (P < 0.023)) (Table 1).

3.2. Obesity Indices and Metabolic Syndrome Except MetS Using ROC Curves. The predicting values for two or more metabolic risk factors and corresponding AUC of BMI, WC, WHR, and WHtR in men are shown in Table 2 and Figure 1. WC at a cut-off value of 94.5 cm resulted in the highest Youden index with corresponding sensitivity of 68% and specificity of 76% to detect MetS. At a traditional cut-off value of <102 cm of WC, the sensitivity dropped to 88%, and specificity slightly rose to 23%.
Table 1: Characteristics of study subjects according to the presence of two or more metabolic risk factors except for WC in the elderly Iranians.

|                | Total          | Absent         | Present        | P value |
|----------------|----------------|----------------|----------------|---------|
| Age (years)    | 71.85 ± 5.44   | 72.15 ± 5.42   | 71.71 ± 5.49   | 0.568   |
| Body mass index (kg/m2) | 25.51 ± 4.02   | 24.36 ± 3.83   | 26.32 ± 3.96   | 0.001   |
| WHR            | 0.94 ± 0.06    | 0.93 ± 0.06    | 0.96 ± 0.05    | 0.001   |
| Waist (cm)     | 94.69 ± 11.10  | 90.86 ± 10.66  | 97.39 ± 10.63  | 0.000   |
| WHtR           | 56.91 ± 6.51   | 54.56 ± 6.40   | 58.55 ± 6.11   | 0.000   |
| Fasting blood sugar (mg/dL) | 104.11 ± 37.67 | 90.12 ± 18.53  | 113.52 ± 44.14 | 0.000   |
| Glucose (2hpp) (mg/dL) | 124.45 ± 56.42 | 103.48 ± 28.21 | 140.74 ± 66.89 | 0.000   |
| Triglycerides (mg/dL) | 151.80 ± 87.78 | 101.25 ± 33.41 | 186.63 ± 96.41 | 0.000   |
| HDL (mg/dL)    | 40.74 ± 10.64  | 48.08 ± 9.43   | 35.80 ± 8.31   | 0.000   |
| Cholesterol (mg/dL) | 199.56 ± 39.40 | 197.35 ± 39.38 | 200.68 ± 39.43 | 0.557   |
| Systolic blood pressure | 134.12 ± 21.40 | 124.12 ± 20.10 | 140.79 ± 19.70 | 0.000   |
| Diastolic blood pressure | 80.12 ± 13.22  | 77.41 ± 10.78  | 81.84 ± 4.39   | 0.023   |
| Low HDL cholesterol (n, (%)) | 98 (48.5)     | 13 (15.9)      | 85 (70.8)      | 0.000   |
| High TG (n, (%)) | 82 (40.8)      | 3 (3.7)        | 79 (66.4)      | 0.000   |
| High blood pressure (n, (%)) | 136 (70.5)    | 35 (46.7)      | 101 (85.6)     | 0.000   |
| High blood sugar (n, (%)) | 54 (26.6)      | 5 (6.1)        | 49 (40.5)      | 0.000   |
| Lipid drug (n, (%)) | 24 (85.7)      | 5 (100.0)      | 19 (82.6)      | 1.000   |
| Diabetes drug regular (n, (%)) | 30 (96.8)    | 5 (100)        | 25 (96.2)      | 1.000   |
| Hypertension drug regular (n, (%)) | 38 (74.5)   | 5 (55.6)       | 33 (78.6)      | 0.150   |

The numerical values are presented as mean ± SD and compared by Student's t-test except for items indicated by § that Mann-Whitney U test was employed. Categorical data is shown as n (%) and tested by chi-square.

∗BMI: body mass index, WC: waist circumference, WHR: waist-to-hip ratio, and WHtR: waist-to-height ratio.
†Triglycerides ≥150 mg/dL or on antilipid agents.
‡HDL-C < 40 for men and <50 for women or on antilipid agents.
§High blood pressure is considered as SBP ≥140 mmHg or DBP ≥90 mmHg or antihypertensive agents.

The BMI at a cut-off value of ≥28 kg/m² and the traditional cut-off value of ≥30 kg/m² were found to be having the lowest Youden index and corresponding sensitivity and specificity.

These results showed that WC (with the AUC of 0.590) was a better indicator for high blood pressure compared to BMI and WHR, whereas BMI (with the AUC of 0.638) was a better indicator of high blood pressure and WHR (with the AUC of 0.595) had a lower discriminating value. WC had greater AUC values compared to BMI and WHR in distinguishing low HDL cholesterol and hypertriglyceridemia only (0.609 and 0.625, resp.). WHtR had better prediction ability to distinguish high blood pressure (AUC of 0.616 (0.527–0.705)).

Based on the indicator of interest, the optimum WC cut-off points in our study population for MetS were 94.5 and for MetS components ranged from 89.5 to 95.5 (Table 2). The best cut-off points of WHR for MetS were 0.95 and ranged from 0.92 to 0.97 for other MetS components. BMI at a cut-off value of the traditional cut-off value of 30 kg/m² were found to be having the lowest Youden index and corresponding sensitivity and specificity. Table 3 shows adjusted odds ratios (OR) for MetS. The model is adjusted for age and smoking status. The lowest AIC is related to WC in both adjusted and unadjusted model. So WC at a cut-off point of 94.5 cm
Table 2: Areas under the ROC curve of WC, BMI, WHR, and WHtR to identify the presence of the metabolic risk factors other than WC in elderly men.

| MetS       | Obesity index | Best cut-off point | Sensitivity | Specificity | Youden | AUC (95% CI) | P value |
|------------|---------------|--------------------|-------------|-------------|--------|--------------|---------|
|            | WC            | 94.5               | 64%         | 68%         | 32%    | 0.683 (0.606–0.761) | 0.000   |
|            | WHR           | 0.95               | 6%          | 69%         | 29%    | 0.645 (0.563–0.727) | 0.001   |
|            | BMI           | 26.65              | 48%         | 76%         | 24%    | 0.641 (0.561–0.722) | 0.001   |
|            | WHR           | 58.66              | 52%         | 0.79        | 31%    | 0.680 (0.602–0.758) |        |
| High blood pressure | WC          | 89.5               | 75%         | 49%         | 24%    | 0.633 (0.542–0.724) | 0.004   |
|            | WHR           | 0.92               | 76%         | 45%         | 22%    | 0.595 (0.503–0.687) | 0.040   |
|            | BMI           | 22.84              | 82%         | 49%         |        | 0.638 (0.540–0.735) | 0.004   |
|            | WHR           | 53.84              | 76%         | 54%         | 31%    | 0.616 (0.527–0.705) |        |
| High triglyceride | WC          | 94.5               | 67%         | 59%         | 26%    | 0.625 (0.545–0.705) | 0.003   |
|            | WHR           | 0.97               | 46%         | 72%         | 19%    | 0.585 (0.502–0.668) | 0.020   |
|            | BMI           | 22.84              | 85%         | 35%         | 21%    | 0.600 (0.519–0.680) | 0.04    |
|            | WHR           | 53.09              | 0.85        | 0.38        | 0.22   | 0.607 (0.527–0.687) | 0.00    |
| Low HDL    | WC            | 94.5               | 63%         | 58%         | 21%    | 0.609 (0.527–0.690) | 0.010   |
|            | WHR           | 0.96               | 52%         | 68%         | 20%    | 0.597 (0.516–0.679) | 0.010   |
|            | BMI           | 24.83              | 63%         | 52%         | 15%    | 0.579 (0.498–0.661) | 0.060   |
|            | WHR           | 53.563             | 81%         | 40%         | 21%    | 0.604 (0.523–0.685) | 0.00    |
| High fasting blood sugar | WC          | 95.5               | 61%         | 58%         | 19%    | 0.617 (0.524–0.709) | 0.014   |
|            | WHR           | 0.95               | 65%         | 58%         | 24%    | 0.605 (0.518–0.691) | 0.027   |
|            | BMI           | 25.54              | 58%         | 58%         | 18%    | 0.578 (0.482–0.673) | 0.101   |
|            | WHR           | 56.04              | 98%         | 15%         | 13%    | 0.512 (0.431–0.593) | 0.00    |

BMI: body mass index, WC: waist circumference, WHR: waist-to-hip ratio, and WHtR: waist-to-height ratio.

Table 3: Association of the best cut-offs of obesity indices with MetS.

|            | Crude OR (95% CI) | Adjusted OR (95% CI) |
|------------|------------------|----------------------|
|            | OR (CI) P value   | AIC                  | OR (CI) P value   | AIC       |
| WC         | 3.835 (0.00–7.11) | 0.000                | 237.55            | 4.564 (2.37–8.81) | 0.000    | 240.19         |
| WHR        | 3.00 (1.63–5.51)  | 0.000                | 243.81            | 3.219 (1.73–6.00) | 0.000    | 248.26         |
| BMI        | 2.954 (1.55–5.62) | 0.001                | 247.1             | 3.115 (1.62–5.98) | 0.001    | 251.78         |
| WHtR       | 4.023 (2.07–7.80) | 0.000                | 238.121           | 4.162 (2.13–8.12) | 0.000    | 243.09         |

OR: odds ratio, CI: confidence interval, BMI: body mass index, WC: waist circumference, WHR: waist-to-hip ratio, and WHtR: waist-to-height ratio. Model is adjusted for age and smoking status.

4. Discussion

The findings of the present study demonstrated the superlative discriminating values of common anthropometric parameters for MetS in elderly Iranian men. While many studies were done among adolescents and adults, but to the best of our knowledge this is the first study which was done on elderly men. After considering Youden’s index, we found that the best cut-off points for WC in men are 94.5 cm instead of 102 cm which is recommended by ATPIII.

In recent years numerous studies have been done to find the best anthropometric indices for detecting MetS, especially, among different ethnics. In our previous study [9] we showed that, among the Iranian population, WC might be the most appropriate indicator to discriminate MetS regardless of gender and age, which has been confirmed with the present study. In this study we found that the best obesity indicator for distinguishing MetS among Iranian elderly men is WC.

There is controversy about the proper values of anthropometric values according to ethnicity, genetic background, sexes, and sociocultural aspects. Beydoun et al. showed that WC is among the most powerful tools to predict MetS and that optimal cut-off points for various indices including WC may differ by sex and race [17]. Beydoun’s suggestion is consistent with other reports by Reeder et al. [16, 18] and Wang et al. [19]. While many studies have been done to find the best similar to our results. For example, Wakabayashi and Daimon illustrated that the associations between obesity and multiple risk factors for atherosclerosis become weaker as age increases, while age does not influence cut-off values of obesity indices except for higher WHtR at an older age in women [18]. Another study which was done by Shao et al. indicated that WHtR might be an optimal anthropometric predictor of MetS risk factors and the cut-off point of WHtR...
was approximately 0.50 in both genders of Chinese adults [20]. Likewise, another report by Dong et al. suggested that WHtR has better association with obesity related cardiovascular risk conditions in both sexes, except for hypertension in Chinese men [21]. An Iranian longitudinal study confirmed the cut-off points for women but decreased them to 90 cm for men. This might be in part due to the linear effect of WC on cardiovascular risk in men compared to women. Hence, among all eleven cut-off points, 90 cm was identified as the best definition of central obesity for men [10]. An eastern study which was done on Japanese subjects reported that VFA [20]. Likewise, another report by Dong et al. suggested that was approximately 0.50 in both genders of Chinese adults [21]. An Iranian longitudinal study confirmed the cut-off values of WC should be advocated and used in highest sensitivity for MetS diagnosis among obesity indices. We found that BMI tended to be the weakest index for identifying MetS risk factors in elderly men. WC exhibited the best predictive index for MetS, almost similar to predictive powers of WHtR for identifying MetS. The two indices of WC and WHtR were better indicators of MetS. WC had WC the highest sensitivity for MetS diagnosis among obesity indices. These cut-off values of WC should be advocated and used in Iranian elderly men.

5. Limitation

The present study is limited by its cross-sectional nature, so we could not evaluate outcome measures. Consequently, the authors are mindful that differences could only be imputed from the previously documented data.

6. Conclusion

We found that BMI tended to be the weakest index for identifying MetS risk factors in elderly men. WC exhibited the best predictive index for MetS, almost similar to predictive powers of WHtR for identifying MetS. The two indices of WC and WHtR were better indicators of MetS. WC had WC the highest sensitivity for MetS diagnosis among obesity indices. These cut-off values of WC should be advocated and used in Iranian elderly men.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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