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Applicatility of the visceral adiposity index (VAI) in the prediction of the components of the metabolic syndrome in elderly

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Abstract

The nutritional assessment may detect a state of malnutrition, overweight and cardiometabolic risk in the elderly. Easy to apply instruments enable the identification of risk factors for cardiovascular diseases (CVD).

***Objective:* to analyze the applicability of Visceral Adiposity Index (VAI) in the prediction of MS components in the elderly.**

***Methods:* cross-sectional study with 221 elderly at a mean age of 70.65 ± 7.34 years; 53.4% female and 46.4% male. Weight, height, waist circumference (WC), fasting glucose, triglycerides (TG), total cholesterol (TC), HDL cholesterol (HDL-C), LDL cholesterol (LDL-C), and blood pressure (BP), data was obtained, as well as information about lifestyle. There were calculated the Body Mass Index (BMI), the Waist-Hip Ratio (WHR), and the VAI. The adiposity measures were compared with the components of MS, and for the VAI there was determined the capability of predicting the occurrence of MS components.**

***Results:* by analyzing the association among the biochemical and pressoric variables and MS components with the anthropometric indicators of obesity, there was a direct and significant correlation of the BMI, the weight and the VAI with blood glucose, HDL and TG (p<0.01); the VAI was the indicator with the strongest correlation for all parameters. The WC associated significantly with the HDL and the TG, and the WHR only with the HDL. Regarding to the applicability of the VAI in the determination of the relative risk of occurrence of MS components, the VAI was good predictor of abdominal obesity (OR = 1.27, p<0.001), hyperglycemia (OR = 1.10, p=0.043), hypertriglyceridemia (OR = 3.64, p<0.001) and low HDL-c (OR = 2.26, p<0.001).**

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APLICABILIDAD DE LA ADIPOSIDAD VISCERAL DEL ÍNDICE VAI EN LA PREDICCIÓN DE COMPONENTES DEL SÍNDROME METABÓLICO EN ANCIANOS

Resumen

La evaluación nutricional puede detectar un estado de desnutrición, sobrepeso y riesgo cardiometabólico en los ancianos. Fácil de aplicar, los instrumentos permiten la identificación de factores de riesgo de enfermedades cardiovasculares (ECV).

***Objetivo:* analizar la aplicabilidad del Índice de Adiposidad Visceral (VAI) en la predicción de los componentes del SM en los ancianos.**

***Métodos:* estudio transversal con 221 personas mayores con una edad media de 70,65 ± 7,34 años; 53,4% mujeres y 46,4% hombres. Se obtuvieron peso, talla, circunferencia de la cintura (CC), glucosa en ayunas, triglicéridos (TG), colesterol total (CT), colesterol HDL (HDL-C), colesterol LDL (LDL-C) y presión arterial (PA), así como información acerca del estilo de vida. No se calcularon el índice de masa corporal (IMC), la relación cintura-cadera (WHR) y el VAI. Las medidas de adiposidad se compararon con los componentes de la MS, y para el VAI no se determinó la capacidad de predecir la ocurrencia de los componentes del SM.**

***Resultados:* el análisis de la asociación entre las variables bioquímicas y de presión y los componentes del SM con los indicadores antropométricos de obesidad evidencia que existe una correlación directa y significativa entre el índice de masa corporal, el peso y el VAI con la glucosa en sangre, colesterol HDL y TG (p < 0,01); el VAI fue el indicador con la correlación más fuerte para todos los parámetros. El WC se asoció significativamente con el HDL y TG, y el RHO solo con el HDL. En lo que respecta a la aplicabilidad de la VAI en la determinación del riesgo relativo de aparición de los componentes del SM, el VAI era buen predictor de obesidad abdominal (OR = 1,27, p < 0,001), hiperglucemia (OR = 1,10, p = 0,043), hipertrigliceridemia (OR = 3,64, p < 0,001) y bajos niveles de HDL-c (OR = 2,26, p < 0,001).**

Conclusion: **the VAI showed association with components of the metabolic syndrome in men and women with increased risk of abdominal obesity, hyperglycemia, hypertriglyceridemia, and low HDL-c, proving to be a good predictor of MS components in the elderly.**

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Key words: *Elderly. Metabolic syndrome. Abdominal obesity.*

Conclusión: **el VAI mostró asociación con componentes del síndrome metabólico en los hombres y las mujeres con mayor riesgo de obesidad abdominal, hiperglucemia, hipertrigliceridemia y bajos niveles de HDL-c, demostrando ser un buen predictor de componentes del SM en los ancianos.**

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Palabras clave: *Ancianos. Síndrome metabólico. Obesidad abdominal.*

Abreviaturas

WC: Waist Circumference.
TC: Total Cholesterol.
CVD: Cardiovascular Diseases.
DM 2: Diabetes Mellitus type 2.
BMI: Body Mass Index.
HDL-c: High Density Lipoprotein.
LDL-c: Low Density Lipoprotein.
BP: Blood Pressure.
DBP: Diastolic Blood Pressure.
SBP: Systolic Blood Pressure.
WHR: Waist to Hip Ratio.
MS: Metabolic Syndrome.
TRI. Triglycerides.
VAI: Visceral Adiposity Index.

Introduction

Population aging is a global reality and Brazil is one of the developing countries that have been hit by the challenging process; that means to face this new reality with creative and viable solutions. To improve life quality of the elderly is a fundamental goal that must be achieved by the social and health policies, responsible for preserving the vitality of each elder. Statistical projections of the World Health Organization (WHO) showed that the number of elderly people in Brazil, in the period from 1950 to 2025, will increase 15 times, while the rest of the population will increase 5 times. Thus, in 2025, Brazil will be the 6th country with about 32 million people over 60 years old[1].

The nutritional assessment may detect a state of malnutrition, overweight and cardiometabolic risk in the elderly to prevent the metabolic syndrome (MS). The prevalence of metabolic syndrome in the elderly is quite high, indicating the need for systematic actions of health professionals in control of risk factors, through strategies of prevention and comprehensive care to the elderly[2].

The MS is defined as a complex disease, represented by a number of cardiovascular risk factors, usually related to the accumulation of abdominal fat and to insulin resistance[3]. The presence of MS is defined according to the criteria of the National Cholesterol Education Programs - Adult Treatment Panel III (NCEPATP III), representing the combination of at least three components: Abdominal obesity (waist circumference >102 cm for men and >88 cm for women); elevated triglycerides (≥150 mg/dL); low HDL cholesterol (<40 mg/dl for men and <50 mg/dl for women); high blood pressure (systolic ≥130 mmHg or diastolic ≥85 mmHg); and increased fasting plasma glucose (≥ 110 mg/dl)[4].

The visceral adipose tissue is a metabolically active organ and the intra-abdominal obesity is an independent risk factor for the metabolic alterations present in the MS[5], which is associated with the development of cardiovascular diseases (CVD) and type 2 diabetes mellitus (T2DM) in children, adolescents and adults[6,7,8]. Exams of image such as computed tomography (CT) can contribute for an excellent diagnosis of metabolic syndrome, however CT is difficult to apply, high cost[9].

Amato and collaborators[4], in a study with a European population, validated a visceral obesity indicator called Visceral Adiposity Index (VAI). The formula takes into account the gender and combines anthropometric measures (waist circumference (WC) and body mass index (BMI)) with biochemical tests triglycerides (TG) and low-density lipoprotein (HDL-C). According to the study, the VAI is an indicator of the function of the visceral adipose tissue and its increase is correlated independently with cardiovascular and cerebrovascular risk. Another study that evaluated the applicability of the VAI in SM prediction showed that it has a significant relation with its components[10].

This study aimed at evaluating the applicability of the VAI as a predictor of MS components in the elderly, because in 2015 Brazil will be the 6th country with the highest number of elderly people seeking for a better quality of life[1]. It was performed by comparing with other anthropometric indicators (BMI, WC, WHR) and its isolated association with risk of MS, in a sample of elderly people in a town of Taquari Valley in the state of Rio Grande do Sul - Brasil.

Methods

The study was conducted in a town in the countryside of Taquari Valley, Rio Grande do Sul - Brazil, after approval by the Research Ethics Committee (CEP/PUC RS), certified by the National Board of Health, under protocol number 0603359, of the Pontifícia Universidade Católica do RS. It is a cross-sectional study, the sample is composed of 221 elderly, of the Basic Health Units of the municipality, who agreed to take part of the research. The participants were included as they appeared in the Basic Health Unit and agreed to participate, where after they signed the Informed Consent Form, and were directed to nutritional consultation. The anthropometric evaluation was performed. There were measured the Blood pressure (BP), weight (kg), height (m) and waist circumference (cm), for subsequent calculation of BMI (kg/m^2) and waist-to-height ratio (WHtR - WC divided by height, both in centimeters). The elderly people who agreed to participate of the study answered a structured questionnaire in which sociodemographic data was recorded. Clinical measurements - weight, height, abdominal circumference and blood pressure - were performed by trained researchers. The weight and height were evaluated with an anthropometric scale with coupled stadiometer Welmy®. The calculation of the Body Mass Index (BMI) was performed considering the weight in kilograms divided by the square of height in meters and classified according to the criteria of the World Health Organization.

The abdominal circumference was measured with inelastic tape at the midpoint between the last rib and the anterior superior iliac crest, at the end of respiratory movement of expiration, standing. The cutoff points for WC adopted were those set by the World Health Organization[13] and NCEP-ATP III[2], being considered abdominal obesity WC≥102 cm for men and ≥88 cm for women[14].

The blood pressure was measured in both arms, the patient seated after 10 minutes rest, with an aneroid sphygmomanometer previously calibrated, using the average of the two values that have been found.

The blood samples were taken with fasting for 12 hours and then analyzed in the Laboratory Hermann Ltda, of Lajeado. For serum glucose, total cholesterol, HDL-c and triglycerides there were used materials of Labtest® brand. The samples were analyzed by enzymatic colorimetric method in semi-automation equipment. For the interpretation of the results, there were used as reference the cutoff points of the Brazilian Society of Diabetes[16] and the Brazilian Society of Cardiology[16]; being blood glucose <100 mg/dl, TC <200 mg/dl, desirable LDL-C <130 mg/dl, desirable HDL-c >40 mg/dl for men and> 50 mg/dl for women, and TG <150 mg/dl.

The Visceral Adiposity Index (VAI) was calculated by using the formula proposed by Amato and collaborators[4]: VAI = (WC(cm)/(39,68+(1.88*BMI) *(TG/1.03) *(1.31/HDL) for men and VAI = (WC(cm)/(36,58+(BMI *1.89) *(TG/0.81) *(1.52/HDL) for women.

The data was analyzed by using the SPSS Statistics software of IBM®, version 20.0.

The significance level adopted was 5% ($p<0.05$). There were performed descriptive univariate statistics (mean, standard deviation and frequency) and bivariate (Student's t test for independent samples and U Mann-Whitney test, correlations of Pearson and Spearman and binary logistic regression). The Kolmogorov-Smirnov test was used to evaluate if the variables followed the normal distribution. The variables with normal distribution were analyzed by the Student's t test and Pearson correlation, and those that did not follow normal distribution were analyzed through the non-parametric Mann-Whitney and Spearman correlation tests. The Pearson correlation and Spearman tests were conducted to correlate the analyzed anthropometric, biochemical and blood pressure parameters; and the Student's t test for independent samples and Mann-Whitney were applied to compare age, blood pressure and the anthropometric and biochemical profiles between genders. The binary logistic regression was performed to analyze the predictive power of the VAI regarding to the components of MS.

Results

The socioeconomic, demographic and lifestyle characteristics of the sample are described in Table 1.

In table II, there are described the mean values of age, biochemical, anthropometric and blood pressure parameters in the general sample, and stratified according to the gender. There was significant difference between the genders for WC, WHR, weight, VAI, TC, HDL, LDL and TG, and the WC, WHR, and weight were significantly higher among men; and VAI, TC, HDL, LDL and TG were significantly higher among women.

By analyzing the association between biochemical variables and blood pressure components of MS with the anthropometric indicators of obesity, there was a direct and significant correlation of the BMI, the weight and the VAI with the blood glucose, the HDL and the TG ($p<0.01$), and the VAI was the indicator with the strongest correlation for all the parameters. The WC was significantly associated with the HDL and the TG, and the WHR only with the HDL. The significance values (p) and correlation coefficients (r) can be checked in Table 3, as well as the stratification according to the gender.

By evaluating specifically the VAI, among women it was significantly associated with the blood glucose, the HDL and the TG, and the increase of VAI is accompanied by an increase of blood glucose and TG and a reduction of HDL. Among men, the VAI correlates with blood glucose, HDL, TG and SBP, and an increase of the VAI implies in a linear increase of blood glucose, TG and SBP and reduction of HDL. Among the indicators of obesity, the VAI obtained the strongest correlation with components of MS, according to the results of Table 3. By analyzing the applicability of

Table I
Socioeconomic, demographic and lifestyle of the sample characteristics

Categorical variables [*n* 221]	n	%
Gender		
Female	118	53,4
Male	103	46,6
Living Zone		
Urban	83	37,6
Rural	138	62,4
Marital Status		
Married	140	63,3
Widow(er)	74	33,5
Divorced	4	1,8
Smoke		
No	138	62,4
Yes	61	27,6
Retired		
No	14	6,3
Yes	207	93,7
Schooling		
Illiterate	13	5,9
Up to Primary (4th year)	50	22,6
Up to 7th year	144	65,2
Up to Upper Secondary education	10	4,5
Systolic Blood Pressure		
Normal	65	29,4
High	156	70,6
Diastolic Blood Pressure		
Normal	158	71,5
High	63	28,5
Waist Circumference		
Normal	182	82,4
High	39	17,6
Glycemia		
Normal	197	89,1
High	24	10,9
HDL cholesterol		
Normal	160	72,4
Low	61	27,6
Triglycerides		
Normal	160	72,4
High	61	27,6

Table I ***(cont.)***
Socioeconomic, demographic and lifestyle of the sample characteristics

Continuous Variables [*n* 221]	Média	Desvio Padrão
Age	70,65	7,34
Systolic Blood Pressure	133,36	17,76
Diastolic Blood Pressure	81,54	9,60
Income in Minimum Salaries	1,59	1,03
Number of people in the House	2,39	1,25
Weight (kg)	69,50	13,62
Body Mass Index (kg/m²)	26,54	4,68
Waist Circumference (cm)	85,86	8,52
Waist to Hip Ratio (WHR)	0,92	0,57
Glycemia (mg/dL)	92,08	26,25
Total Cholesterol (mg/dL)	223,28	52,49
LDL cholesterol (mg/dL)	142,81	45,36
HDL cholesterol (mg/dL)	53,91	16,07
Triglycerides (mg/dL)	129,55	66,62
Visceral Adiposity Index (VAI)	4,41	3,55

Categorical variables: Frequencies described in percentages (%). Continuous variables: Frequency described in Mean and Standard Deviation

the VAI to determine the relative risk of occurrence of the MS components, the VAI was good predictor of abdominal obesity (OR=1.27, p<0.001), hyperglycemia (OR=1.10, p=0.043), hypertriglyceridemia (OR=3.64, p<0.001) and low HDL-c (OR=2.26, p<0.001). The results can be checked in Table IV.

Discussion

There is still an absence of studies using the VAI to evaluate cardiometabolic risk in the elderly. Some results already outlined stand out, where the studied anthropometric indexes (BMI, Waist Circumference (WC), Hip Circumference (HC), Waist/Hip Ratio (WHR), Body Adiposity Index (BAI), and Visceral Adiposity Index (VAI) and several adipocytokines (visfatin, resistin, leptin, adiponectin, ghrelin, adipsin), the VAI had a greater relation with the adipocytokines and the lipids, showing to be effective to evaluate the adiposity[16].

By analyzing specifically the VAI, the study of Knowles *et al.*[17] found an association with all the components of MS; being stronger for hypertriglyceridemia and low HDL-c in both genders, similar to the results of this study, where the VAI also had higher correlation with HDL-C and TG. Considering that these two biochemical parameters (TG and HDL-c) comprises the VAI formula, there can be established a hypothesis

Table II
Characterization of the sample according to average values of age and anthropometric, biochemical and blood pressure parameters.

	Average (SD) General [*n* 221]	Average (SD) ♀ [*n* 118]	Average (SD) ♂ [*n* 103]	p
Age	70,65 (7,34)	71,19 (7,95)	70,03 (6,57)	0,459
BMI	26,54 (4,68)	26,85 (4,50)	26,19 (4,88)	0,297
WC	85,86 (8,52)	84,05 (8,53)	87,93 (8,06)	0,001
WHR	0,92 (0,57)	0,91 (0,78)	0,92 (0,07)	<0,001
Weight	69,50 (13,62)	65,40 (10,89)	74,19 (14,91)	<0,001
VAI	4,41 (3,55)	5,23 (3,95)	3,48 (2,76)	<0,001
Glucose	92,08 (26,25)	93,63 (30,73)	90,29 (19,93)	0,595
TC	223,28 (52,49)	235,81 (54,38)	208,91 (46,48)	<0,001
HDL-c	53,91 (16,06)	55,85 (16,63)	51,69 (15,17)	0,038
LDL-c	142,81 (45,36)	151,34 (46,32)	133,20 (42,46)	0,003
TG	129,55 (66,62)	137,80 (68,47)	120,10 (63,47)	0,006
SBP	133,36 (17,75)	132,86 (17,80)	133,93 (17,78)	0,870
DBP	81,54 (9,60)	80,51 (8,25)	82,73 (10,86)	0,142

SD = Standard Deviation; ♀ = Female Gender; ♂ = Male Gender; Body Mass Index (BMI) = weight in kg divided by height in square meters; WC = waist circumference in centimeters; WHR = waist-hip ratio; Visceral Adiposity Index = VAI. Glucose levels, TC (total cholesterol); HDL-c (HDL cholesterol), LDL-c (LDL cholesterol) and TG (triglycerides) described in mg/dL. SBP (systolic blood pressure) and DBP (diastolic blood pressure) described in mmHg. Student's t test (parametric variables) or Mann-Whitney test (non-parametric variables) for comparison between the genders, considering significant p<0.05 (5%).

for such association. Assessing the risk of MS components through the adiposity indicators, the VAI proved to be the best predictor of increased TG and decreased HDL-C, in agreement with the findings of this study.

In a study[18] conducted with 528 adult subjects with a mean age of 51.3 ± 12.8 years old, with the objective of evaluating the existent correlation among the obstructive sleep apnea, VAI and metabolic syndrome, the visceral adiposity index increased with the resistance to insulin, but did not predict the severity of sleep apnea. This data suggests interactions related to the gender and obstructive sleep apnea, obesity and metabolic disorders. The visceral adiposity index was a good marker of the metabolic syndrome, but not of obstructive sleep apnea[18].

According to Schuster *et al*[19], there was a significant difference between the genders for all the parameters, except LDL-c and DBP, and the age, BMI, WC, WHtR, blood glucose and SBP were significantly higher among males, and %BF (body fat percentage), VAI, TC, HDL-c and TG were significantly higher among women. Unlike this study, not all the parameters were significant between the genders, where there was a significant difference between genders for WC, WHR, weight, VAI, TC, HDL, LDL and TG; the WC, WHR and weight were significantly higher among men, and VAI, TC, HDL, LDL and TG were significantly higher among women.

Analyzing the applicability of the VAI to determine the relative risk of occurrence of the components of MS, in the study of Schuster al[19], the VAI was good predictor of abdominal obesity (OR=1.86, p<0.01), hypertriglyceridemia (OR=30.74, p<0.001) and low HDL-c (OR=3.95, p <0.001). Among the indicators of obesity, the VAI showed higher area under the curve for increased TG and low HDL; similar data was found in this study, except for hyperglycemia, in this study the VAI, in determining the relative risk of occurrence of components of the MS, the VAI was good predictor of abdominal obesity (OR=1.27, p<0.001), hyperglycemia (OR=1.10, p= 0.043), hypertriglyceridemia (OR=3.64, p<0.001) and low HDL-c (OR=2.26, p<0.001).

It still lacks prospective studies that can assign a prognostic role for the VAI regarding to the cardiovascular risk. Given the simplicity of measurement of TG, WC, and BMI, and assessment of HDL cholesterol, the VAI would be an easy tool for evaluating the dysfunction of the adipose tissue associated to the cardiometabolic risk in several populations[20].

The limiting factor of this study was the lack of studies applying the VAI in the elderly. Therefore, the data of this study were compared with adults, because there is no one described with the elderly in the literature.

Conclusion

The VAI showed association with components of MS in older men and women at increased risk of ab-

Table 3.
Correlation between the biochemical and blood pressure components of the Metabolic Syndrome with anthropometric indicators of obesity.

General Sample										
[*n*221]	**BMI**		**WC**		**WHR**		**Weight**		**VAI**	
	r	p	r	p	r	p	r	p	r	p
Glucose	0,228	0,001	0,073	0,278	0,093	0,168	0,178	0,008	0,242	0,013
HDL-c	-0,270	<0,001	-0,211	0,002	-0,247	<0,001	-0,293	<0,001	-0,696	<0,001
TG	0,326	<0,001	0,162	0,016	0,130	0,054	0,229	0,001	0,922	<0,001
SBP	0,049	0,469	0,000	0,996	0,050	0,460	0,046	0,493	0,126	0,061
DBP	-0,088	0,190	0,021	0,751	0,068	0,312	-0,021	0,760	0,033	0,628
Women										
[*n*118]	**BMI**		**WC**		**WHR**		**Weight**		**VAI**	
	r	p	r	p	r	p	r	p	r	p
Glucose	0,243	0,008	0,143	0,123	0,099	0,286	0,162	0,080	0,212	0,021
HDL-c	-0,159	0,085	-0,191	0,038	-0,246	0,007	-0,167	0,071	-0,833	<0,001
TG	0,237	0,010	0,331	<0,001	0,248	0,007	0,258	0,005	0,927	<0,001
SBP	0,017	0,856	0,001	0,991	0,038	0,681	0,025	0,790	0,076	0,414
DBP	-0,113	0,222	-0,003	0,977	0,072	0,443	-0,090	0,333	0,045	0,628
Men										
[*n*103]	**BMI**		**WC**		**WHR**		**Weight**		**VAI**	
	r	p	r	p	r	p	r	p	r	p
Glucose	0,218	0,027	0,032	0,747	0,185	0,061	0,250	0,011	0,298	0,002
HDL-c	-0,419	<0,001	-0,166	0,094	-0,228	0,021	-0,377	<0,001	-0,753	<0,001
TG	0,368	<0,001	0,083	0,406	0,304	0,002	0,369	<0,001	0,920	<0,001
SBP	0,076	0,443	0,012	0,907	0,099	0,320	0,092	0,357	0,194	0,050
DBP	-0,054	0,585	-0,001	0,922	-0,009	0,930	-0,034	0,730	0,136	0,171

r = correlation coefficient; Body Mass Index (BMI) = weight in kg divided by height in meters squared; WC = waist circumference in centimeters; WHR = waist-hip ratio; VAI = Visceral Adiposity Index. Glucose levels, TC (total cholesterol); HDL-c (HDL cholesterol), LDL-c (LDL cholesterol) and TG (triglycerides) described in mg/dL. SBP (systolic blood pressure) and DBP (diastolic blood pressure) described in mmHg. Pearson correlation test (parametric variables) or Spearman correlation (non-parametric variables) for the correlation among variables, considering significant p<0.05 (5%).

Table 4.
Effectiveness of the Visceral Adiposity Index in the evaluation of the Metabolic Syndrome (MS) risk from its relation with the components of MS.

Visceral Adiposity Index (VAI)						
[*n* 221]	**Regression coefficient**	**SE**	**Wald**	**p**	**OR**	**CI 95% (OR)**
Abdominal Obesity	0,237	0,056	18,071	<0,001	1,268	1,136 – 1,414
Hyperglycemia	0,093	0,048	3,746	0,043	1,097	0,999 – 1,205
Low HDL-c	0,817	0,114	51,335	<0,001	2,263	1,810 – 2,830
Hypertriglyceridemia	1,291	0,196	43,245	<0,001	3,638	2,476 – 5,346
SBP increased	0,011	0,041	0,068	0,794	0,989	0,913 – 1,072
DBP increased	0,021	0,044	0,222	0,638	0,979	0,898 – 1,068

Abdominal obesity, increased blood glucose, low HDL-c, hypertriglyceridemia, SBP and DBP increased: as parameters of the National Cholesterol Education Programs – Adult Treatment Panel III (NCEP-ATP III). SE = standard error; Wald: Wald test; p = significance of the Wald test; OR = odds ratio; 95% CI = 95% confidence interval.

dominal obesity, hyperglycemia, hypertriglyceridemia, and low HDL-c, proving to be a good predictor of MS components in the elderly. It is a simple instrument, easy to apply and low cost. Therefore, it may be used in other studies with the elderly to be an important tool in the detection of cardiometabolic risk of this population.

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