Statistical Reassessment of the Association between Waist Circumference and Clustering Metabolic Abnormalities in Japanese Population

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Aim: The use of ethnic-specific cutoff values of waist circumference (WC) has been recently recommended, but they were originally developed on different statistical grounds. We investigated whether different statistical procedures and clinical settings generate different WC cutoff values in one ethnic population.

Methods: We recruited 3810 Japanese subjects and performed the following three statistical analyses: 1) search for WC cutoff points associated with the risk of clustering metabolic abnormalities, 2) calculation of WC associated with certain body mass index (BMI) levels, 3) evaluation with receiver operating characteristic (ROC) curves for the risk. We also simulated population models to evaluate whether WC cutoff values depend on the clinical settings of the study population.

Results: First, in risk analysis, males and females had the same risk when females had 10 cm larger WC than males, although the risk increased almost linearly, without any clear threshold. Second, WC corresponding to BMI of 25 kg/m² was 87 cm in males and 85 cm in females, with a slight sex difference. Third, ROC curves showed that the male optimal cutoff value was 85 cm, larger than the female one (79 cm). However, simulated population models with various WC distributions gave different ROC curves and different WC cutoff values. Furthermore, WC cutoff values varied by age in any of the three statistical procedures.

Conclusions: Different statistical grounds could generate different WC cutoff values. If one plans to establish a unified trans-ethnic diagnostic tool of metabolic syndrome, ethnic-specific WC cutoff values should be primarily provided based on a unified statistical ground.


Key words: Waist circumference, Statistical reassessment, Metabolic syndrome

Introduction

Ever since cardiovascular disease was identified as the major cause of mortality and morbidity in the last century, a number of clinical investigations have revealed its contributing risk factors, such as hypertension, dyslipidemia, and diabetes. It has also become apparent that these metabolic abnormalities often coexist in the same individual with visceral adiposity. Visceral adiposity has been often evaluated by waist circumference (WC), because it is a crude but relevant index of the visceral fat deposits measured by computed tomography (CT)1).

A cluster of metabolic abnormalities on the basis of visceral adiposity is now well recognized as metabolic syndrome and many working groups in the world have developed their own diagnostic definition of the syndrome and have determined their own WC cutoff values on the basis of their own causes and clinical settings. For example, Japan developed their origi-
nal WC cutoff values of 85 cm in males and 90 cm in females because these WC levels corresponded to CT-evaluated visceral fat deposits which were related to the absolute risk of metabolic abnormalities in the population. On the other hand, Western countries derived their WC cutoff values from the correlation with body mass index (BMI), whereas other Asian groups tried to develop their WC cutoff values with the use of receiver operating characteristic (ROC) curves for accumulating metabolic abnormalities. The International Diabetes Federation (IDF) thereafter proposed a unified diagnostic tool for the purpose of easy comparison of data among different countries.

In the unified diagnostic tool, IDF recommended the use of ethnic-specific WC cutoff values. However, their proposed cutoff values were not based on a unified statistical procedure; some WC cutoff values were derived from the correlation with BMI, whereas others were by reference to analyses with ROC curves. Different statistical procedures could generate different cutoff values even in one ethnic population, but few reports have focused on this issue.

Furthermore, for Japanese population, IDF newly proposed “Asian values” (90 cm in males and 80 cm in females), seemingly derived from other Asian data analyzed with ROC curves. However, further investigations of Japanese population found that the cutoff values obtained from ROC curves were different from IDF’s “Asian values”. Different characteristics of study subjects, such as age and WC distribution, might influence the derived WC cutoff value, but there has been no report so far directly showing this point.

Aims

The aim of the current study was to investigate whether different statistical procedures and different clinical settings would generate different WC cutoff values in Japanese population.

Subjects and Methods

Study Population and Definitions

We used cross-sectional data in the Amagasaki Visceral Fat Study (UMIN000002391). The study was approved by the human ethics committee of Osaka University and written informed consent was obtained from every participant, as described elsewhere. We recruited 3810 Japanese employees of the city office of Amagasaki, Hyogo, who underwent an annual health checkup in 2004, before national health promotion measures against metabolic syndrome were formulated.

The health checkup included anthropometric measurements (height, body weight, and WC), sphygmonanometry, and laboratory examinations. WC was measured as recommended in the original diagnostic criteria in Japan. Body mass index (BMI) was calculated from height and body weight. Blood pressure was measured with a standard mercury sphygmonanometer on the right arm after the subject had rested in a sitting position for at least for 10 minutes. Venous blood samples were collected for examination of glucose, HDL cholesterol and triglyceride levels.

On the basis of these measurements, hypertension, dyslipidemia, and hyperglycemia were defined as follows. Hypertension was diagnosed when systolic blood pressure was \( \geq 130 \text{ mmHg} \) or diastolic blood pressure was \( \geq 85 \text{ mmHg} \) or subjects were being treated with antihypertensive medications. Dyslipidemia was determined as HDL cholesterol \( < 1.04 \text{ mmol/L} \), fasting or postprandial triglyceride \( \geq 1.69 \text{ mmol/L} \) or \( 2.27 \text{ mmol/L} \), or having been treated for dyslipidemia. Hyperglycemia was defined as fasting or postprandial glucose \( \geq 6.1 \) or \( 7.8 \text{ mmol/L} \), or the use of hypoglycemic medications. A cluster of metabolic abnormalities was identified when they had two or more of these metabolic abnormalities.

Statistical Analysis

Data are given as the means and standard deviations (SD) for continuous variables or as percentages for dichotomous variables. We performed the following three familiar statistical procedures in search of the optimal WC cutoff value. First, we investigated the association between WC and the risk of accumulating metabolic abnormalities. In addition to the search for a WC threshold above which the risk would increase sharply, we examined WC levels corresponding to a certain probability of the risk, with the use of a logistic regression model, as well as a probit model. In the logistic regression model, a cluster of metabolic abnormalities was employed as the dependent variable, whereas the number of metabolic abnormalities was employed in the probit model. Although age was expected to have a substantial influence on the association of WC with the risk of metabolic abnormalities, the current WC cutoff values proposed throughout the world have not taken its influence into consideration. Therefore, we first performed these risk analyses of WC levels without adjustment for age, and subsequently assessed the influence of age on the associations of WC levels with the risk.

Second, we investigated the association between WC and BMI using correlation analysis and linear
regression analysis, by which the WC cutoff values in Western countries were originally developed\(^6\). The validity of the cutoff values was assessed by calculating the odds ratio (OR) for a cluster of metabolic abnormalities\(^7\).

Third, we assessed the predictive impact of WC using receiver operating characteristic (ROC) curves for a cluster of metabolic abnormalities, from which optimal cutoff values were obtained\(^6\).

We further simulated various population models to investigate whether WC cutoff values depend on the clinical settings of the study population. We first simulated various age groups, that is, 30-, 45-, and 60-year-old populations. Since WC was expected to be associated with age, we prepared age-specific WC distributions when required. The WC distribution of each age group was considered to be a normal distribution with SD equal to that of the original population, and the mean was obtained from the sex-specific linear regression model between WC and age. We also simulated populations with various WC distributions as follows: 1) a normal distribution with the mean and SD equal to those of the original study population, 2) a right shift with the mean WC increased by 5 cm from the original distribution, and 3) a left shift with the mean WC decreased by 5 cm from the original. In the latter two models, the estimated 2.5 percentile of WC, or mean \(-1.96 \times SD\), was set to be unchanged from the original distribution. The age distributions of the simulated populations were considered to be equal to those of the original population. The probability of accumulating metabolic abnormalities was obtained from the risk analysis models in the original population described above.

A \(p\) value less than 0.05 was considered to be significant and 95% CI is given when required. Statistical analyses were performed using IBM SPSS Statistics Version 19 (SPSS Inc.).

**Results**

A total of 2849 males and 961 females were recruited. Their age ranged from 21 to 68 years (48.4 \(\pm\) 10.7 in males and 45.5 \(\pm\) 10.1 in females), and 1638 males (57%) and 594 females (62%) were 40-60 years old. Their WC and BMI were 84.2 \(\pm\) 8.4 cm and 24.1 \(\pm\) 3.1 kg/m\(^2\) in males, and 76.5 \(\pm\) 9.6 cm and 22.2 \(\pm\) 3.5 kg/m\(^2\) in females, respectively. WC and age had a significant correlation with each other (\(p<0.001\) in both males and females) and the linear regression equations were as follows: \(WC (\text{cm}) = 0.17 \times Age\) (years) + 75.88 in males, and \(WC (\text{cm}) = 0.41 \times Age\) (years) + 58.04 in females, respectively. The prevalence of hypertension, dyslipidemia, and hyperglycemia was 52%, 37%, and 14% in males and 27%, 11%, and 7% in females. A cluster of metabolic abnormalities was found in 28% of males and 9% of females.

The crude sample number of males who were 30 and 60 years old was 40 and 125, whereas the corresponding sample number in females was 23 and 20, respectively. The crude prevalence of hypertension, dyslipidemia, and hyperglycemia was 13%, 20%, and 0% in 30-year-old males, 70%, 41%, and 22% in 60-year-old males, 9%, 4%, 0% in 30-year-old females, and 40%, 15%, 15% in 60-year-old females, respectively. The crude prevalence of a cluster of metabolic abnormalities was 0%, and 42% in 30- and 60-year-old males, and 0% and 10% in 30- and 60-year-old females.

**Waist Circumference and Risk of Accumulating Metabolic Abnormalities**

We divided the WC dataset of each sex into octiles to evaluate the association of WC and the prevalence of metabolic abnormalities. As shown in Fig. 1A, those with higher WC levels were more likely to have accumulating metabolic abnormalities both in males and in females. The prevalence of metabolic abnormalities, however, increased in an almost linear fashion as WC levels were elevated, which did not provide any clear threshold above which the prevalence would increase sharply.

We subsequently integrated male and female subgroups into one model and investigated OR for a cluster of metabolic abnormalities. As a result, males had a higher risk than females with similar WC; males with a similar risk to females had smaller WC (Fig. 1B). The multivariate logistic regression model, into which WC and sex variables were entered, showed that WC and male sex were independently associated with a cluster of metabolic abnormalities; their adjusted ORs were 1.09 [1.08, 1.10] in 1 cm increments and 2.38 [1.85, 3.05] relative to females, respectively. There was no significant interaction effect between the two variables (\(p=0.368\)). These findings mean that the risk posed by the sex difference (OR=2.38) was equivalent to that of 10 cm WC difference (OR=1.09\(^{10}\)). Fig. 1C shows the association of the WC and the sex-specific probability of a cluster of metabolic abnormalities.

A further investigation found, however, that this conversion of the sex difference to WC was not always 10 cm but was dependent on age. In the logistic regression model into which age as well as WC and sex variables were entered, there were not only significant associations of all the three variables with a cluster of metabolic abnormalities (\(p<0.001\) in each vari-
WC was not determined to be one constant value independent of age but rather varied by age. The model showed that the OR of WC in 1 cm increments...
was expressed as \( \text{Exp}(0.191 - 0.0022 \times \text{Age}) \), suggesting that the OR of WC decreased with age. For example, the OR of WC in the 60-year-old population was calculated to be \( \text{Exp}(0.191 - 0.0022 \times 60) \), that is, 1.06 in 1 cm increments. On the other hand, the ORs in 54- and 30-year-old populations were calculated to be 1.10 and 1.13, respectively. Given that the OR of males relative to females was 2.31 in this model, the risk posed by the sex difference was equivalent to that of 14, 9, and 7 cm WC difference in 60-, 45-, and 30-year-old populations, respectively.

The sex difference in the association of WC with the risk of metabolic abnormalities was also demonstrated by the use of probit analysis. In the bivariate model, WC and sex variables both had significant associations (\( p < 0.001 \)) and the number of metabolic abnormalities \( n \) was given as follows: \( \Phi^{-1}(p = n/3) = 0.038 \times WC + a \), where \( \Phi^{-1}(p) \) was the inverse function of the cumulative standard normal distribution, and \( a = -3.67 \) or \( -4.05 \) if the subject was male or female. Sex difference therefore carried the same risk as \( |(-3.67) - (-4.05)|/0.038 = 10 \) cm of WC difference. The WC cutoff values corresponding to having more than one metabolic abnormality was calculated to be 84 cm in males and 94 cm in females. However, when age was additionally entered into the model, the WC cutoff values were here again found to be dependent on age. All three variables had significant associations with a cluster of metabolic abnormalities independently of one another (\( p < 0.001 \) in each variable), and there was a statistically significant interaction effect between WC and age (\( p < 0.001 \)).

The model was given as follows: \( \Phi^{-1}(p = n/3) = 0.057 \times WC + 0.064 \times \text{Age} - 0.0050 \times WC \times \text{Age} + b \), where \( b = -6.29 \) or \( -6.66 \) if the subject was male or female. The male and female WC cutoff values were therefore calculated to be 93 cm and 102 cm in the 30-year-old population, 87 cm and 97 cm in the 45-year-old population, and 75 cm and 89 cm in the 60-year-old population, respectively.

**Association between Waist Circumference and BMI**

Fig. 2A shows the association between WC and BMI. There was a strong correlation both in males \( (r = 0.851, \ p < 0.001) \) and females \( (r = 0.867, \ p < 0.001) \). Linear regression equations determined that WC corresponding to BMI of 25 and 30 kg/m² were 87 and 103 cm in males, and 85 and 101 cm in females, with their sex difference as small as 2 cm. Using these WC levels as cutoff values provided statistically significant OR for a cluster of metabolic abnormalities; the WC cutoff values corresponding to 25 and 30 kg/m² of BMI gave OR of 3.06 [2.59, 3.63] and 4.33 [2.63, 7.12] in males, and 4.64 [2.93, 7.36] and 7.66 [2.84, 20.7] in females, respectively.

Further investigations provided, however, two important indications. First, we investigated the influence of age and found that different age groups had different associations of WC with BMI (Fig. 2B). The subsequent linear regression model adjusted for age also affirmed this age-dependent association and the equations were given as follows: \( BMI = 0.324 \times WC - 0.048 \times \text{Age} - 0.842 \) in males and \( BMI = 0.333 \times WC - 0.036 \times \text{Age} - 1.639 \) in females. From these equations, WC corresponding to BMI of 25 kg/m² in 30- and 60-year-old populations were, for example, calculated to be 84 and 89 cm in males, and 83 and 86 cm in females, respectively.

Second, the calculation of OR at various WC levels revealed that the statistical significance of OR was not limited by these WC cutoff values corresponding to BMI of 25 and 30 kg/m² but that a wider range of WC levels gave statistically significant OR. As shown in Fig. 2C, every WC cutoff value within the range of 68-118 cm in males and 64-113 cm in females gave OR which was significantly larger than 1.00. Note that the lower limits of those ranges (68 cm in males and 64 cm in females) were far below the WC levels corresponding to BMI of 22 kg/m², the optimal BMI for Japanese population (77 cm in males and 76 cm in females). Furthermore, simulated population models with various WC distributions or of various age groups, as well as the categorization of the studied population by age, showed that the OR generated by a certain WC cutoff value differs from population to population (Fig. 3 and 4).

**ROC Curves of Waist Circumference for Clustering Metabolic Abnormalities**

Fig. 5A shows the ROC curves of WC for a cluster of metabolic abnormalities; the area under the curves and their 95% CI were calculated to be 0.693 [0.672, 0.714] in males and 0.775 [0.727, 0.824] in females. The optimal WC cutoff values providing the smallest value of the square root of \( [(1 - \text{sensitivity})^2 + (1 - \text{specificity})^2] \) were 85 cm in males and 79 cm in females, where the male cutoff value was 6 cm larger than the female value.

Simulated population models, as well as the categorization of the studied population by age, however, demonstrated a variety of ROC curves and WC cutoff values. As shown in Fig. 5B, different WC distributions generated different ROC curves and different WC cutoff values. Furthermore, different age groups also generated different ROC curves and different WC...
values in accordance with a unified standard is one of the major healthcare issues that have been long discussed. WC cutoff values could vary partially by the site where WC was measured19-23, and IDF proposed in their diagnostic criteria that WC should be measured.

### Discussion

The establishment of ethnic-specific WC cutoff values (Fig. 5C and D).

**Fig. 2.** Association of waist circumference with BMI.  
A: Sex-specific scatterplots of waist circumference (WC) and BMI. Shaded solid lines represent regression lines, whereas dotted lines show the correspondence of WC to BMI of 25 kg/m² and 30 kg/m². B: Sex-and age-specific scatterplots of WC and BMI. Both males and females were divided into two subgroups: younger (under the median age: 52 years in males and 47 years in females) and older (the median age and over). Dotted and solid lines represent the regression lines of the younger and older groups, respectively. C: The odds ratio given by each cutoff value of WC for a cluster of metabolic abnormalities. Solid line represents the odds ratio which subjects with WC equal to and higher than a certain WC cutoff value had in comparison to those with lower WC. Dotted lines show 95% confidence interval of the odds ratio.
Reassessment of Waist Circumference

Different statistical procedures and different clinical settings could generate different cutoff values, although few previous data measured in a determined and unified way. However, the variety of WC cutoff values could arise not merely from the variety of measurement sites, but also from the different analytic grounds. Different statistical procedures and different clinical settings could generate different cutoff values, although few previous data

Fig. 3. The OR given by each cutoff value of waist circumference (WC) for the risk of a cluster of metabolic abnormalities in populations with varied WC distributions. The following three WC distributions were simulated: a left shift by 5 cm from the original study distribution (A), a normal distribution with the mean and SD equal to those of the original population (B), and a right shift by 5 cm from the original distribution (C). Bold solid lines represent the simulated OR, whereas bold and narrow dashed lines represent 95% confidence intervals of the OR with the simulated sample size $n=1,000$ and $n=10,000$. 
Fig. 4. The OR given by each cutoff value of waist circumference (WC) for the risk of a cluster of metabolic abnormalities in populations with varied age.

A and C: The studied male (A) and female (C) population were divided into two subgroups: younger (under the median age: 52 years in males and 47 years in females) and older (the median age and over). Solid line represents the odds ratio which subjects with WC equal to and higher than a certain WC cutoff value had in comparison to those with lower WC. Dotted lines show 95% confidence interval of the odds ratio. B and D: The following three age groups in males (B) and females (D) were simulated: a 30-, 45-, and 60-year-old populations. Bold solid lines represent the simulated OR, whereas bold and narrow dashed lines represent 95% confidence intervals of the OR with the simulated sample size $n=1000$ and $n=10,000$. 
Fig. 5. ROC curves of waist circumference for a cluster of metabolic abnormalities.
A: Sex-specific ROC curves in the original study population. B: ROC curves in the simulated populations with varied distributions of waist circumference (WC), namely, 1) normal distribution with the mean and SD equal to those of the original study population (solid line), 2) right shift by 5 cm from the original distribution (bold line), and 3) left shift by 5 cm from the original (dashed line). C: ROC curves in the younger and older subgroups of the original study population. Younger subgroups were under the median age (52 years in males and 47 years in females), whereas older subgroups were of the median age or over. D: ROC curves in the simulated 30-, 45-, and 60-year-old populations, represented by bold, solid, and dashed lines, respectively. Open circles in A, B, C, and D represent the cutoff values where the square root of $\sqrt{((1 - \text{sensitivity})^2 + (1 - \text{specificity})^2)}$ reached the smallest value in each population.
have focused on this important issue. We investigated in the current study whether different statistical grounds would generate only one WC cutoff value in Japanese population.

To assess the influence of statistical procedures on derived cutoff values, we first performed risk analyses (Fig. 1), which are a familiar approach to determine the cutoff point of a continuous variable in many clinical settings. The analyses in the current field, however, could not detect any clear WC threshold above which the risk of accumulating metabolic abnormalities would increase sharply. We subsequently explored WC cutoff values corresponding to a certain probability of the risk. As a result, both logistic regression model and probit model demonstrated that females had larger WC than males when they had the same probability of the risk. For instance, WC corresponding to the risk of having more than one metabolic abnormality was calculated to be 84 cm in males and 94 cm in females (Table 1). The current risk analyses also revealed that age had a significant influence on the association of WC with the risk, indicating that WC cutoff values corresponding to a certain probability of the risk could vary by age group.

The second statistical approaches we employed were the assessment of the association with BMI (Fig. 2), by which Western WC cutoff values were originally developed. As is well known, their WC corresponding to 25 and 30 kg/m² of BMI was calculated to be 94 and 102 cm in males, and 80 and 88 cm in females, whose validity as cutoff values was later supported by their provision of statistically significant OR for accumulating metabolic abnormalities. On the basis of these observations, these WC values were conclusively employed as cutoff values in Europe as well as the United States, and they were passed to the IDF worldwide definition. In our current study, similarly significant OR were obtained using the WC corresponding to 25 and 30 kg/m² of BMI in the Japanese population. The sex difference of the WC cutoff values was, however, only about 2 cm (Fig. 2A), which was much smaller not only than that of Europeans (14 cm), but also than that of IDF’s “Asian values” (10 cm). Furthermore, we revealed that age had a significant influence on the association between WC and BMI (Fig. 2B); the older group had larger WC than the younger group when they had the same BMI. Given that the aging process brings about many changes in body composition, including an increased percent body fat, these observations are not surprising. We also found that statistically significant OR were given not only by these limited WC levels but also other WC levels within a wide range (Fig. 2C). Additionally, the OR could vary by WC distribution and age of the studied population (Fig. 3 and 4). Evaluating the statistical significance of the OR, therefore, might support the validity of the WC cutoff values corresponding to a certain BMI level, but could not support their superiority to other corresponding values.

The third and last statistical approaches we employed were ROC curves (Fig. 5). After the WC cutoff values were established in Western countries, other ethnic groups used these statistical procedures to argue the inadequacy of applying these Western cutoff values to their ethnic population and the necessity of providing unique cutoff values for their population. In light of these historical lessons, we also drew ROC curves, which revealed that the male cutoff value was in turn larger than the female value (Fig. 5A). However, these WC cutoff values again could vary by the clinical setting of the studied population, because ROC curves of a test value for a risk could generally depend both on the distribution of the test value and on the association of the test value with the risk. In the current study, we demonstrated that age had a significant influence on the association of WC with the risk, as well as a significant association with WC itself, and therefore it was no surprise that different age groups produced different ROC curves (Fig. 5C and D). In addition, our simulated population models demonstrated that the ROC curves varied simply by WC distribution (Fig. 5B). As is well known, WC distribution can vary by area and community, even in one ethnic population. Although no precise data are so far available about prefectural differences in WC distribution in Japan, recent national surveys revealed that mean BMI also varied by prefecture from 22.3 to 24.3 kg/m² and that the prevalence of overweight (BMI ≥ 25 kg/m²) in each prefecture ranged

### Table 1. Different cutoff points of waist circumference on different statistical grounds

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<td>Risk analysis</td>
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<td>Association with BMI</td>
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Data are the cutoff points of waist circumference in the study population on different statistical grounds. In the risk analysis (top), the cutoff point presented in the table corresponded to having more than one of three metabolic abnormalities, which was obtained from probit analysis. In the analysis of the association with BMI (middle), the cutoff values corresponded to 25 kg/m² BMI. In the ROC-curve analysis (bottom), the cutoff values were those with the smallest value of [(1 − sensitivity)² + (1 − specificity)²]⁰.⁵.
from 19.5% to 46.7% in males and from 15.8% to 39.4% in females. It could be safely expected from these national observations that there is a considerable prefectural variation of WC distribution in Japan. WC distribution can also vary across years, which means that community-specific WC cutoff values should be updated continuously.

All of these three statistical observations in the current study (Fig. 1 to 5) showed that different statistical procedures could generate different cutoff values in one ethnic population (Table 1). WC cutoff values derived from the association with BMI had little sex difference, whereas risk analyses found that females had a larger WC cutoff point than males. In contrast, ROC curves demonstrated that male cutoff values were larger than female values. WC cutoff values on one statistical ground cannot be used as a substitute for those from another statistical ground. To establish a worldwide, trans-ethnic diagnostic tool of metabolic syndrome, it would be essential to determine ethnicspecific WC cutoff values using a unified statistical procedure. Otherwise, the diagnostic definition would only lead to clinical confusion, rather than achieving the IDF’s original goal, that is, easy comparison among different countries.

Furthermore, our current study suggests that different clinical settings could generate different cutoff values. We revealed that statistically “optimal” cutoff values of WC could vary by age when any of the three statistical procedures was employed. WC cutoff values could also vary simply by WC distribution, especially when ROC curves were used. When one simple sex-specific WC cutoff value is proposed regardless of age and WC distribution in a population, it is important to be aware that the WC cutoff value is the representative value derived from a certain population in a certain clinical setting of the ethnic group.

Conclusion

Different statistical analyses based on different hypotheses and different clinical settings could generate different “optimal” cutoff values. If one plans to establish a unified trans-ethnic diagnostic tool of metabolic syndrome, ethnicspecific WC cutoff values should be primarily provided based on a unified statistical ground.

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