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Visceral and dysfunctional adiposity indexes: Relationship with cardiometabolic risk factors

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Abstract

Objective: Obesity is a worldwide disease in which visceral obesity is related to increased cardiometabolic risk. The aim of this study was to estimate the associative capacity of visceral adiposity index and dysfunctional adiposity index on cardiometabolic risk in the working population.

Material and methods: Descriptive study of 418,343 workers during health surveillance in their companies. VAI and DAI were calculated according to their equations and cardiometabolic risk with arterial hypertension, diabetes and atherogenic dyslipidemia, lipid triad, diabesity, and hypertriglyceridemic waist. Mean VAI and DAI values and associative capacity with ROC curves were calculated. The statistical program used SPSS 27.0, with statistical significance $p<0.05$.

Results: Percentage values of all parameters and assessment methods used are higher in men than in women ($p<0.0001$) Mean values of VAI are higher than those of DAI and higher in men ($p<0.0001$). VAI and DAI show high associative capacity for atherogenic dyslipidemia, lipid triad and hypertriglyceridemic waist in both sexes with the area under the AUC curve>0.9 in all cases. In diabesity only AUC>0.8 values are obtained for VAI and for diabetes, both VAI and DAI only in women exceed AUC>0.8, in men In HT, VAI, and DAI do not show associative capacity in men or in women (AUC<0.7).

Conclusions: Cardiometabolic risk estimation is different in men and women and varies according to the method used. Adiposity indices VAI and DAI show high associative capacity in cardiometabolic risk, especially in atherogenic dyslipidemia, lipid triad, and hypertriglyceridemic waist in both sexes.

Introduction

Obesity is a global disease that currently affects more than 2 billion people (1) and in which the excessive accumulation of intra-abdominal adipose tissue, called visceral obesity, is closely related to the group of cardiometabolic risk factors (2). In recent years, the importance of early detection of obesity-associated complications has been highlighted, and for this, visceral adiposity index (VAI) and dysfunctional adiposity index (DAI) can be used as associative tools for preventive actions against complications such as obesity syndrome. metabolism, type 2 diabetes, cardiovascular risk or insulin resistance (3).

Despite the recognized increased risk of morbidity and mortality associated with elevated body weight, there is now increasing evidence highlighting the importance of intra-abdominal adipose tissue and the increased risk of metabolic complications. This dysmetabolic profile predicts a substantially increased risk of cardiovascular disease even in the absence of hyperglycemia, elevated low-density cholesterol, or hypertension. Therefore, it is of interest to identify subgroups of individuals with a higher risk of being carriers of the characteristics of the metabolic syndrome (4).

The objective of this work is to estimate the associative capacity of the visceral adiposity index (VAI) and the dysfunctional adiposity index (DAI) in cardiometabolic risk with 5 methods: Atherogenic Dyslipidemia (AD), Hypertriglyceremic Waist Phenotype (HTWP), Lipid Triad (LT), Diabesity and Arterial Hyperpression (HT) in the working population.

Material and methods

A cross-sectional study was carried out on 418,343 workers during health surveillance examinations from different autonomous communities in Spain and with different job occupations during the period from January 2019 to September 2021. The study population was obtained from the database anonymous from the university school ADEMA-UIB (University of the Balearic Islands) (5). The inclusion criteria were age between 18 and 67 years, being an active worker, and voluntary acceptance of participation in the study.

Anthropometric measurements of height and weight, clinical and analytical, were carried out by the health personnel of the different occupational health units participating in the study, after homogenizing the measurement techniques.

Waist circumference was measured in cm with a SECA model 20 tape measure. Blood pressure was determined in the supine position with an OMRON M3 automatic sphygmomanometer calibrated after 10 minutes of rest (cuff size adjusted to arm circumference). Three measurements were made at 1-minute intervals and the average of the three was calculated. Blood samples were obtained by peripheral venipuncture after fasting for 12 hours and sent to reference laboratories where they were processed within 48-72 hours.

To calculate atherogenic dyslipidemia (AD) the following parameters are used: basic lipid profile, which includes total cholesterol, triglycerides, LDL-C and HDL-C. The cLDL is determined by a mathematical calculation, using the Friedewald formula: cLDL = TC – [cHDL / triglycerides/5] (in mg/dl).

The lipid triad includes (low high-density lipoprotein cholesterol [HDL-C] < 35 mg/dL, elevated triglyceride (TG) levels (≥ 200 mg/dL), and an elevated HDL-C total cholesterol ratio (TC/HDL -C>5) (6) Diabesity coexistence of BMI over 30 and diabetes (7). Glycemia values were classified according to the criteria of the American Diabetes Association (8).

High cholesterol from 200 mg/Dl (9) and Formulas for VAI and for DAI (10,11):

VAI = [WC(cm)/(39.68+(1.88*BMI))]*(TG/1.03)*(1.31/HDL) for males and VAI = (WC(cm)/ (36.58+(1.89*BMI)))*(TG/0.81)*(1.52/HDL) for females.

DAI=[WC/[22.79+[2.68*BMI]]]*[triglycerides (TG, mmol/L)/1.37]*[1.19/high density lipoprotein-cholesterol (HDL-C, mmol/L)] for male and [WC/[24.02+[2.37*BMI]]]*[TG(mmol/L)/1.32]*[1.43/HDL-C(mmol/L)] for female.

The study was approved by the Clinical Research Ethics Committee of the Balearic Islands Health Area (IB 4383/20).

Statistical analysis

For the statistical study, a descriptive analysis of the categorical variables was performed, calculating the frequency and distribution of responses in each variable. In the case of quantitative variables, the mean and standard deviation were calculated. To assess the normality of the sample, the Kolmogorov-Smirnov test was applied. To assess the utility of the different methods in the prediction of metabolic syndrome with the three methods, ROC curves were made and the area under the curve (AUC) was determined as the cut-off points with their sensitivity, specificity, and Youden index when AUC>0.8. Statistical analysis was performed using the SPSS 27.0 program, with the

Table 1: Percentage distribution according to the sex of the parameters and methods included in the study

Parameters and estimation methods	Male (N=246061)		Female (N=172282)		p- value
	Normal	High	Normal	High	
	%	%	%	%	
Glycemia	92.35	7.65	96.16	3.84	**<0.0001**
Arterial hypertension	71.21	28.79	86.46	13.54	**<0.0001**
Triglycerides	76.12	23.88	92.02	7.98	**<0.0001**
Cholesterol	59.87	40.13	63.07	36.93	**<0.0001**
Diabesity	96.68	3.32	98.36	1.64	**<0.0001**
AD	92.27	7.73	96.02	3.98	**<0.0001**
LT	97.81	2.19	99.00	1.00	**<0.0001**
CHTG	91.70	8.30	98.44	1.56	**<0.0001**

AD-atherogenic dyslipidemia. LT-lipid triad. CHTG-hypertriglyceremic waist. Statistical sensitivity- $p < 0.05$

accepted level of statistical significance being 0.05.

Results

The percentage values of all the parameters and assessment methods used were higher in men than in women (p<0.0001) (**Table 1**).

The VAI values are always higher than the DAI values, and higher in men, both increase according to HT and blood glucose levels and with the presence of diabesity, hyper-triglyceridemic waist phenotype (HTWP), LT, and AD (p<0.0001) (p<0.0001) (**Table 2**).

The associative value of VAI and DAI is high in both sexes for HTWP, LT, and AD with AUC>0.9 in all cases. In diabesity, it only exceeds AUC>0.8 for VAI in both sexes, and for diabetes, both VAI and DAI only in women (AUC>0.8), in men AUC<0.8. In HT, VAI and DAI do not show associative capacity in men or women (AUC<0.7) (**Table 3**) (**Figures 1, 2, and 3**).

Discussion

The modern concept of obesity implies a determination that accompanies the classic estimate of the Body Mass Index (BMI) and its typification into degrees with greater precision depending on the type of obesity. For this reason, it is recommended to introduce the measurement of visceral and body fat tissue into the routine of daily practice, if possible with ultrasonographic measurement of both fatty tissue deposits (12). The results of the Quebec Health Survey show that the additional and simultaneous measurement and interpretation of other parameters such as waist circumference and fasting triglyceride concentrations to BMI can improve the physician's ability to identify subjects with abdominal obesity, and atherogenic and diabetogenic profiles. In addition, this high-risk clinical phenotype is very common in adults (13,14).

The cost of these techniques, which are not accessible in primary care, leads to the use of indirect methods, among which we incorporate the VAI and the DAI in our work.

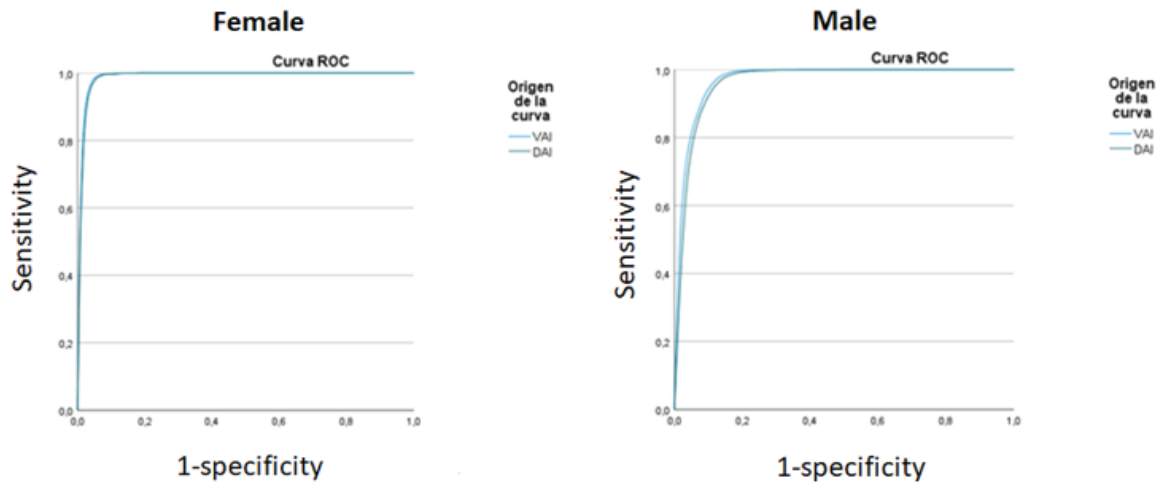
The associative value of these indices in cardiovascular and metabolic risk with the different parameters and estimation methods included in our study is based on previous references collected by other authors. The aforementioned work by Lemieux I et al refers to the association of a triad of metabolic markers (high levels of insulin and apolipoprotein B, and small, dense, low-density lipoprotein particles) with a substantially increased risk of arterial coronary disease and the simultaneous presence of a high waist circumference and moderate hypertriglyceridemia is associated with this atherogenic metabolic triad and a probability of more than 80% of the risk in cardiovascular health.

In our study, the associative capacity of the VAI and DAI adiposity indices in relation to the lipid triad was very high, as is the case with the hypertriglyceridemic waistline and atherogenic dyslipidemia. Previous works indicate that despite controlling the lipid risk factors, a residual risk persists, especially if non-insulin-dependent diabetes mellitus, obesity, or metabolic syndrome are added, in what has been called the lipid triad (15). Acting in prevention in this triad means reducing cardiovascular risk. This implies a comprehensive approach and it is expected that future prospective investigations will confirm the

Table 2: Mean values of VAI and DAI by sex according to the parameter and method used.

Parameters and estimation methods		n	Female				n	Male			
			VAI		DAI			VAI		DAI	
			mean (dt)	p	mean (dt)	p		mean (dt)	p	mean (dt)	p
Arterial hypertension		87498	2.41 (1.31)	**<0.0001**	0.86 (0.51)	**<0.0001**	52405	5.63 (4.40)	**<0.0001**	0.74 (0.53)	**<0.0001**
	PreHTA	64274	2.86 (1.75)		0.96 (0.68)		127372	7.00 (5.86)		0.87 (0.68)	
	HTA 1	16293	3.41 (2.06)		0.62 (0.33)		51375	9.13 (7.81)		1.08 (0.87)	
	HTA 2	4217	3.84 (2.73)		0.72 (0.43)		14909	10.95 (9.25)		1.24 (0.98)	
Glycemia	Normal	152613	2.60 (1.50)	**<0.0001**	0.67 (0.38)	**<0.0001**	191102	6.72 (5.48)	**<0.0001**	0.84 (0.63)	**<0.0001**
	Prediabetes	17378	3.36 (2.09)		0.84 (0.52)		46211	9.09 (7.74)		1.08 (0.87)	
	Diabetes	2291	4.82 (3.59)		1.20 (0.88)		8748	13.15 (12.29)		1.49 (1.34)	
AD	No	165431	2.51 (1.18)	**<0.0001**	0.64 (0.30)	**<0.0001**	227030	6.34 (4.64)	**<0.0001**	0.80 (0.55)	**<0.0001**
	Yes	6851	7.50 (3.27)		1.87 (0.82)		19031	20.01 (10.68)		2.25 (0.18)	
LT	No	170566	2.65 (1.47)	**<0.0001**	0.68 (0.36)	**<0.0001**	240669	7.01 (5.47)	**<0.0001**	0.87 (0.62)	**<0.0001**
	Yes	1716	8.41 (5.23)		2.10 (1.31)		5392	24.44 (16.80)		2.76 (1.85)	
Diabesity	No	169448	2.67 (1.60)	**<0.0001**	0.68 (0.40)	**<0.0001**	237903	7.14 (6.07)	**<0.0001**	0.89 (0.70)	**<0.0001**
	Yes	2834	4.78 (2.90)		1.17 (0.71)		8158	14.78 (11.66)		1.54 (1.20)	
CHTG	No	169586	2.61 (1.41)	**<0.0001**	0.67 (0.35)	**<0.0001**	225630	6.21 (4.28)	**<0.0001**	0.79 (0.52)	**<0.0001**
	Yes	2696	8.74 (3.50)		2.14 (0.87)		20431	20.42 (10.88)		2.28 (1.18)	

VAI- visceral adiposity index. DAI- dysfunctional adiposity index. AD-atherogenic dyslipidemia. LT-lipid triad. CHTG-hypertriglyceremic waist. Statistical sensitivity- $p < 0.05$



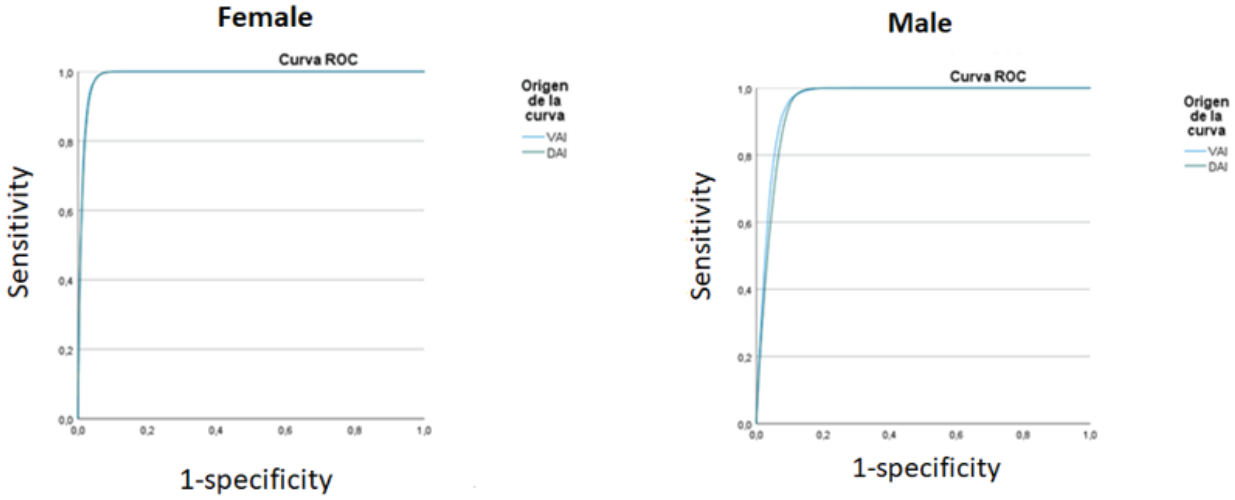
VAI Cut-off point 5.4 sensitivity 0.966 specificity 0.961 Youden 0.927
DAI Cut-off point 1.34 sensitivity 0.96 specificity 0.959 Youden 0.919

VAI-AUC 0,989 (CI95%0,989-0,990) **DAI-AUC 0,988 (CI95%0,987-0,988)**

VAI Cut-off point 11.45 sensitivity 0.916 specificity 0.915 Youden 0.831
DAI Cut-off point 1.34 sensitivity 0.911 specificity 0.906 Youden 0.817

VAI-AUC 0,970 (CI95%0,969-0,971) **DAI-AUC 0,963 (95%0,962-0,964)**

Figure 1: Associative relationship between the VAI and the DAI in the estimation of the CHTG comparative by sex according to the area under the ROC Curve



VAI Cut-off point 4.81 sensitivity 0.960 specificity 0.959 Youden 0.919
DAI Cut-off point 1.21 sensitivity 0.961 specificity 0.957 Youden 0.918

VAI-AUC 0,988 (CI95% 0,988-0,989) **DAI-AUC 0,988 (CI95% 0,987-0,988)**

VAI Cut-off point 11.82 sensitivity 0.923 specificity 0.920 Youden 0.843
DAI Cut-off point 1.37 sensitivity 0.914 specificity 0.912 Youden 0.826

VAI-AUC 0,966 (CI95%0,965-0,967) **DAI-AUC 0,960 (CI95% 0,959-0,961)**

Figure 2: Associative relationship of the VAI and DAI in the estimation of the AD Comparative by sex according to the area under the ROC Curve

benefit obtained with their results (16).

In the case of the hypertriglyceremic waist, our results are confirmed by previous studies that highlight the importance of identifying subclinical atherosclerosis, where abdominal visceral adiposity can improve risk stratification beyond traditional cardiovascular risk factors, being the waist hypertriglyceridemic, a marker of visceral adiposity that is associated with high-risk features and is confirmed as an independent marker of high-risk atherosclerotic features (17).

Finally, for HT our work has shown low associative capacity of VAI and DAI. In previous studies, other

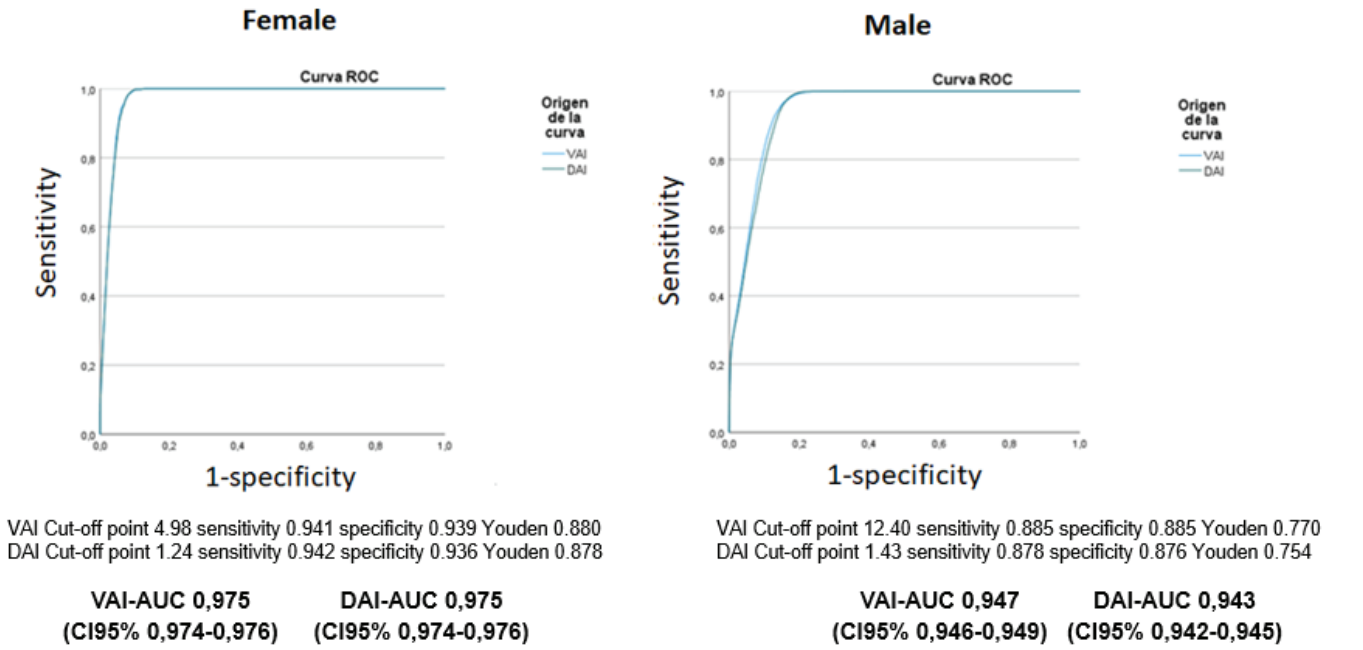


Figure 3: Associative relationship of the VAI and DAI in Estimation of the LT comparative by sex according to the area under the ROC Curve

authors obtained similar results when evaluating the ability of different obesity indices, including VAI, as indicators with associative capacity of hypertension in high-risk populations. VAI was shown to be weakly associated with the risk of HT, but to a lesser extent than others, with waist circumference standing out in this work (18). The strength of this work is considered to be its sample size, the use of specific adiposity indices such as the VAI and the DAI in the prediction of cardiometabolic risk, and the comparison made with the different methods and parameters used. The greatest weakness is not having a comparison by labor sectors in this extensive population sample, being a cross-sectional study and doubts in the generalization of the results.

Conclusions

The estimation of cardiometabolic risk is different in men and women and varies depending on the method used. The VAI and DAI adiposity indices increase their mean values as the risk in the cardiometabolic risk parameters increases. The values of VAI are always higher than those of DAI and both show high associative capacity in cardiometabolic risk,

Table 3: Associative relationship-ROC curves-Area under the curve in the different parameters and estimated methods

Parameters and estimation methods	Female		Male	
	VAI	DAI	VAI	DAI
	AUC (CI 95%)	AUC (CI 95%)	AUC (CI 95%)	AUC (CI 95%)
HTA	0.669 (0.665-0.673)	0.660 (0.656-0.664)	0.662 (0.660-0.665)	0.638 (0.635-0.640)
Diabetes	0.709 (0.703-0.716)	0.701 (0.694-0.707)	0.693 (0.689-0.697)	0.671 (0.667-0.675)
CHTG	0.989 (0.989-0.990)	0.988 (0.987-0.988)	0.970 (0.969-0.971)	0.963 (0.962-0.964)
Diabesity	0.805 (0.798-0.813)	0.787 (0.779-0.795)	0.814 (0.810-0.818)	0.756 (0.751-0.781)
AD	0.988 (0.988-0.989)	0.988 (0.987-0.988)	0.966 (0.965-0.967)	0.960 (0.959-0.961)
LT	0.975 (0.974-0.976)	0.975 (0.974-0.976)	0.947 (0.946-0.949)	0.943 (0.942-0.945)

VAI- visceral adiposity index. DAI- dysfunctional adiposity index. AUC-area under the ROC curve. AD- atherogenic dyslipidemia. LT-lipid triad. CHTG-hypertriglyceremic waist. statistical sensitivity- $p < 0.05$

especially in atherogenic dyslipidemia, lipid triad and hypertriglyceremic waist in both sexes. In diabesity and arterial hypertension its associative capacity is moderate.

Conflict of interest

The authors report no conflict of interest.

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Ethical approval:

The study was approved by the Clinical Research Ethics Committee of the Balearic Islands Health Area (IB 4383/20).

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Contributions

Research concept and design: **TVH, MES, AALG**
Data analysis and interpretation: **TVH, VRIT**
Collection and/or assembly of data: **MES, VRIT, AALG**
Writing the article: **TVH, MES, VRIT, AALG**
Critical revision of the article: **TVH**
Final approval of the article: **TVH, MES, VRIT, AALG**

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