Sagittal abdominal diameter to triceps skinfold thickness ratio:
A novel anthropometric index to predict premature coronary atherosclerosis

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Abstract

Objective: We aimed to compare the accuracy of a novel index defined by us, as a ratio of Sagittal abdominal diameter (SAD) and triceps skinfold thickness (TSF) with other indices of adiposity for prediction of presence, severity and extension of premature coronary artery disease (CAD).

Methods: A cross-sectional study was conducted on 238 younger patients (females < 55 years; males < 45 years) who underwent coronary angiography. Anthropometric indices including TSF, SAD, waist circumference, and hip circumference were measured before catheterization and body mass index, waist-to-hip ratio, abdominal diameter index, index of central obesity as well as our proposed index, SAD-to-TSF ratio, were calculated accordingly. Evaluation of severity and extension of coronary stenosis was by Gensini score and extent score, respectively.

Results: After adjustment for age and sex in multivariate regression models, the SAD-to-TSF ratio was the best predictor for the presence (OR = 2.49, 95% CI = 1.44–4.30; p = 0.001) and extension (β = 1.10, p = 0.004) of premature CAD. TSF and the SAD-to-TSF ratio were the only indices that significantly predicted the Gensini score and the correlation remained significant even after adjustment for age and sex (β = -0.10, p < 0.001 and β = 3.76, p < 0.0001, respectively).

Conclusion: We showed that our proposed index, SAD-to-TSF ratio, has a substantially better accuracy than do the known indices of obesity like body mass index, waist circumference, and waist-to-hip ratio for the prediction of premature CAD. Furthermore, our index was the only index that positively correlated with the severity of premature CAD.

1. Introduction

Obesity is recognized as a continuously growing global public health problem [1,2]; and in parallel with the explosion of obesity and metabolic syndrome in younger adults, the incidence of cardiovascular disease (CVD) at younger ages will undoubtedly continue to increase [3]. Hence, detection and management of obesity might be one of the most effective approaches for the prevention of CVD in young individuals.

Central fat mass (CFM) is increasingly recognized as an independent risk factor for CVD [4,5] and components of the insulin-resistance syndrome like diabetes, hyperlipidemia, and hypertension. Interestingly, it has been shown that contrary to CFM, peripheral fat mass (PFM) has a favorable impact, even with a possible protective role, on CVD and diabetes [6–13]. As a result, combined anthropometric indices which consider both CFM and PFM have recently attracted great interest. In other words, since CFM and PFM have been shown to have positive and negative
In adult populations, waist circumference (WC) and waist-to-hip ratio (WHR) are the most commonly used indicators of abdominal adiposity. WC has been shown to be a better measure of CVD risk than WHR, because it correlates more strongly with visceral fat than does WHR [14,15]. Sagittal abdominal diameter (SAD) may be an even better predictor of CVD risk than is WC, because it may be a stronger correlate of visceral fat as a result of the movement of subcutaneous fat to the sides of the waist when measurement is taken. Based upon the aforementioned concept that the CFM-to-PFM ratio might be a stronger predictor of CVD, we proposed that adding the data of PFM to SAD would improve its power for the prediction of cardiovascular and metabolic diseases. With this in mind, we hypothesized that a novel parameter defined by us, as a ratio of SAD and triceps skinfold thickness (as a marker of FFM), would correlate better with premature coronary atherosclerosis than would the other indices of central adiposity like WC and WHR.

2. Methods

2.1. Study population

To define premature CAD, the study participants were recruited from consecutive female patients under 55 years of age and male patients under 45 years old with symptoms related to CAD or non-invasive tests compatible with myocardial ischemia. From a total of 1474 patients scheduled for elective diagnostic coronary angiography at our center between April 2011 and June 2011, 261 (17.7%) patients met the inclusion criteria. After excluding 23 patients with a history of previous percutaneous coronary intervention (PCI) or coronary artery bypass grafting surgery (CABG), a total of 238 patients were retained for final analyses. The study protocol was approved by the Ethics Committees of AJA University of Medical Sciences and Tehran Heart Center, and all the patients completed a written informed consent form.

2.2. Anthropometric indices

A single trained staff member measured anthropometric indices and blood pressure prior to coronary angiography. Body weight was measured to the nearest 0.1 kg using a calibrated manual weighing scale (Seca 709, Les Mureaux, France). Height was measured to the nearest 0.5 cm on a standardized wall-mounted height board. TSF was measured halfway between the inferior border of the coracoid process and the tip of the olecranon process using the Holtain Skinfold Caliper (Holtain, Dyfed, Wales, UK) [1,2]. For each skinfold measure, a skinfold of about 1.5 cm in depth was picked up between the thumb and forefinger and the caliper jaws applied. SAD was measured as the height of the abdomen from the table in the supine position (cm) measured at the waist after gentle expiration, using a portable sliding-beam caliper (Seca 709, Les Mureaux, France). The upper arm of the caliper was brought down to an abdominal mark made midway between the iliac crests, which approximates the level of the L4-L5 interspace [16]. The abdominal diameter index was calculated by dividing SAD by the thigh circumference measured 10 cm proximal to the superior patellar border. WC was measured at the minimum circumference between the iliac crest and the rib cage at minimal respiration. The “index of central obesity” (ICO) was calculated by dividing WC to height [17]. HC was measured at the maximum protuberance of the buttocks, and WHR was calculated. Finally, the body mass index (BMI) was calculated as weight in kg divided by height in m^2.

2.3. Definitions

The metabolic syndrome was defined according to adapted NCEP ATP-III criteria as the presence of at least three of the following characteristics: abdominal obesity (WC > 102 cm for men and > 88 cm for women); blood pressure ≥130/85 mm Hg (or use of antihypertensive medication); fasting blood sugar (FBS) level (≥100 mg/dl); triglyceride level ≥150 mg/dl; and low level of high-density lipoprotein cholesterol (HDL-C) levels (<40 mg/dl in men and <50 mg/dl in women). Risk factors such as hypertension, hyperlipidemia, diabetes mellitus, smoking, and family history of premature CAD were recorded on the basis of standard definitions [18–20].

2.4. Coronary angiogram

Coronary angiography was performed using standard techniques and recorded in multiple projections for left and right coronary arteries. CAD was defined as ≥50% luminal diameter stenosis in one or more major epicardial vessel. The following measures of severity and extension of coronary atherosclerosis were used for the assessment of the severity and extension of premature CAD.

The Gensini Score. This severity score has been described previously [21]. Briefly, the coronary arterial tree was divided into segments with multiplying factors according to the geographic functional importance of any given segment (5 for the left main stem to 0.5 for the most distal segments) as well as the percent reduction in the lumen diameter. The roentgenographic appearance of concentric lesions and eccentric plaques was assigned a score (0, 1, 2, 4, 8, 16, or 32 according to the degree of luminal stenosis). The sum of the segmental scores yielded the Gensini score.

The Extent Score. This score was used to assess the extension of coronary atherosclerosis [22,23]. In brief, the coronary circulation is divided into fifteen segments, eight of which are classified as first-order segments: left main coronary artery; proximal, middle, and distal portions of the left anterior descending; proximal and middle portions of the right coronary artery; and proximal and distal portions of the circumflex. There were also 7 s-order segments: distal right coronary artery; posterior descending artery; distal circumflex; obtuse marginal branch; posterolateral branch of the circumflex; and the first two diagonal branches of the left anterior descending. If there was any evidence of atherosclerosis, the first-order segments received a score of 1 and the second-order segments a score of 0.5. The overall diffuseness score was the sum of the individual segment scores, and the maximum score attainable was 11.5.

All the angiograms were assessed by a single cardiologist, blinded to the patients’ medical and anthropometric status.

2.5. Statistical analysis

The Kolmogorov–Smirnov test was applied to examine normal distribution. The continuous variables are expressed as mean ± SD and they were compared using the Student t-test. The categorical variables were compared using a chi-square test or the Fisher exact test, as appropriate, and they are presented as absolute frequencies with percentages. The predictive values of the anthropometric indices for the presence and extension of premature CAD were assessed via multiple logistic and linear regression analyses. First, univariate regression analysis was employed to assess the relationship between the anthropometric indices and either the presence or the extension of premature CAD and thereafter the correlation was adjusted for age and sex using multivariate regression analysis.
For all the analyses, the statistical package SAS version 9.1 for Windows (SAS Institute Inc., Cary, NC, USA) was used. All p values were two-tailed with significance defined as p ≤ 0.05.

3. Results

Of a total of 238 study subjects, compatible with our selection criteria (mean age of 47.0 ± 5.8 years), 54 (22.7%) were men. Seventy-one (29.8%) patients were found to have CAD, and the remaining 167 subjects were considered as normal controls. The baseline clinical, anthropometric, and laboratory characteristics of the study patients are presented in Table 1.

Table 1, density lipoprotein cholesterol.

The number of the components of MetS, WC, WHR, SAD, the SAD-to-TSF ratio, TG, FBS, prevalence of diabetes mellitus, hypertension, hyperlipidemia, and current smoking was significantly higher in the patients with CAD (all p values < 0.05). Age (p = 0.06), male sex (p = 0.06), BMI (p = 0.06), and total cholesterol (p = 0.07) showed borderline significant differences between the two groups. TSF and HDL-C were significantly lower in the patients with premature CAD than in the normal controls.

In our univariate analysis, WC (OR = 1.03, 95% CI = 1.01–1.05; p = 0.015), WHR (OR = 235.53, 95% CI = 3.85–14411.59; p = 0.009), SAD (OR = 114, 95% CI = 1.05–1.25; p = 0.003), COI (OR = 40.81, 95% CI = 140–1188.13; p = 0.031), and the SAD-to-TSF ratio (OR = 1.57, 95% CI = 1.30–1.89; p < 0.0001) correlated with premature CAD. BMI showed a borderline significant correlation with premature CAD as well (OR = 1.05, 95% CI = 1.00–1.10; p = 0.066). A significant negative correlation was also observed between TSF and premature CAD (OR = 0.92, 95% CI = 0.89–0.96; p < 0.0001). ADI did not show a significant correlation with the presence of premature CAD (p = 0.10). After adjustment for age and sex, the odds ratios showed slight variations, except for WHR, which was no further significantly correlated with the presence of premature CAD (Table 2).

Table 2

3. Results

Coronary artery disease

3. Results

4. Discussion

As is seen in Table 3, WC (β = 0.04, p = 0.010), WHR (β = 6.74, p = 0.004), SAD (β = 0.15, p = 0.017), ICO (β = 5.09, p = 0.030), and the SAD-to-TSF ratio (β = 0.66, p < 0.0001) were significantly correlated with the extent score. A significant negative correlation was also observed between TSF and the extension of premature CAD (β = −0.12, p < 0.0001). ADI did not show any significant correlation with the extension of premature CAD (p = 0.151). After adjustment for age and sex, the correlations remained significant, except for WHR, which was no longer correlated with the extension of premature CAD and WC showed a borderline significant correlation (p = 0.073).

Linear regression analysis was used to assess the correlation between the anthropometric indices and the severity of premature CAD, measured via the Gensini score (Table 4). TSF and the SAD-to-TSF ratio were the indices that significantly predicted the Gensini score and the correlation remained significant even after adjustment for age and sex (β = −7.28, p < 0.0001 and β = 3.76, p < 0.0001, respectively).

To compare the ability of the anthropometric indices to predict the presence and extension of premature CAD, odds ratios and regression coefficients of tertiles of the indices were obtained using univariate and multivariate regression analyses (Table 5). Although WHR had the highest odds ratio, it was not statistically significant (OR = 3.51, 95% CI = 0.82–15.15; p = 0.092). Hence, the SAD-to-TSF ratio was the best predictor for the presence of premature CAD (OR = 2.49, 95% CI = 1.44–4.30; p = 0.001). The SAD-to-TSF ratio was also the best predictor for the extension of premature CAD amongst the anthropometric indices (β = 1.10, p = 0.004).

In this study, we tested the predictive value of our novel index “the sagittal abdominal diameter to triceps skinfold thickness ratio” for the presence, severity, and extension of premature coronary atherosclerosis. The main finding of our study was that our index has a substantially better accuracy than do the known indices of obesity like BMI, WC, and WHR for the prediction of premature CAD. Furthermore, our index was the only index that positively correlated with the severity of coronary stenosis measured by the Gensini score.

Kahn et al. [16] proposed that ADI might be more effective at estimating visceral adipose tissue and, hence, a better predictor of CVD than WHR. Smith et al. [24] tested this hypothesis and observed that of the six anthropometric measures (BMI, WC, WHR, ADI, SAD, and waist-to-thigh ratio), ADI gave the largest and most significant standardized odds ratio for coronary heart disease. However, in our study, ADI could not predict the presence of
premature CAD and nor was it correlated with the severity or the extension of premature CAD.

Parikh et al. [17] described a novel anthropometric index, namely “the index of central obesity” (ICO), which is defined as the ratio of WC and height. It has been shown by more recent studies that ICO has a better predictive value for the development of diabetes and CVD with a higher area under curve than does WC in the ROC analysis [25,26]. Interestingly, our index, the SAD-to-TSF ratio, was more powerfully correlated with the presence, severity, and extension of premature coronary atherosclerosis than was ICO.

In addition to defining a novel anthropometric index, one of the novel aspects of our study was that we diagnosed patients as having CAD based on angiographic results, which preferentially evaluate atherosclerosis and optimally reflect the atherogenicity of metabolic risk factors. Moreover, unlike previous studies [24], we quantified the severity and extent of CAD with several standard scoring systems. However, it should be mentioned that in this study we used Gensini’s scoring system as a widespread and familiar scoring system for quantification of severity of coronary artery disease. However, at present, there are more updated and accurate scoring systems for this purpose like “Syntax score” [27] that did not administered in this study and should be acknowledged as a limitation of our study. Be that as it may, there are potential limitations in our study that need to be mentioned. In this study, insulin levels measurement, as a measure of insulin resistance, as well as CT and MRI measurements of abdominal fat was not conducted because the principal aim of this study was to explore the relationship between anthropometric indices and premature CAD. Our novel parameter can be validated and compared to other indices of central adiposity looking at its correlation with body fat distribution measured radiologically, and insulin resistance measured biochemically. Another limitation of our study was that our study population was Caucasian and the ethnic variation of body fat distribution is well known. Hence, conclusions derived from the present study should only be used in Caucasian populations and further studies in other races are needed to assess the value of our index to predict cardiometabolic derangements.

TSF and SAD measurements are not only easy to perform in daily practice but are also cost-effective, non-invasive, and non-time-consuming. In addition, as “the SAD-to-TSF ratio” is more

### Table 3
Linear regression analysis for the predictive value of anthropometric indices for extension of premature coronary artery disease.

<table>
<thead>
<tr>
<th>Univariate</th>
<th>Multivariate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>0.04</td>
</tr>
<tr>
<td><strong>WC (cm)</strong></td>
<td>0.04</td>
</tr>
<tr>
<td><strong>HC (cm)</strong></td>
<td>0.01</td>
</tr>
<tr>
<td><strong>TSF (mm)</strong></td>
<td>−0.12</td>
</tr>
<tr>
<td><strong>SAD (cm)</strong></td>
<td>0.15</td>
</tr>
<tr>
<td><strong>WHR</strong></td>
<td>6.74</td>
</tr>
<tr>
<td><strong>ADI</strong></td>
<td>5.27</td>
</tr>
<tr>
<td><strong>ICO</strong></td>
<td>5.09</td>
</tr>
<tr>
<td><strong>SAD/TSF</strong></td>
<td>0.66</td>
</tr>
</tbody>
</table>

* Adjusted for age and sex. CI, Confidence Interval; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; TSF, triceps skinfold thickness; SAD, sagittal abdominal diameter; ADI, abdominal diameter index; ICO, index of central obesity.

### Table 4
Linear regression analysis for the predictive value of anthropometric indices for severity of premature coronary artery disease.

<table>
<thead>
<tr>
<th>Univariate</th>
<th>Multivariate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>0.03</td>
</tr>
<tr>
<td><strong>WC (cm)</strong></td>
<td>0.18</td>
</tr>
<tr>
<td><strong>HC (cm)</strong></td>
<td>−0.01</td>
</tr>
<tr>
<td><strong>TSF (mm)</strong></td>
<td>−8.09</td>
</tr>
<tr>
<td><strong>SAD (cm)</strong></td>
<td>0.96</td>
</tr>
<tr>
<td><strong>WHR</strong></td>
<td>39.71</td>
</tr>
<tr>
<td><strong>ADI</strong></td>
<td>60.88</td>
</tr>
<tr>
<td><strong>ICO</strong></td>
<td>16.22</td>
</tr>
<tr>
<td><strong>SAD/TSF</strong></td>
<td>4.32</td>
</tr>
</tbody>
</table>

* Adjusted for age and sex. CI, Confidence Interval; BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; TSF, triceps skinfold thickness; SAD, sagittal abdominal diameter; ADI, abdominal diameter index; ICO, index of central obesity.

### Table 5
Odds ratios and regression coefficients for presence and extension of premature coronary artery disease by each tertile increment of anthropometric indices.*

<table>
<thead>
<tr>
<th>Premature coronary artery disease</th>
<th>Extent score</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>1.55</td>
</tr>
<tr>
<td><strong>WC (cm)</strong></td>
<td>1.86</td>
</tr>
<tr>
<td><strong>SAD (cm)</strong></td>
<td>2.30</td>
</tr>
<tr>
<td><strong>WHR</strong></td>
<td>3.51</td>
</tr>
<tr>
<td><strong>ICO</strong></td>
<td>1.45</td>
</tr>
<tr>
<td><strong>SAD/TSF</strong></td>
<td>2.49</td>
</tr>
</tbody>
</table>

* Adjusted for age and sex. CI, Confidence Interval; BMI, body mass index; WC, waist circumference; WHR, waist-to-hip ratio; SAD, sagittal abdominal diameter; ICO, index of central obesity.
powerfully associated with premature CAD than are WC, WHR, ICO, and ADI, and because it is the only anthropometric index that positively correlates with the severity of premature CAD, it might improve the prediction of cardiovascular risk in men and women in future studies and it should be deemed an important candidate for the evaluation in large epidemiologic and clinical investigations of obesity and cardiovascular disease.

References


