Intra-abdominal Thickness by Ultrasonography to Predict Risk Factors for Cardiovascular Disease and Its Correlation With Anthropometric Measurements

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The aim of this study was to determine if intra-abdominal thickness measured by ultrasonography (IATU) in men and women had a correlation with cardiovascular risk factors, to compare it with anthropometric measures (waist circumference [WC] and abdominal sagittal diameter [SDi]), and to find a cut-off value for IATU to predict risk factors for cardiovascular disease (CVD). In a cross-validation study, intra-abdominal fat tissue measured by CT at L4-L5 was significantly correlated with ultrasonography (US) intra-abdominal thickness. A total of 191 and 231 healthy men and women, respectively, aged 20 to 60 years, were evaluated by anthropometric indexes (body mass index [BMI], WC, and SDi), and systolic blood pressure (SBP) and diastolic blood pressure (DBP), fasting total plasma cholesterol (Chol), high-density lipoprotein (HDL) cholesterol, triglyceride (TG), and glucose (Glu) levels. IATU was evaluated by the distance between the internal face of abdominal muscles and posterior wall of the aorta. All measurements were taken by the same physician. The subjects were divided into 3 cardiovascular risk groups, according to the presence of 2 or more risk factors—(1) moderate-risk (MR) group with 2 or more of the following: total Chol > 200 mg/dL, HDL cholesterol < 45 mg/dL, TG > 200 mg/dL, Glu > 126 mg/dL, SBP > 140 mm Hg, DBP > 90 mm Hg, comprising 68 men and 72 women; (2) high-risk (HR) group with 2 or more of the following: total Chol > 240 mg/dL, HDL cholesterol < 35 mg/dL, TG > 200 mg/dL + HDL cholesterol < 35 mg/dL, Glu > 126 mg/dL, SBP > 140 mm Hg, DBP > 90 mm Hg, comprising 34 men and 55 women; and (3) no-risk (NR) group with only 1 or none of the risk factors indicated in the MR and HR groups. IATU presented association with risk factors and presented a higher level of accuracy and specificity than SDi and WC (odds ratio [OR] = 2.27 [95% confidence interval (CI), 1.05 to 4.80] for men and OR = 3.69 [95% CI, 1.98 to 66.90] for women). The cut-off length to predict moderate risk was 7 cm for both sexes (OR = 2.86 [95% CI, 1.44-5.68] for men and OR = 3.01 [95% CI, 11.61 to 5.62] for women), whereas the value of 9 cm predicted high risk for CVD (OR = 5.55 [95% CI, 2.32 to 13.28]) in men and of 8 cm in women (OR = 3.27 [95% CI, 1.63 to 6.56]). In conclusion, IATU is a useful tool to evaluate visceral fat and seems to be predictive of risk factors associated with CVD.

VISCERAL ADIPOSE TISSUE accumulation is highly correlated with metabolic abnormalities that could contribute to an increased risk for cardiovascular disease (CVD).[1-10] Metabolic alterations are more likely to be observed above the threshold value for visceral fat accumulation by computed tomography (CT) at the L4-L5 level. This value was greater than 110 cm^2 for females, according to Willians et al.[11] Després and Lamarche[12] indicated a value greater than 100 cm^2 for both men and women, associated with significant alterations in the CVD risk profile, and values greater than 130 cm^2 were correlated with further deterioration of the metabolic profile. CT is considered the standard method for visceral fat evaluation, but it is not used as a routine procedure because it is expensive and involves x-ray exposure[13-20]. Waist-to-hip ratio, waist circumference (WC), and abdominal sagittal diameter (SDi) are useful markers of intra-abdominal fat, although not always very accurate.[21-24] Ultrasonography (US) has been suggested as an alternative to evaluate abdominal fat since 1990, considering that it is easier, not expensive, does not involve x-ray exposure, and has a high correlation (r = 0.67) with CT.[25] Some studies did not show good accuracy with US,[26,27] and probably demonstrated variability in their results because of different populations, methodologies, and technical expertise.

The aim of our study was to evaluate the correlation of intra-abdominal thickness measured by US (IATU) and risk factors associated with CVD, comparing the procedure with anthropometric measures (WC and SDi), and to determine a cut-off point for IATU that could define risk for CVD. In a preliminary study, intra-abdominal adipose tissue measured by CT was compared with IATU to verify validity and reliability of the latter in comparison to the standard technique.

PATIENTS AND METHODS

Patients

From March 1996 to July 1997, in a clinic-based study, we screened 191 male and 231 female healthy volunteers, aged 20 to 60 years. We obtained informed consent from all subjects, as well as from the appropriate institutional internal review board. Any previous cardiovascular event (myocardial infarction, stroke, angina pectoris) was considered exclusion criterion, as was the subjects using any medication known to affect lipoprotein or insulin metabolism. Three ethnic groups were included—caucasian, black, and mulatto—corresponding to the population profile seen at the University Hospital. The patients were classified according to 3 age groups (20 to 35, 36 to 50, >51 years) and body mass index (BMI) (20 to 24.9, 25 to 29.9, 30 to 40 kg/m^2), and were selected to represent the study population by weight and age. Thirty-nine of female subjects (16.9%) were in the menopausal state, ie, at least 1 year without any menses, and none were on hormone-replacement therapy. The anthropometric parameters assessed were weight, height, BMI, WC (minimal abdominal circumference between the lower rib edges and iliac crests, in standing posi-

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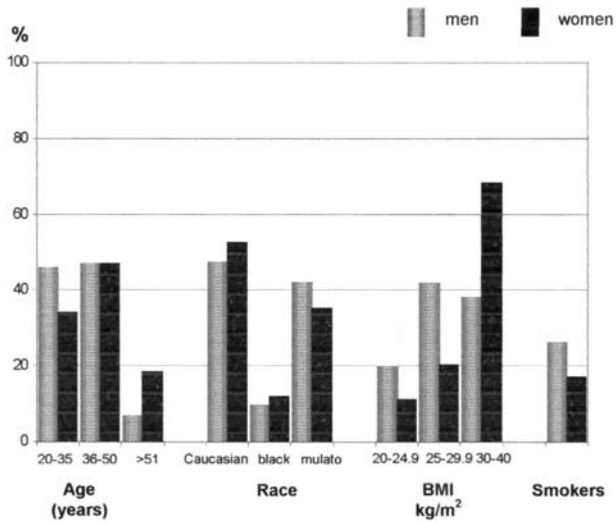

Fig 1. Clinical characteristics of the 422 subjects studied (191 men and 231 women).

tion),[28] and SDi (measured with subjects recumbent and using a tape measure from the back of the subject to the umbilicus level).[29] Systolic (SBP) and diastolic (DBP) blood pressure were measured in the sitting position to the nearest 2 mm Hg on the left arm, at the level of the heart, after a 5-minute rest. Corrections according to the subject's arm circumference were made.[30] The mean of 2 measurements was used in the analysis.[31] Blood samples were collected in the postabsorptive state from an anticubital vein, in the sitting position, for plasma glucose (Glu), triglycerides (TG), total cholesterol (Chol), and high-density lipoprotein (HDL) cholesterol.

Analytic Procedures

Plasma Glu, total Chol, HDL cholesterol, and TG were determined by an automated enzymatic method (Cobas Integra Plus equipment [Kaiseraugust, Switzerland] using commercial kits from Roche Diagnostic System [Mannheim, Germany]). The intra- and interassay coefficients of variation were less than 5% for all measurements.

CT Scanning

CT scanning for measuring subcutaneous fat area and intra-abdominal visceral fat area was performed with subjects in the supine position, at the L4-L5 level, using a Philips Tomoscan LX (Best, Holland).[32] The coefficient of variation for the CT tecnique was found to be 0.6% by repeated analysis of 20 scans.

Ultrasonography

The intra-abdominal thickness was measured using a Toshiba Sonolayer SSA-250A with 3.75-MHz transducer (Otawara Shi, Tochigi-ken, Japan). IATU was determined directly from the frozen images on the screen by positioning electronic calipers on the internal face of the abdominal muscles and posterior wall of the aorta,[33] 1 cm above the umbilicus on the xiphoumbilical line. All examinations were made by the same observer (D.M.). The intraindividual coefficient of reproducibility in our study was 6.5% in 30 subjects evaluated twice (these subjects were part of the 422 individuals studied).

Comparison Between CT and US

In a preliminary study, 29 subjects not included in the present investigation, aged 16 to 50 years with a BMI range of 24 to 37 kg/m^2, were submitted to CT and US at the same day to verify the correlation for visceral and subcutaneous adiposity.

Metabolic Parameters

The volunteers were classified in 3 groups according to risk factors—(1) moderate risk for CVD (MR group) with 2 or more of the following values: total Chol $>$ 200 mg/dL, HDL cholesterol $<$ 45 mg/dL, TG $>$ 200 mg/dL, Glu $>$ 126 mg/dL, SBP $>$ 140 mm Hg, DBP $>$ 90 mm Hg; (2) high-risk (HR) group with 2 or more of the following: total Chol $>$ 240 mg/dL, HDL cholesterol $<$ 35 mg/dL, TG $>$ 200 mg/dL + HDL cholesterol $<$ 35 mg/dL, Glu $>$ 126 mg/dL, SBP $>$ 140 mm Hg, DBP $>$ 90 mm Hg; and (3) no-risk (NR) group

Table 1. Clinical Data for the Cardiovascular Risk Groups of the 422 Subjects Studied

	NR		MR		HR	
Clinical Characteristics	Men (n = 89)	Women (n = 104)	Men (n = 68)	Women (n = 72)	Men (n = 34)	Women (n = 55)
Age (yr)						
20-35	57.3*	49.0	44.1	30.5	20.6	11.0
36-50	40.4	40.2	52.9	55.5	52.9	49.1
>51	2.2	10.6	2.9	13.9	26.4	40.0
Race						
Caucasian	47.2	50.0	48.5	61.1	47.0	45.5
Mulatto	44.9	38.5	41.2	32.0	38.2	34.5
Black	7.9	11.5	10.3	7.0	14.7	20.0
BMI (kg/m^2)						
20-24.9	28.1	16.3	11.8	5.5	14.7	9.1
25-29.9	26.9	24.0	44.1	26.4	55.9	5.4
30-40	44.9	59.6	44.1	68.0	29.4	85.4
Smokers	22.5	16.3	33.8	22.2	20.6	12.7
Menopause		11.5		13.9		30.1
WC (cm)	93.8 ± 11.2†	94.8 ± 12.6	100.2 ± 10.6	102.3 ± 12.2	105.4 ± 14.7	104.6 ± 10.8
SDi (cm)	21.2 ± 3.7	22.5 ± 4.1	22.6 ± 2.9	23.6 ± 3.6	24.7 ± 4.6	25.3 ± 4.5
IATU (cm)	7.0 ± 2.3	6.3 ± 2.4	8.1 ± 2.0	7.4 ± 1.9	9.3 ± 2.6	8.5 ± 2.6

*Percentage in each group.
†Mean ± SD.

Table 2. Risk Factors for Cardiovascular Disease in the 422 Subjects Studied

Risk Factors	NR		MR		HR	
	Men (n = 89*)	Women (n = 104)	Men (n = 68)	Women (n = 72)	Men (n = 34)	Women (n = 55)
SBP > 140 mm Hg	4.5*	8.6	29.4	34.7	76.5	78.1
DBP > 90 mm Hg	1.1	0	0	0	47.0	50.9
Glucose > 126 mg/dL	0	0.9	0	1.4	17.6	16.3
Total Chol (mg/dL)						
>200	31.5	33.6	75.0	70.9	58.8	74.5
>240	10.1	13.5	14.7	9.7	35.3	49.0
HDL cholesterol (mg/dL)						
<45	43.8	31.7	85.3	45.8	64.7	100.0
<35	16.8	10.6	32.3	23.6	32.3	30.9
Triglycerides > 200 mg/dL	2.2	0	39.7	22.2	47.0	41.8
Triglycerides > 200 mg/dL + HDL cholesterol < 35 mg/dL	0	0	10.3	5.5	23.5	25.4

*Percentage in each group.

with only 1 or no risk factor described in the MR and HR groups. The initial inclusion of the subjects was to the HR group and none were included in the MR group since the classification in one group precluded the inclusion in the other one. The risk factor analysis was classified according to the recommendation by the National Cholesterol Education Program (NCEP)[34] and to plasma glucose range by the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus.[35]

Statistical Analysis

Means of continuous variables of the risk factors for each group were compared by standard Student *t* test, as were the differences of anthropometric measurements and IATU among the cardiovascular risk groups. IATU cut-off values were obtained by a logistic regression model from the values of sensitivity, specificity, and accuracy generated by the model. In effect, in the model of logistic regression, the dependent variable was the probability of the occurrence of disease risk and the independent one was the IATU. In this model, the sensitivity and specificity were calculated for every probability value for disease risk (receiver operating characteristic [ROC] curve), jointly maximizing sensitivity (true positive) and specificity (true negative) and accuracy (ability to identify correctly the results), thus allowing the obtention of IATU cut-off values. Multivariate analysis (logistic regression) with a step-wise selection process was used to evaluate IATU as a marker for CVD risk factors with no influence of other variables. Two-tailed *P* values less than .05 were considered significant.[36]

RESULTS

In the preliminary study of 29 subjects (mean age, 34 years; mean BMI, 31.2 kg/m^2), the correlation between US and CT was 0.79 for subcutaneous thickness and 0.84 for visceral adipose tissue.

The clinical characteristics of the 422 subjects of the study are shown in Fig 1 and Table 1. Eighty-nine men (46.5%) and 104 women (59.1%) were classified as not presenting cardiovascular risk according to the risk factors indicated, whereas 68 men (35.6%) and 72 women (40.9%) presented moderate risk, and 34 men (17.8%) and 55 women (34.6%) were at high risk. Clinical, anthropometric, and metabolic characteristics of these groups are listed in Tables 1 and 2. The mean values of WC, SDi, and IATU increased proportionally to greater CVD risk. Comparison of the mean values of WC, SDi, and IATU among the 3 CVD risk group (Table 3) indicated that only IATU was statistically different in all comparisons.

Sensitivity, specificity, and accuracy of anthropometric measurements (WC, SDi, IATU) within each risk factor group are indicated in Table 4 and Fig 2. IATU specificity and accuracy levels were higher than the 2 other anthropometric measurements in the group of women with moderate risk and in both sexes with high CVD risk.

The association of moderate and high risk factors with IATU values is indicated in Table 5. For men in the MR group, only SBP greater than 140 mm Hg was significantly associated with IATU, while in the HR group, all factors, except DBP greater than 90 mm Hg and HDL cholesterol less than 35mg/dL, were statistically associated with IATU values. For women in the MR group, an association with IATU values was observed with SPB greater than 140 mm Hg and TG values, with the former at a higher significance level. In the HR group, all risk factors were significantly associated with IATU; the association coefficient was lower for total Chol but still significant. It should be noted that for all moderate- and high-risk factors in both sexes, the mean ± SD values were higher when the factors were present, but not always statistically significant, except for total Chol greater than 200 mg/dL.

The cut-off values for IATU were 7 cm for both sexes (odds ratio [OR] = 2.86 [95% confidence interval (CI), 1.44 to 5.68] for men, and OR = 3.01 [95% CI, 1.61 to 5.62] for women) for

Table 3. Comparison of the Mean Waist Circumference, Sagittal Diameter, and US Intra-abdominal Thickness Among the Three Cardiovascular Risk Groups

	LR *v* MR		LR *v* HR		MR *v* HR	
	Men	Women	Men	Women	Men	Women
WC	$P < .05$	$P < .05$	$P < .05$	$P < .05$	NS	NS
SDi	NS	NS	$P < .05$	$P < .05$	$P < .05$	NS
IATU	$P < .05$	$P < .05$	$P < .05$	$P < .05$	$P < .05$	$P < .05$

Abbreviation: NS, not significant.

Table 4. Sensitivity, Specificity, and Accuracy of Waist Circumference, Sagittal Diameter, and US Intra-abdominal Thickness in the Moderate-and High-Risk Groups

	MR			HR		
Gender	SEN	SP	ACCU	SEN	SP	ACCU
Male						
WC	71.9*	52.8	60.8	52.6	77.5	70.1
SDi	76.3	47.1	58.9	43.8	80.5	70.6
IATU	59.4	59.6	59.5	52.9	82.0	74.0
Female						
WC	97.2	14.1	48.3	89.1	30.8	50.9
SDi	80.6	34.4	52.5	66.7	59.4	61.8
IATU	54.2	68.3	62.5	50.9	76.0	67.3

*Percentage.

Abbreviations: SEN, sensitivity; SP, specificity; ACCU, accuracy.

the MR group, with 59% and 54% sensitivity and 60% and 68% specificity for men and women, respectively. As to the HR group, the cut-off point for IATU was 9 cm for males (OR = 5.55 [95% CI, 2.30 to 13.28]) with a sensitivity of 53% and a specificity of 82%. On the other hand, in females, the IATU cut-off point was 8 cm (OR = 3.27 [95% CI, 1.63 to 6.56]) with a sensitivity of 51% and a specificity of 76% (Fig 2 and Table 5).

In a multivariate analysis of the risk variables (age, BMI, abdominal measurements, and menopause, if present), IATU was found to be the significant marker for CVD risk in both males (P = .03) and females (P = .01). The risk was assessed in comparison to the MR group since it was similar in both sexes (Table 6).

DISCUSSION

Abdominal visceral fat is considered an important marker to assess CVD risk.[33] CT scanning is the standard for the study of visceral fat volume and area but it is not routinely used.[32] US is a practical method to measure abdominal thickness and it useful for evaluation visceral fat,[35] as demonstrated in our study by an excellent correlation between IATU and abdominal visceral fat area by CT, as previously described by Armellini et al.[25,37-39] Anthropometric determinations (WC and SDi), although easy to perform, do not always present good accuracy, despite their significant correlation with visceral fat.[17]

We enrolled a significant number of obese women and overweight men (Fig 1) and the results demonstrated higher mean IATU levels in men, independent of BMI, considering that visceral fat mass is higher in males.[40,41] In effect, when the IATU values were compared in males versus females by pooling the data from all subjects, the mean values were 7.8 ± 2.4 and 7.2 ± 2.5 (P < .004) in males and females respectively. Moreover, the values increased according to age[41] (Table 1), leading to a greater proportion of subjects in

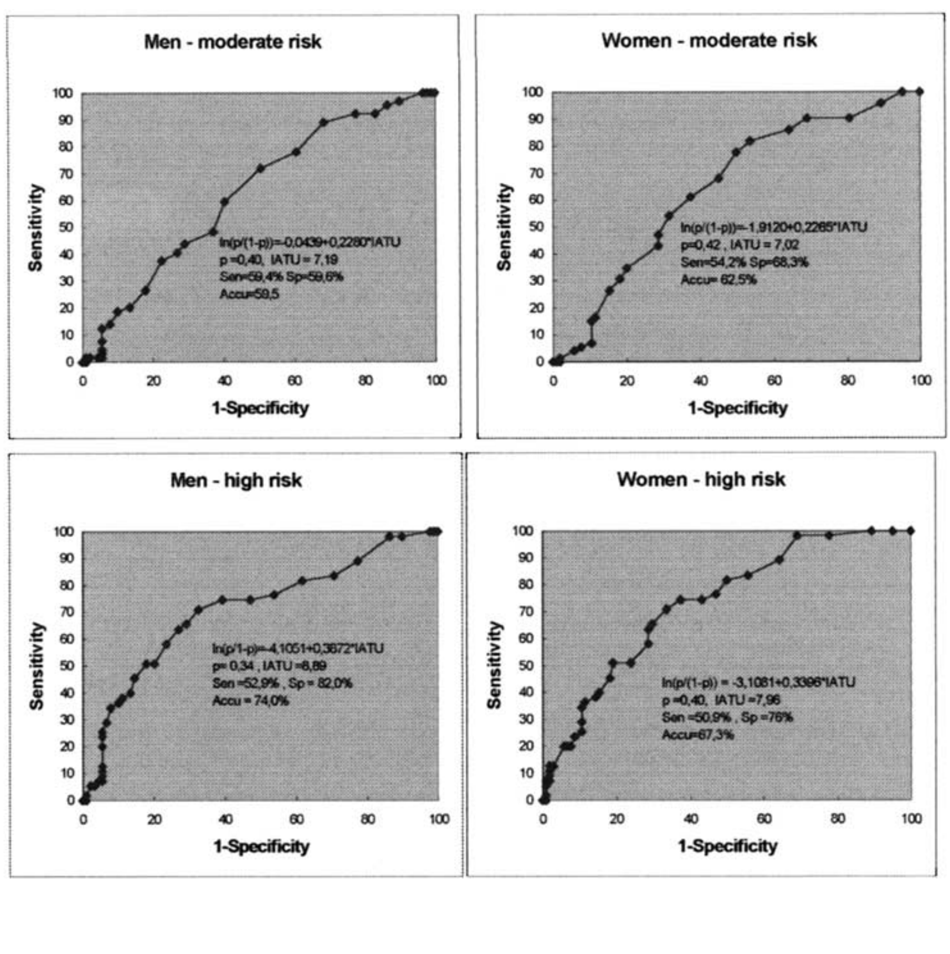

Fig 2. Sensitivity and specificity values for each intra-abdominal thickness measured by US (IATU) (ROC curve). Sen, sensitivity; Sp, specificity; Accu, accuracy.

Table 5. Association Between Risk Factors for Cardiovascular Disease and Intra-abdominal Thickness Measured by US

	MR Group				HR Group			
	Men		Women		Men		Women	
Risk Factor	IATU	*P*	IATU	*P*	IATU	*P*	IATU	*P*
SBP > 140 mm Hg								
Absent	6.87 ± 2.00*	<.001†	6.43 ± 2.09	.003†	7.29 ± 2.40	.004†	6.31 ± 2.29	<.001†
Present	8.04 ± 2.26		8.02 ± 2.70		8.86 ± 2.80		8.52 ± 2.80	
DBP > 90 mm Hg								
Absent	7.32 ± 2.15	.082	—		7.60 ± 2.53	.202	6.75 ± 2.58	.003†
Present	8.19 ± 2.41		—		8.42 ± 2.81		8.37 ± 2.72	
Chol > 200 mg/dL								
Absent	7.48 ± 2.33	.920	6.64 ± 2.60	.552				
Present	7.44 ± 2.13		6.85 ± 1.94					
Chol > 240 mg/dL								
Absent					7.34 ± 2.47	.001†	6.79 ± 2.62	.049†
Present					9.29 ± 2.54		7.74 ± 2.72	
TG > 200 mg/dL								
Absent	7.41 ± 2.33	.480	6.63 ± 2.30	.047†				
Present	7.66 ± 1.37		7.83 ± 1.98					
HDL cholesterol < 45 mg/dL								
Absent	7.49 ± 2.19		6.56 ± 2.33	.294				
Present	4.20 (1 pt)		6.92 ± 2.26					
HDL cholesterol < 35 mg/dL								
Absent					7.61 ± 2.57	.607	6.78 ± 2.54	.010†
Present					7.91 ± 2.67		8.21 ± 2.97	
TG > 200 mg/dL + HDL cholesterol < 35 mg/dL								
Absent					7.52±2.53	.009†	6.86 ± 2.61	.010†
Present					9.96 ± 2.30		8.77 ± 2.75	
Glu > 126 mg/dL								
Absent					7.42 ± 2.40	<.001†	6.85 ± 2.59	<.001†
Present					10.55 ± 2.93		9.78 ± 2.35	

*Means ± SD (cm)
†*P* < .05: significant for all comparisons.

the HR group, as expected. Despite not being statistically significant, higher IATU levels were observed in the black population as compared with the other 2 groups (data not shown). Our observation in black women contradicts the findings described in the literature when compared to white females.[43-46] However, the number of black individuals studied in our series was much lower than that of the other groups.

Comparing IATU with the other anthropometric measurements of visceral fat, our data indicated greater specificity and accuracy of IATU than WC and SDi to determine moderate and high risk for CVD. The exception was male individuals at moderate risk, who demonstrated similar results for the 3 measurements (Table 3).

It could be stated that there was a positive correlation of IATU with the presence of the CVD risk factors evaluated in our study and higher values were associated with more risk factors (Table 4).

Table 6. Selection of Risk Variables for CVD

	Men			Women		
Risk Variables	*P**	OR	95% CI	*P*	OR	95% CI
Age (yr)						
36-50	.09	1.79	0.91-3.54	.08	1.93	0.92-4.05
>51	.06	8.93	0.87-9.10	.50	1.76	0.33-9.23
BMI (kg/m^2)						
25-29.9	.47	1.39	0.56-3.47	.59	0.64	0.13-3.15
30-40	.42	1.68	0.46-6.16	.43	0.48	0.08-2.93
WC (cm)	.47	1.53	0.47-5.01	.20	2.77	0.56-13.5
SD: (cm)	.63	0.81	0.34-1.93	.21	1.60	0.76-3.37
IATU (cm)	.03	2.27	1.05-4.89	.01	3.69	1.98-6.90
Menopause	—	—	—	.87	1.11	0.28-4.38

**P* < .05 significant.

A cut-off point of 7 cm for IATU was demonstrated for both sexes in the MR group, and of 9 and 8 cm for men and women, respectively, in the HR group. As far as we know, this study is the first to report cut-off values for IATU in the analysis of CVD risk factors.

By means of a univariate logistic regression analysis, the only significant risk factor was IATU ($P = .03$), as indicated in Table 5.

Based on our observations, it could be concluded that US provided a better index in comparison with anthropometry in the prediction of CVD risk factors. The findings presented here will need to be verified in larger cohorts.

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