

Short Communication

Diagnostic value of anthropometric indices for initial stage of atherosclerosis in adult women

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Excess body weight is a cardiovascular risk factor. The relationship between anthropometric indices and cardiovascular health is not completely understood. Carotid Intima-Media Thickness (CIMT) is a subclinical marker of atherosclerosis. This study aimed to investigate the best anthropometric obesity indicator for diagnosis of initial stage of atherosclerosis by CIMT. This cross-sectional study included 100 adult women, aged 18-50 years. Anthropometric indices were measured with standard protocol and CIMT was measured by non-invasive ultrasound. Receiver Operating Characteristics (ROC) curve analysis was carried out to determine the optimal cut-off values of anthropometric indices, and the best indices for atherosclerosis diagnosis. On ROC curve analysis the suggested appropriate cut-offs of waist circumference (WC), waist to hip ratio (WHR), waist to height ratio (WHtR), body mass index (BMI) and percentage body fat (%BF) were 96 cm, 0.86, 0.64, 31.29 kg/m² and 30.42%, respectively. The area under the ROC curve of BMI (AUC=0.74, 95%CI=0.62-0.86) and WHtR (AUC=0.74, 95%CI=0.63-0.85) were greater than other anthropometric indices. The AUC for WHR was the lowest among the studied obesity indices AUC=0.68 (95% CI=0.54-0.81). In our study, WHtR and BMI were the best diagnostic parameters of initial stage of atherosclerosis while WHR was the worst based on AUC.

Key Words: anthropometric indices, atherosclerosis, carotid arteries, cut-off values, ROC analysis

INTRODUCTION

Excess body weight is a cardiovascular risk factor, but it is not clear which anthropometric obesity measure provides the best independent diagnostic value of cardiovascular disease (CVD).¹ Prospective epidemiological studies have shown increased abdominal fat accumulation as an independent risk factor for type 2 diabetes mellitus and CVD, such as coronary artery disease (CAD), stroke, and hypertension.² Although the pathogenesis of atherosclerotic is complex but plays an important role in CVD etiology. The most significant changes in the early subclinical period of atherosclerotic disease is endothelial dysfunction leading to an increased intima-media thickness in all arterial beds.³ A non-invasive ultrasound measurement of carotid wall intima-media thickness (CIMT) is considered as a general marker for atherosclerosis that correlates with the extent of CAD in adults, and predicts future cardiovascular events.⁴ Higher levels of body fat increases the risk of the disease; however, the deposited excess fat appears to have particular implications.^{5,6} For example, a greater concentration of adipose tissue in the abdomen, specifically in the visceral area, is directly related to metabolic and cardiovascular risk in adults.⁷

Various anthropometric indices of obesity have been

suggested to diagnose the risk of CVD and diabetes mellitus. Among them, body mass index (BMI) seems to be the most thoroughly studied index and its relation to cardiovascular risk factors and outcomes have been well elucidated by cross-sectional and prospective studies^{8,9} but it does not reflect body fat distribution and in particular abdominal fat mass. The pattern of body fat distribution has been noted to be a determinant of CVD risk. Accumulation of the fat in the abdominal region is particularly related to an increased risk of CVD.¹⁰ However, there are increasing doubts about the appropriateness of overall obesity index in the diagnosis cardiovascular events, and evidence is mounting for other indices such as waist circumference (WC), waist to hip ratio (WHR), waist to height ratio (WHtR), and ASD (abdominal sagittal diameter).¹¹

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Skinfold thickness is also used as a measure of adiposity,^{12,13} but studies comparing its diagnostic ability to other measures of adiposity have produced inconsistent findings.^{14,15}

As anthropometric indices seems to be easier, cheaper and more available than ultrasound techniques. There are limited studies to introduce indicator of obesity related atherosclerosis particularly among Iranian population. This study aimed to investigate the best anthropometric obesity indicator for diagnosis of the initial stage of atherosclerosis.

MATERIALS AND METHODS

Subjects

This cross sectional study included 100 adult women, aged 18-50 years. Eligible subjects were randomly selected from one of the Tabriz university sub-specialized clinics, which is one of the most important referral clinics where patients are referred to from the entire province. Random selection was performed based on the patients' sequence order using computer randomly generated numbers. This schedule was chosen to avoid selection bias. The sample size was determined based on sensitivity of 96%¹⁶ and specificity of 60%¹⁷ for (WC)-the best indicators of CVD risk factors and abdominal obesity,^{18,19} and 95% confidence level using Dr Lin Naing software.²⁰

Inclusion criteria were to be healthy without known chronic or acute diseases, ie, CVD, diabetes, renal disease, hypothyroidism and hyperthyroidism, as well as taking glucose and lipid lowering or hypertensive medication. Pregnant, breastfeeding and menopausal women, those treated by steroids, growth hormone, oral contraceptives and any anabolic drug, alcohol or drug users, those with renal disorders, diabetes, hypertension and lipid disorders were excluded. The relevant ethics committee of Tabriz University of Medical Sciences granted approval for this research. A questionnaire and informed consent form were completed for the subjects. Systolic and diastolic blood pressures were measured on the right arm after 15 minutes of rest in the sitting position.

Anthropometric measurements

Weight was measured by Seca scales (Germany) to the nearest 100 g with minimal clothing and without shoes. Height was measured in a standing position, without shoes while the shoulders were in a normal position to the nearest 0.5 cm. Waist circumference and hip circumference (HC) were measured using un-stretchable tape in a standing position without applying any pressure to the body's surface, and was recorded to the nearest 0.1 cm. Waist circumference and HC were measured in the middle of the lowest gear and the top of the iliac crest (the most narrow waist circumference) and on the biggest environmental gluteal muscle, respectively. Body mass index was estimated as weight (kg) divided by height (m) squared. Waist to hip ratio was calculated as WC (cm) divided by HC (cm) and WHtR as WC (cm) divided by height (cm). Subcutaneous fat was measured at four regions (biceps, triceps, subscapular, suprailiac) using caliper (Slimguide Model, Creative health, USA). All skinfold measurements were measured three times on the right side of the body and the average was used for analy-

sis. Validity and reliability of anthropometric measurements were assessed separately. To avoid subjective error all measurements were done by the same person.

Body density was estimated with the Durnin and Womersley equation and then body fat (%) was calculated using the Siri's equation as follows:

$$\text{Body fat (\%)} = 495/\text{density} - 450$$

Common carotid IMT

CIMT was measured using non-invasive ultrasound. All images were taken from the right and left common carotid artery. Medison system (model V10) and 10-MHz Linear transducer was used. All images of the right and left common carotid arteries were captured by the same radiologist who had no known clinical condition of the subjects. The participants were asked to lie in the supine position during the ultrasound procedure. Imaging of the left common carotid artery was performed with the subject turning her head 45 degrees to the right and reversely. Imaging was performed in B-mode with transducer movement in longitudinal and latitudinal sections. The transducer was manipulated until maximum thickness in area bolb (1 cm proximal to the common carotid bifurcation) of both carotids were acquired. Then we obtained image with high quality from the desired area in longitudinal section. By placing a marker, measurement was performed electronically by the device. The far-wall IMT was measured at three measurement points on the right and left and finally maximum thickness was recorded on each side. Those with thickness over 1.2 mm were considered as plaque and were excluded from the study. Precision of ultrasound devices was 0.1 mm.

Statistical analysis

All data were analyzed by the SPSS (version 11.5) and STATA (version 10) softwares. Quantitative data were reported as mean±standard deviation (SD). Pearson correlation coefficient was used to determine the relationship between anthropometric indices and mean CIMT. By the receiver operating characteristic (ROC) analysis and considering the optimal combination of sensitivity and specificity, we determined the best cut-off points for anthropometric indices. Likelihood ratios, positive and negative predictive values with 95% confidence intervals (CI) were assessed in each cut-off point levels for diagnosis of initial stages of atherosclerosis. In addition the ROC curve comparison tests were used to identify the best anthropometric indices in detecting the best predictor of CVD events. To determine our binary state variable, CIMT higher than 0.8 mm was defined as "at risk subjects" and CIMT equal and less than 0.8 mm was defined as "healthy subjects".²¹ *P* values <0.05 were considered as significant.

RESULTS

Mean±SD age of subject was 30.9±8.1 years. Anthropometric characteristics and CIMT of subjects are shown in Table 1. After logistic regression analysis, there was no significant relationship between age and CIMT. Also we investigated the relationship between CIMT as dependent variable and some biochemical variables as independent variable, we didn't observe any significant relationships

Table 1. Anthropometric characteristics, CIMT and biochemical factors of subjects

Anthropometric indices	Mean±SD
Weight (kg)	72.9±18.3
Height (m)	1.6±0.05
Waist circumference (cm)	95.9±0.17
Hip circumference (cm)	110±0.12
BMI (kg/m ²)	28.9±7.25
WHR	0.87±0.08
WHtR	0.61±0.11
SUM (biceps, triceps, suprailiac, subscapular)(mm)	68.5±26.0
% Body Fat	31.2±6.08
Right thickness (mm)	0.64±0.16
Left thickness (mm)	0.62±0.16
Mean CIMT (mm)	0.63±0.15
Fasting blood glucose (mg/dL)	89.7±8.96
HgA1C (%)	5.3±0.71
Triglyceride (mg/dL)	110±33.4
HDL (mg/dL)	50.2±8.7
LDL (mg/dL)	103±20.3
Total Cholesterol (mg/dL)	180±26.2
T4 (ng/dL)	7.73±1.66
T3 (ng/dL)	117±29.4
TSH (mIU/mL)	2.4±1.4

BMI, body mass index; WHR, waist to hip ratio; WHtR, waist to height ratio; CIMT, carotid intima media thickness; HgA1C, hemoglobin A1C; HDL, high density lipoprotein; LDL, low density lipoprotein; TSH, thyroid stimulating hormone.

There were no significant relationship between FBS, HgA1C, HDL, LDL, Total Cholesterol, T3, T4 and TSH with CIMT based on logistic regression (All $p>0.05$, data not shown).

between the biochemical variables (Table 1) and CIMT (All $p>0.05$, data not shown).

There were significant correlations between anthropometric indices and mean CIMT except for triceps skin fold thickness. Among the indices, WHtR ($r=0.39$, $p<0.001$) showed the strongest and WHR ($r=0.27$, $p=0.006$) the weakest correlation with mean CIMT.

The AUC of WC, BF (%), BMI, WHR and WHtR showed no significant difference among the diagnostic ability of these variables (χ^2 (df=4) =2.55, $p=0.636$). However, the area under the ROC curve of BMI (AUC=0.74, 95% CI = 0.62-0.86) and WHtR (AUC=0.74, 95% CI = 0.63-0.85) were greater than other anthropometric indices. The AUC for WHR was the lowest among the studied obesity indices AUC=0.68 (95% CI = 0.54-0.81), (Table 2)(Figure 1).

Waist circumference showed the highest sensitivity (99.1%) vs. CIMT, while the sensitivity of BF(%), BMI and WHtR was the lowest (81.8%). Furthermore, BMI and BF (%) revealed the highest and the lowest specificities (66.3%, 49.4%) as well as the highest and the lowest likelihood ratios (2.43, 1.62), respectively. Sensitivity for WC showed that 99.1 % (and 95% CI = 73-100) of at risk subjects (CIMT >0.8 mm) had WC values higher than 96 cm. Specificity for BMI showed that 66.3 % (and 95% CI = 56-75) of healthy subjects (CIMT ≤0.8 mm) had BMI values lower than 31.3. The LR+ (positive Likelihood

Ratio) for BMI showed that in the BMI ≥ 31.3 kg/m² groups, individuals are 2.43 (95% CI = 1.62-3.63) times more likely to be at risk of initial stages of atherosclerosis (CIMT >0.8 mm, true positive) than not to be at risk of initial stages of atherosclerosis (CIMT ≤0.8 mm, false positive). The LR- for BMI showed that the false negative rate is 0.27 (95% CI = 0.08-0.97) times more likely than the true negative rate in the BMI <31.3 kg/m² groups (Table 2).

DISCUSSION

In this study the association between different obesity indices and CVD predictor among healthy women were assessed to determine the best diagnostic parameter for initial stage of atherosclerosis. In our study, WHtR and BMI were the best diagnostic parameters of initial stage of atherosclerosis while WHR was the worst, based on AUC. Epidemiological evidences show that abdominal obesity is a better predictor for CVD than overall obesity. A number of studies have recommended WC as a tool to assess CVD risk^{22,23} while other studies showed that WHR is probably better than BMI and WC in predicting myocardial infarction.²⁴ A study reported WHtR as abdominal index probably better than WHR to predict CVD event in both sexes.²⁵ It seems both WC and HC are positively associated with CVD and therefore their ratio (WHR) represented the weakest association, while WHtR is a simple index to calculate, compared with BMI. Our study suggests that a WC of 96 cm should be considered as indicating obesity among the Iranian population. It seems that the Caucasian-based cut-off value is not necessarily applicable to Asian populations.²⁶⁻²⁷ In Western populations, the WC cut-off value for defining central obesity is 88 cm in women.²⁸⁻²⁹ Jolliffe and Janssen have suggested sex- and age-specific WC cut-off based on the National Cholesterol Education Program (NCEP), Adult Treatment Panel (ATP) and International Diabetes Federation (IDF) adult criteria. The ATP and IDF adult criteria for WC are 102 cm for males and 88 cm for females and 94cm for males and 80cm for females, respectively. The upper levels have been adopted by the NCEP.³⁰ The only prospective outcome-based cohort study in Iran found an identical WC cut-off value of 94.5 cm for both men and women that could predict the incidence of CVD.³¹

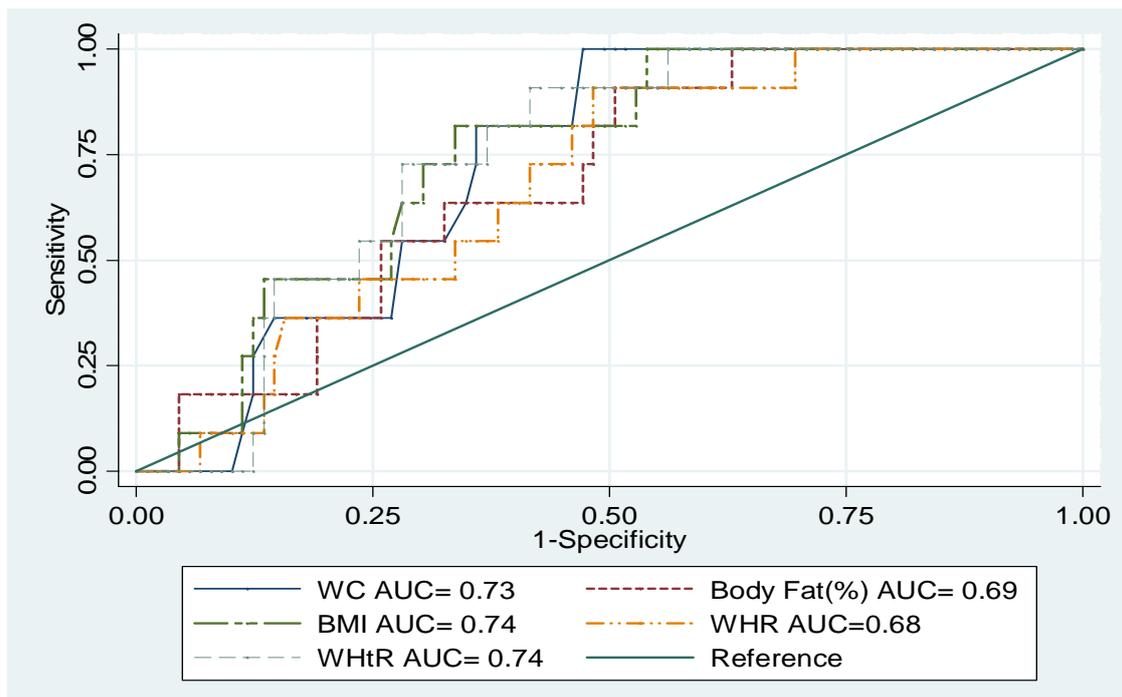
Our findings suggest the use of higher cut-off values for WHtR for Iranian subjects (cut-off 0.64). Another study in Iran have also found that lower cut-off vales for WHtR (cut-off 0.62) are applicable.³¹ WHtR has already been suggested as a common measure of central obesity for an Asian population³²⁻³⁴ and has been proposed as a better predictor of CVD risk^{35,36} and mortality.³⁷ The cut-off level of 0.5 for WHtR has been recommended for both sexes in European populations.³⁸

The BMI cut-off value to diagnose CVD risk for women was 31.3 in our study. Studies showed BMI as the best predictor of hypertension.³⁶ Katsis *et al.*³⁹ found that BMI may be an important factor for carotid atherosclerosis. The IDEA (International Day for the Evaluation of Abdominal Obesity) study reported that BMI and particularly WC, to be strongly linked to CVD.⁴⁰ According to WHO recommendations, the BMI threshold for increas-

Table 2. Area under the receiver operating characteristic curve (and 95% confidence interval) and optimal cut-off values of diagnostic measures of obesity indices against CIMT

	AUC (95%CI)	Cut-off	Sen (%) (95%CI)	Spc (%) (95%CI)	LR+ (95%CI)	LR- (95%CI)
WC (cm)	0.73 (0.61-0.83)	96	99.1 (73-100)	52.8 (42-63)	2.1 (1.67-2.63)	0.02 (0-8.11)
Body fat(%)	0.69 (0.55 -0.82)	30.4	81.8 (52-95)	49.4 (39-59)	1.62 (1.14-2.29)	0.37 (0.10-1.31)
BMI (kg/m ²)	0.74 (0.62-0.86)	31.3	81.8 (52-95)	66.3 (56-75)	2.43 (1.62-3.63)	0.27 (0.08-0.97)
WHR	0.68 (0.54-0.81)	0.86	90.9 (62-98)	51.7 (41-62)	1.88 (1.41-2.50)	0.18 (0.03-1.15)
WHtR	0.74 (0.63-0.85)	0.64	81.8 (52-95)	58.4 (48-68)	1.97 (1.36-2.85)	0.31 (0.09-1.10)

Sen, sensitivity; Spc, specificity; LR, likelihood ratios; WC, waist circumference; BMI, body mass index; WHR, waist to hip ratio; WHtR, waist to height ratio. There are no significant difference among AUCs (χ^2 (df=4)=2.55, $p=0.636$)

**Figure 1.** Comparison of AUC of the anthropometric indices for diagnosis of atherosclerosis

ing disease risk in Caucasian populations is ≥ 25 kg/m² for both men and women.⁴¹ This value was suggested to be 23 kg/m² in Asian men and women. Cut-off values reached by our study include those suggested for Caucasian populations, but are higher than those recommended for Asians. The BMI Cut-off value to predict various CVD risk factors in an Iranian population in another study was 29.2 kg/m² for women.³¹

The cut-off value for WHR in this study to identify risk of atherosclerosis was 0.86. These figures are in close agreement with the findings of previous studies.⁴²⁻⁴⁴ Waist to hip ratio has been shown as a better predictor of CVD risk than BMI.^{24,45,46} Cohort studies in the United States and Sweden have found that higher WHR or WC are strongly associated with increased risk of IHD in women.^{45,47} A WHR cut-off value of 0.9 for women was suggested to predict CVD in an outcome-based cohort study involving an Iranian population.³¹

In our study, the cut off value for %BF to identify risk of initial stage of atherosclerosis was 30.42%. The relationship between %BF and CVD risk factors is not clearly defined.⁴⁸⁻⁵¹

Result of this study showed that the lowest diagnostic value of WHR were contradictory with the recent Dallas

Heart Study and Raymond finding ie the strongest relationship between WHR and subclinical atherosclerosis.⁵² the INTER HEART study showed that WHR has a stronger independent association with the prevalence of myocardial infarction.²⁴

Ethnic difference between communities and differences in age ranges and BMI of subjects can justify the difference between the various studies. In addition, using different cut-off anthropometric indices in various study and various definition of risk factors of CVD can also result in differences in findings.^{53,54}

Although this study was only done on females in a single geographic area and could be considered a limited, it was conducted on healthy subjects without CVD and we could assess the relationship between obesity indices and initial stage of atherosclerosis and determine the cut-off points of obesity indices based on highest sensitivity.

Our findings support the superior value of WHtR and BMI among other anthropometric indices for diagnosis of adiposity related atherosclerosis. As there are contradictory findings on anthropometric indices and atherosclerosis, future investigations based on larger population in both genders are.

AUTHOR DISCLOSURES

The authors have no conflicts of interest.

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Short Communication

Diagnostic value of anthropometric indices for initial stage of atherosclerosis in adult women

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成人女性的體位測量指標對初期動脈硬化之診斷值

體重過重是心血管疾病的危險因子。體位測量指標與心血管健康的關聯性尚未完全明瞭。頸動脈中層厚度(CIMT)是動脈硬化的臨床前期標記。此研究目的為找出以 CIMT 診斷的初期動脈硬化之最佳體位肥胖指標。這個橫斷性研究包含 100 名 18-50 歲的成人女性。體位測量值是依據標準流程進行測量，而 CIMT 則是以非侵入性的超音波測量。以接受器操作特性曲線(ROC)分析來決定體位測量指標的理想切點及動脈硬化診斷的最適指標。由 ROC 分析所建議的腰圍、腰臀圍比、腰圍身高比、身體質量指數(BMI)及體脂肪比率的最適切點，分別是 96 公分、0.86、0.64、31.29 kg/m² 及 30.42。身體質量指數(AUC=0.74，95%CI=0.62-0.86)和腰圍身高比(AUC=0.74，95%CI=0.63-0.85)的 ROC 曲線下面積較其他體位測量指標高。腰臀圍比的曲線下面積是這些肥胖指標中最低的(AUC=0.68，95%CI=0.54-0.81)。在本研究中，依據 AUC 結果顯示，腰圍身高比及身體質量指數是動脈硬化初期最佳的診斷參數，而腰臀圍比是最差的。

關鍵字：體位測量指標、動脈硬化、頸動脈、切點、接受器操作特性曲線