

Waist circumference cutoff point determination for defining metabolic syndrome in type 2 diabetes mellitus in Ethiopia

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ARTICLE INFO

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Key words:

cutoff point, diabetes mellitus,
metabolic syndrome,
waist circumference

ABSTRACT

Background

Metabolic syndrome (MetS) is a complex disorder characterized by a cluster of interrelated cardiovascular risk factors. So far, cutoff point variability of waist circumference was documented to define MetS.

Objective

To determine the classification power and cutoff point of waist circumference to define MetS among patients with type 2 diabetes.

Methods

An institution-based cross sectional study was conducted from March to April 2017 at Ayder Comprehensive Specialized Hospital among patients with type 2 diabetes. Using systematic sampling technique, 520 participants were enrolled into the study. Data were collected by checklist, anthropometric measurements and biochemical analyses. Data were entered to Epi-info 3.5.1 and transferred to SPSS 20 for analysis. Participants having more than one abnormal MetS components were categorized as patients and the

others were considered as control. The classification power of waist circumference to distinguish patients from controls was determined by ROC curve analysis. Waist circumference cutoff points were determined by taking the point that had a maximum youden index.

Results

Among the 520 participants, 308 (59.2%) were females. The mean age of the participants was 56 ± 10.8 years for males and 55 ± 11.4 years for females. The classification power of waist circumference was 0.67 (0.58-0.75) for male and 0.63 (0.52-0.73) for females. The optimal waist circumference cutoff point to distinguish patients from controls were 95.5 cm (sensitivity 39.8%, specificity 86.3%, $p < 0.001$) for males, and 87.5 cm (sensitivity 73.1%, specificity 54.5%, $p < 0.017$) for females.

Conclusion

The positive predictive value of waist circumference was 93% for females and 90% for males in Northern Ethiopia using 87.5 and 95.5 cm points cut-off for females and males, respectively.



INTRODUCTION

Metabolic syndrome (MetS) is a complex disorder characterized by a cluster of interrelated factors that increase the risk of cardiovascular disease (CVD). In type 2 diabetic patients (T2DM) and those with other non-communicable diseases (1), MetS increases the complication rate (2).

Various international organizations are using five parameters including elevation of waist circumference (WC), blood pressure (BP), triglycerides (TG), fasting blood glucose (FBG), and reduced HDL-C level to define MetS (3).

Elevated WC is characterized by the accumulation of fat in the visceral part of the abdomen and plays a central role in the pathogenesis of MetS (4).

To precisely assess the visceral fat volume, abdominal computed tomography (CT) has been considered as the most accurate and reproducible technique (5). However, CT scans are costly and time consuming (6). Because of this limitation, a variety of alternative methods are applied to assess abdominal obesity.

Waist to hip ratio and WC are correlated with abdominal imaging. Among them, WC is considered to be simple and inexpensive measure with excellent correlation with the CT results (7). In addition, it is used to define MetS based on various international criteria and different scholars indicted that WC appears to be the best central obesity indicator than BMI and waist to hip ratio (8).

Many organizations and expert groups recommend WC as one of the criteria to define MetS. International Diabetes Federation (IDF), particularly, needs elevation of WC as an obligatory criterion with a different cutoff point in accordance with ethnicity and gender. Recent publications report that WC cutoff point is quite variable among different ethnic groups and between genders. However, based on ethnicity and gender, until now, the IDF established WC cutoff point for the general populations for two regions only to define MetS, for the European and Asian populations.

In this regard, the African region has no cutoff point for WC to define MetS yet (9). A number of studies support the necessity of locality based WC cutoff points. Consequently, this study aimed to determine WC cut points among T2DM patients in Ayder Comprehensive Specialized Hospital (ACSH), Northern Ethiopia.

MATERIALS AND METHODS

Samples and design

An institution based cross-sectional study was conducted among T2DM patients from March to April 2017 in ACSH. Five hundred twenty participants were selected based on systematic random sampling techniques.

Data collection

Data were collected on the basis of self-administered standardized questionnaires and the measurement of anthropometric, blood pressure and biochemical parameters. A self-administered standardized questionnaire was customized on the basis of the WHO STEP wise approach to non-communicable disease risk factor surveillance (10).

Measurements

Blood pressure was measured after the participants had rested for at least 5 minutes. The measurements were taken using left arm at the heart level, using BP monitor MB 300-D digital instrument. In each case, the mean of two results was used for analysis (11).

BMI was calculated as weight (kg) divided by height squared (m²). WC was taken by positioning the non-elastic measuring tape midway between the lower rib margin and the iliac crest. It was measured to the nearest 0.5 cm (12). Fasting (8 to 12 hour) 5 mL venous blood was also collected in clot activated test tubes. Serum was separated within 30 minutes (2000 rpm, 5 minutes). FBG, TG and HDL-C were determined using a Pentra C400 clinical chemistry analyzer.

Data analysis and interpretation

The data were entered into EpiData 3.1 and then transferred to SPSS version 20. Data cleaning was done before analysis, descriptive and summary statistics were also performed. Participants who had one or more abnormal MetS components

(excluding WC and FBS), were coded as case and the others as control (9, 13). The classification potential (AUC) of WC to distinguish cases from control was determined using ROC curve for both sexes separately. Sensitivity and specificity of WC to distinguish cases from controls was calculated at several WC points. For each WC point Youden index (YI) was calculated. The WC points, having the maximum YI was taken as the optimum cutoff point of WC to classify case from controls. In all conditions, *P*-value of < 0.05 was considered as statistically significant.

RESULTS

Among the 520 participants, 308 (59.2%) were females. The mean (\pm SD) ages of the participants were 56 ± 10.8 and 55 ± 11.4 years for males and females, respectively. A majority of the participants, 457/520 (87.9%), were from the urban area (Table 1).

The mean duration of diabetes co-morbidity after diagnoses was 4.7 ± 2.9 years for males and 4.6 ± 2.5 years for females. All of the study participants are taking anti-diabetic drugs. Seventy two (35%) male and 144 (46.8%) female participants were overweight and obese (Table 2).

Four hundred thirty six patients were investigated for MetS (275 females and 161 males). Reduced HDL-C was the most typical abnormal component of MetS in both genders, it was present in 221 (42.5%) patients. High blood pressure was detected in 157 patients (30.2%) (Table 3).

The classification power of WC to define MetS was characterised by AUC. The value of AUC was 0.67 (95% CI, 0.58-0.75) for males and 0.63 (95% CI, 0.52-0.73) for females, respectively (Figure 1).

The classification power of WC to define the reduced HDL-C was lower as compared to the other MetS components in both sexes (0.60 in males and 0.53 in females) (Table 4).

Among men, WC at a cut-off value of 95.5 cms yielded the highest YI (0.261) with a corresponding sensitivity of 39.8% and specificity of 86.3%.

For women, the WC at a cut-off value of 87.5 cms yielded the highest YI (0.276) with a sensitivity of 73.1% and specificity of 54.5 % (Table 5).

Table 1 Socio-demographic characteristics of patients with diabetes mellitus at Ayder Comprehensive Specialized Hospital, Northern Ethiopia, 2017 (N=520)

| Variables | | Male n (%) | Female n (%) | Total N (%) |
|----------------|------------------|---------------|-----------------|----------------|
| Age (years) | 30-39 | 11 (5.2) | 18 (5.8) | 29 (5.6) |
| | 40-49 | 45 (21.2) | 81 (26.3) | 26 (24.2) |
| | 50-59 | 8 (36.8) | 95 (30.8) | 173 (33.3) |
| | 60-69 | 55 (26.0) | 76 (24.7) | 131 (25.2) |
| | ≥ 70 | 23 (10.8) | 38 (12.4) | 61 (11.7) |
| Occupation | Governmental | 80 (37.7) | 68 (22.1) | 148 (28.5) |
| | Non-governmental | 19 (9.0) | 13 (4.2) | 32 (6.1) |
| | Self employee | 68 (32.0) | 56 (18.2) | 124 (23.8) |
| | House wife | 0 (0.0) | 128 (41.5) | 128 (24.6) |
| | Farmer | 22 (10.4) | 11 (3.6) | 33 (6.35) |
| | No | 23 (10.9) | 32 (10.4) | 55 (10.6) |
| Marital status | Single | 17 (8.0) | 9 (6.2) | 36 (6.9) |
| | Married | 181 (85.4) | 212 (68.8) | 393 (75.6) |
| | Divorced | 8 (3.8) | 19 (6.2) | 27 (5.2) |
| | Widowed | 6 (2.8) | 58 (18.8) | 64 (12.3) |
| Ethnicity | Tigris | 208 (98.1) | 305 (99.0) | 513 (98.6) |
| | Other | 4 (1.9) | 3 (1.0) | 7 (1.4) |

| | | | | |
|-------------------|------------------------------|------------|------------|------------|
| Educational level | No formal schooling | 29 (13.7) | 79 (25.7) | 108 (20.7) |
| | Less than Primary school | 14 (6.6) | 43 (13.9) | 57 (10.8) |
| | Primary school completed | 47 (22.2) | 60 (19.5) | 107 (20.6) |
| | Secondary school completed | 38 (17.9) | 53 (17.2) | 91 (19.0) |
| | College/University completed | 84 (39.6) | 73 (23.7) | 157 (28.9) |
| Residence | Rural | 29 (13.7) | 34 (11.1) | 63 (12.2) |
| | Urban | 183 (86.3) | 274 (88.9) | 457 (87.8) |
| Religion | Orthodox | 191 (90.1) | 288 (93.5) | 479 (92.1) |
| | Muslim | 18 (8.5) | 18 (5.8) | 36 (6.9) |
| | Other | 3 (1.4) | 2 (0.7) | 5 (1.0) |

Table 2 Frequency of clinical, behavioral and anthropometric measurements of T2DM patients at Ayder Comprehensive Specialized Hospital, Northern Ethiopia, 2017 (N=520)

| Variables | | Male n (%) | Female n(%) | Total N (%) |
|---|-------------------------------------|---------------|----------------|----------------|
| Medication status | Anti-DM Only | 123 (58.0) | 170 (55.2) | 293 (56.3) |
| | Anti-DM +Anti-HT | 34 (16.0) | 27 (8.8) | 61 (11.7) |
| | Anti-DM +Anti-Dyslipidemia | 25 (11.8) | 58 (18.8) | 83 (16.0) |
| | Anti-DM + HT + Anti-Dyslipidemia | 30 (14.2) | 53 (17.2) | 83 (16.0) |
| Duration of diabetes comorbidity (Yrs) | Less than one year | 20 (9.4) | 25 (8.1) | 45 (8.7) |
| | 1-5 years | 101 (47.6) | 154 (50.0) | 255 (49.0) |
| | 6-10 years | 39 (18.4) | 75 (24.4) | 114 (21.9) |
| | More than10 years | 52 (24.5) | 54 (17.5) | 106 (20.4) |

| | | | | |
|---------------------|---------------|------------|------------|------------|
| Alcohol consumption | Yes | 46 (21.7) | 14 (4.5) | 60 (11.5) |
| | No | 166 (78.3) | 294 (95.5) | 460 (88.5) |
| Cigarette Smoking | Yes | 5 (2.4) | 0 (0.0) | 5 (1.0) |
| | No | 207 (97.6) | 308 (100) | 515 (99.0) |
| BMI | Under weight | 11 (5.0) | 10 (3.2) | 21 (4.0) |
| | Normal weight | 129 (60.0) | 154 (50.0) | 283 (54.5) |
| | Over weight | 65 (31.7) | 116 (37.7) | 181 (34.8) |
| | Obese | 7 (3.3) | 28 (9.1) | 35 (6.7) |

DM: diabetic mellitus; HT: hypertension.

Table 3 Frequency of individual components of MetS among T2DM patients in Ayder Comprehensive Specialized Hospital, Northern Ethiopia, 2017 (n=520)

| Variables | Male | | Female | | Total (N%) |
|-----------|------------|-----------|------------|-----------|------------|
| | n (%) | 95 % CI | n (%) | 95 % CI | |
| High TG | 79 (37.3) | 30.7-44.0 | 134 (56.5) | 37.1-49.0 | 213 (40.9) |
| high BP | 75 (35.4) | 28.9-42.3 | 82 (26.6) | 21.2-31.3 | 157 (30.2) |
| low HDL-C | 116 (54.7) | 47.6-61.7 | 105 (34.1) | 20.6-47.6 | 221 (42.5) |

Clusters of abnormal components

| | | | | | |
|-----------------------|------------|-----------|------------|-----------|------------|
| At least 1 component | 161 (75.9) | 70.2-81.6 | 275 (89.3) | 85.4-92.4 | 436 (83.8) |
| At least 2 components | 78 (36.8) | 30.7-43.5 | 131 (42.5) | 36.7-47.7 | 209 (40.2) |
| At least 3 components | 57 (26.9) | 20.6-32.9 | 99 (32.1) | 27.3-37.2 | 156 (30.0) |
| All components | 26 (12.3) | 7.9-16.7 | 45 (14.6) | 11.0-19.2 | 71 (13.6) |

BP: Blood Pressure; HDL-C: High density lipoprotein cholesterol; TG: Triglyceride.

Figure 1 ROC curves of WC cutoff value to discriminate cases from controls among T2DM patients for both sexes in Ayder Comprehensive Specialized Hospital, Northern Ethiopia

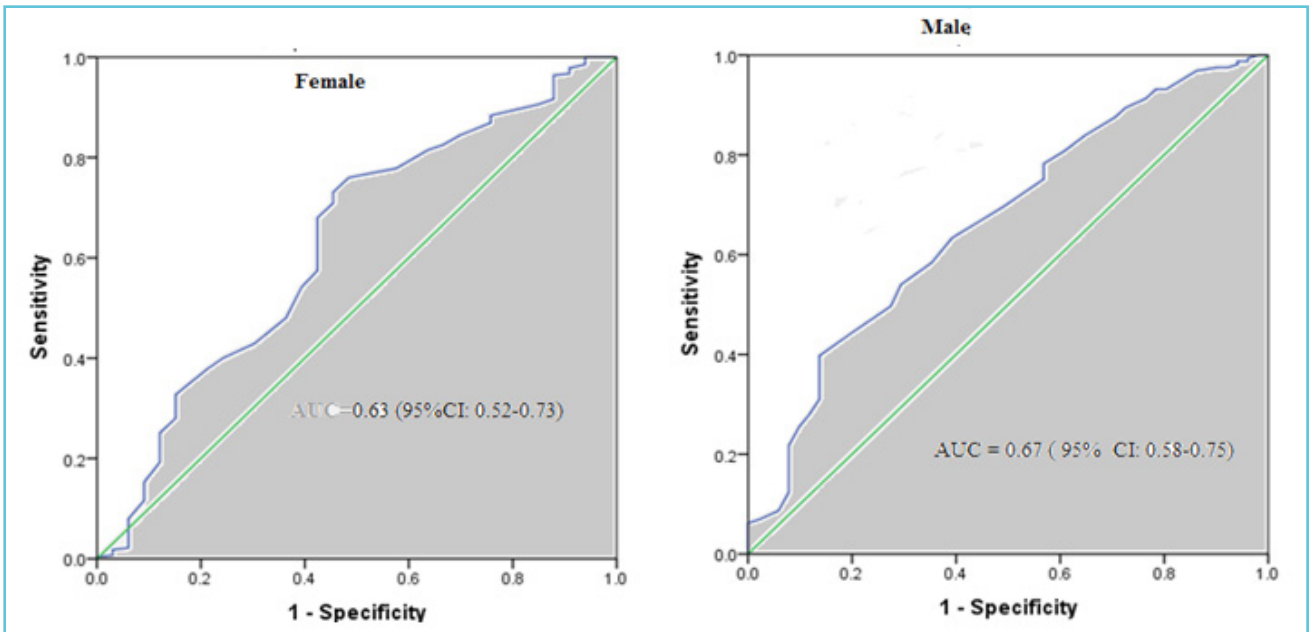


Table 4 Characteristics of AUC value of the ROC curves WC to define cases and MetS components among T2DM patients in Ayder Comprehensive Specialized Hospital, Northern Ethiopia, 2017 (N=520)

| Sex | MetS components | AUC (95% CI) | Sensitivity | Specificity | P value |
|--------|----------------------|-----------------|-------------|-------------|---------|
| Male | Hypertension | 0.67 (.60 -.75) | 0.51 | 0.76 | ≤0.001 |
| | Hypertriglyceridemia | 0.67 (.60 -.74) | 0.49 | 0.76 | ≤0.001 |
| | Low HDL-C | 0.60 (.52 -.67) | 0.39 | 0.73 | 0.013 |
| | Cases | 0.67 (.58 -.75) | 0.40 | 0.86 | ≤ 0.001 |
| Female | Hypertension | 0.63 (.56 -.70) | 0.79 | 0.33 | 0.001 |
| | Hypertriglyceridemia | 0.57 (.52 -.65) | 0.75 | 0.34 | 0.010 |
| | Low HDL-c | 0.53 (.44 -.61) | 0.72 | 0.59 | 0.017 |
| | Cases | 0.63 (.52-.73) | 0.73 | 0.45 | 0.01 |

Table 5 Performance of different WC cutoff-points for discriminating patients from controls among T2DM patients at Ayder Comprehensive Specialized Hospital, Northern Ethiopia, 2017 (N=520)

| Sex | WC cutoff points (cm) | Sensitivity (95%CI) | Specificity (95%CI) | PPV (95%CI) | NPV (95%CI) | Youden index |
|-----------------|-----------------------|---------------------|---------------------|-------------|-------------|--------------|
| Male (n=212) | 90 | 63.4 | 60.8 | 83.6 | 34.4 | 0.242 |
| | 92 | 54.4 | 70.6 | 85.3 | 32.7 | 0.250 |
| | 94 | 44.1 | 80.4 | 87.7 | 31.3 | 0.245 |
| | 95.5 | 39.8 | 86.3 | 90.1 | 31.2 | 0.261 |
| | 98 | 27.9 | 88.2 | 88.2 | 27.9 | 0.161 |
| | 100 | 21.7 | 92.2 | 89.7 | 27.2 | 0.139 |
| Female (308) | 80 | 88.4 | 24.2 | 87.3 | 20.0 | 0.126 |
| | 82 | 84.4 | 30.3 | 91.0 | 18.9 | 0.147 |
| | 85 | 81.4 | 36.4 | 91.4 | 19.0 | 0.178 |
| | 87.5 | 73.1 | 54.5 | 93.0 | 19.6 | 0.276 |
| | 88 | 70.9 | 54.5 | 92.8 | 18.4 | 0.254 |
| | 90 | 61.8 | 57.6 | 92.4 | 15.3 | 0.194 |

CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value.

DISCUSSION AND CONCLUSIONS

Central obesity is the major component of metabolic risk factors. WC is considered to be simple and inexpensive measure with excellent correlation with the results of CT. As a good indicator of visceral fat, WC is widely used to predict the outcome of MetS. WC cutoff values are age, gender and ethnicity specific for MetS.

Therefore, in the current study, WC had classified patients from controls with statistically

significant power for both sexes (P-value <0.001 and <0.017 for males and females, respectively), but it had a poor classification power to categorize patients from controls in both sexes. The optimal WC cutoff value was 87.5 cm (sensitivity 73.1% and specificity 54.5%) for females and 95.5 cm (sensitivity 39.8% and specificity 86.3 %) for males for identifying patients from controls.

Even though the classification power of WC was statistically significant, it had poor classification

power for males (AUC=0.67; 95% CI: 0.58-0.75), and for females (AUC =0.63; 95% CI 0.52-0.73) to discriminate cases from controls (14). Similar to our study, the classification power of WC to classify patient from control was poor in a study conducted in Benin, where, the AUC was 0.67 for males and 0.68 for females (15). Moreover, in Egypt it was also 0.69 for males and 0.63 for females (16).

On the contrary, in several studies such as in Angola (0.85 in males and 0.79 in females) (17), and in Congolese adults (0.899 in males and 0.844 in females) (18), WC had a good classification power to classify patient from control in both sexes.

In our study, the optimal WC cutoff point that best predicts cases was 95.5 cm for the T2DM males, which is relatively higher than the value for females. The finding from the present study is slightly higher than the IDF recommended value for males, which is 94 cm (9).

In contrast to our study, WC cutoff point in urban African teachers was 90 cm in men (19) and the same to that in black South African T2DM male patients were also 90 cm (20). These values were somewhat different to that found in T2DM male patients in our study area.

The WC cutoff value for T2DM females determined in this study is 87.5 cm which is similar to the study in University employees in Angola (87.5 cms) (21).

The result from this study was higher than the recommended cutoff points to define cases for African females, which is ≥ 80 cms. Whereas our finding is lower than the study conducted with African females, which was 98 cm (19) and a study from Egyptian adults (96.25 cms) (16).

The present study suggested that the WC cutoff point for females is lower than males, which is in agreement with the recommended value.

Some studies show that the WC cutoff point for African populations is higher in rural South African females (92 cms) than males (86 cms) (22), in Cape Town 94 cm for females and 83.9 cm for males (23).

Similarly, in Benin, the cutoff is 94 cm for females and 80 cm for males, which is the exact reverse of the recommended value (24). Furthermore, a study in Congolese community also shows higher WC value for females (99 cms) compared to the males (95 cms) (18).

In general, several studies in Africa that determined WC cutoff points showed a higher WC value in females as compared to males. On the contrary, our finding is higher in males than females, which is in agreement with the IDF.

On the other hand, a study from Tunisian adults showed equal value of WC for both males and females which was 85 cm (25). Although the WC value in adult Egyptian females (96.2 cms) wasn't higher than males (100.5 cms), it is higher than the IDF recommended value for African females (16).

Further study in prospective cohort is better to determine the optimal WC cutoff point among T2DM patients to define MetS. In addition, studies which can consider the confounders such as lipid lowering medications, age of the participants and duration of diabetes are advisable in order to increase the classification power of WC.



List of abbreviations

AUC: Area Under the Curve

BMI: Body Mass Index

BP: Blood Pressure

CT: Computed Tomography

CV: Cardiovascular

CVD: Cardiovascular Disease

FBG: Fasting Blood Glucose

HDL-C: High Density Lipoprotein cholesterol

HT: Hypertensive

IDF: International Diabetes Federation

IR: Insulin Resistance

LDL-C: Low Density Lipoprotein cholesterol

MetS: Metabolic syndrome

NCD: Non Communicable Disease

NCEP/ATPIII: National Cholesterol Education
Program Adult Treatment Panel III

NT: Normotensive

ROC: Receiver Operating Characteristics

T₂DM: Type two Diabetes Mellitus

TG: Triglyceride

VAT: Visceral Adipose Tissue

WC: Waist Circumference

WHO: World Health Organization

YI: Youden Index



Ethical issue

Ethical clearance was obtained from the Institutional Review Board of the University of Gondar. The purpose and importance of the study were explained to the participants. The data were collected after a full written consent was received.

Author's contribution

SH conceived the idea, carried out the proposal writing, participated in the data collection, data analysis and drafted the manuscript. TM and MA participated in data analysis and interpretation of the findings. TM participated on final write-up of the paper. All authors reviewed the manuscript and approved for publication.

Conflict of interests

The authors declared no conflict of interests.

Funding

No specific fund for this research work.

Acknowledgments

The authors would like to acknowledge the study participants and the Ayder Comprehensive Specialized Hospital.



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