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ORIGINAL ARTICLE

Analysis of the Influence of Abdominal Obesity on Systemic Arterial Hypertension and on the Lipid Profile on Cardiometabolic Risk Stratification in Adult Women

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Abstract

Background: Obesity is a public health problem and has been associated with the development of metabolic disorders that have a strong relationship with the onset of cardiovascular diseases (CVD).

Objective: The objective was to analyze the influence of abdominal obesity (AO) on systemic arterial hypertension (SAH) and on the lipid profile in cardiovascular risk stratification in adult women.

Methods: Altogether, 91 women participated in the research. Lifestyle information was collected, in addition to the analysis of clinical measures of cardiovascular risk and biochemical parameters. Unpaired Student's t-test, logistic regression, and Pearson's correlation were performed for data analysis, with a value of $p < 0.05$ considered significant.

Results: The prevalence of AO was 62.6%. Logistic regression showed that AO increased the chance of developing SAH by 2.9-fold. The same behavior was observed in the TG/HDL-c lipid ratio (3.93 ± 0.3 vs. 2.16 ± 0.2), representing an 82% increase in obese women. The present study also demonstrated that the best anthropometric parameter to analyze cardiovascular risk in the studied population was the waist/height ratio (AUC = 0.707).

Conclusions: It can therefore be concluded that AO plays a significant role in the development of SAH and changes in lipid values that predict increased cardiovascular risk, configuring a strong influence factor for CVD.

Keywords: Obesity, Abdominal; Cardiovascular Diseases; Hypertension; Metabolic Syndrome; Risk Stratification; Adult; Women; Lipidic Metabolism; Hyperlipidemias.

Introduction

In Brazil, the prevalence of overweight individuals reaches values close to 60% of the total population. This is due to changes in the economic policies of the state that have been responsible for socioeconomic transformations in recent years, leading the country to a situation called epidemiological transition.[1]

This transition promoted changes in the morbidity and mortality profile of the population, thus replacing a profile where the main causes of death were due to infectious communicable diseases, for a new reality in which chronic non-communicable diseases (NCDs) are the main causes of morbidity and mortality in the country.[2-4]

This fact can be attributed to a better socioeconomic situation, associated with a greater consumption of refined, energy-dense, and lower-cost foods, favoring a significant increase in overweight and obesity, especially in developing countries.[4-6] Thus, obesity should be understood as an NCD that is characterized by excess body fat resulting from the imbalance between the individual's dietary intake and energy expenditure.[7,8]

Thus, obesity has become a major public health problem, since it has been associated with metabolic and

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hemodynamic risk factors that strongly contribute to the development of metabolic syndrome parameters, such as systemic arterial hypertension (SAH), dyslipidemias, insulin resistance (IR), and glucose intolerance.[9-11]

In the Northeast region, obesity has taken on alarming proportions and is associated with the increase in the incidence of SAH, especially in the female population, which has a significant prevalence of morbidities associated with the metabolic syndrome.[12] Thus, this study aimed to verify the influence of abdominal obesity on hypertension and lipid profile, as well as to evaluate the best anthropometric method to help stratify cardiometabolic risk in adult women.

Methods

Study type and location

This was an observational, quantitative, descriptive, cross-sectional study, developed between October 2016 and July 2017, through the collection and analysis of sociodemographic, biochemical, anthropometric data, and lifestyle habits in a convenience sample of 91 women over the age of 18 years living in the city of Petrolina, Pernambuco. These volunteers were recruited through an invitation made through social networks, and their participation in the research was manifested through their own request.

Ethical considerations

The present work respected the standards for research with human beings, established by the Declaration of Helsinki, and meets all ethical requirements according to Resolution 466/2012 of the National Health Council. The work meets the requirements of the Ethics and Deontology in Studies and Research Committee (CEDEP) of the Federal University of Vale do São Francisco, logged under protocol number CAAE 62537316.3.0000.5196.

All participants volunteered to participate by signing the Informed Consent Form (ICF), where they were instructed on the procedure to be performed and on the possible risks and benefits.

Data Collection Instrument

Data collection was performed in two stages. In the first stage, the volunteers answered a structured questionnaire containing sociodemographic and health questions, habits, lifestyle, and medication use. In the second stage, the participants were referred to perform a peripheral venipuncture to collect blood samples.

Obtaining and analyzing blood samples

Prior to blood sampling, all volunteers were instructed to fast for 12 to 14 hours and not to drink alcoholic beverages in the previous 72 hours. The samples were then stored in test tubes without anticoagulant to obtain serum and transported in thermal boxes to avoid alterations until the processing site, which took place on the same day of collection.

Fasting blood glucose, total cholesterol, HDL-cholesterol, and triglycerides were determined by specific colorimetric enzymatic methods (LABTEST, BR). The quantification of low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) was estimated by the Friedewald equation (FRIEDEWALD, 1972). From the lipid profile determinations, the lipid ratios indicating cardiovascular risk were determined: Total cholesterol/HDL-cholesterol (TC/HDL-c), LDL-cholesterol/HDL-cholesterol (LDL-c/HDL-c), and Triglycerides/HDL-cholesterol (TG/HDL-c).

Anthropometric measurements

Height, and abdominal and hip circumference measurements were obtained with an inextensible measuring tape. Weight was taken from a portable scale calibrated by the National Institute of Metrology, Standardization, and Industrial Quality (INMETRO).

To take the abdominal circumferences, the volunteers remained standing with arms extended along the body and feet together. For waist circumference measurement, the tape was positioned on the smallest curvature located between the last costal arch and the iliac crest, based on the techniques of Callaway and collaborators (1988).[13]

Blood pressure (BP) measurement

The measurement of systolic blood pressure (SBP) and diastolic blood pressure (DBP) was obtained by means of a portable pulse device, duly calibrated and validated by INMETRO. The volunteers remained seated with legs uncrossed, feet flat on the floor, and backs resting on the chair. The blood pressure levels were measured in two moments, the first after five minutes of rest in a calm environment (the patient was instructed not to talk during the measurement) and the second, 20 minutes after the first measurement. The arithmetic mean of the two measurements was used.

Diagnosis of abdominal obesity and hypertension

To diagnose an individual with SAH according to the VII Brazilian Guideline of Hypertension, 2016, the individuals had to present SBP and DBP with values equal to or greater than 140 mmHg and 90 mmHg, respectively, measured using a sphygmomanometer (SBC, 2016).[14]

According to the National Cholesterol Education Program's Adult Treatment Panel III - NCEP ATP III, to be diagnosed as abdominal obesity, a woman must have an abdominal circumference of 88 cm or more.[15,16]

Statistical Analysis

The database was built in Microsoft Excel program and exported to STATVIEW (version 5.0, 1998) and GraphPad Prism 5.01 programs. The population profile was evaluated by calculating percentage frequencies, where the respective distributions of abdominal obesity and hypertension frequencies were built, together with the lipid ratios of cardiovascular risk in the population in question. Previously, sample distribution normality was verified using the Kolmogorov-Smirnov Test.

The unpaired Student's t-test was performed to compare parameters of SAH and cardiovascular risk lipid ratios in women with and without abdominal obesity. Thus, continuous variables were described by mean ± standard deviation (SD). Pearson's coefficient descriptive statistics were used to verify the correlation between the increase in abdominal circumference and lipid ratios, and to correlate abdominal circumference with SBP and DBP in relation to SAH. In cases where the relationship was significant, odds ratios were calculated through logistic regression, used to measure the chance that obese people have of developing hypertension when compared to participants who are not obese. All conclusions were obtained considering the significance level of 5% and the 95% Confidence Interval (CI) ($p<0.05$), with all statistical analyses adjusted for age.

To identify the respective cut-off points, along with the sensitivity and specificity of the anthropometric methods, the Receiver Operating Characteristic (ROC) curve technique was performed using the MedCalc software (version 17.9) to discriminate the best relationship between abdominal obesity and cardiovascular risk among the anthropometric indicators.

Results

Abdominal obesity prevalence was 62.6%. From this, analyses of clinical and laboratory parameters were performed in two distinct groups – one with the presence and the other with the absence of abdominal obesity – in order to study its effect on such parameters.

When the presence or absence of abdominal obesity was assessed in relation to blood pressure levels, searching for a relationship between abdominal obesity and hypertension, it was observed that SBP and DBP values were altered when compared to non-obese women, as shown in Figure 1 (a) and (b), respectively. Nevertheless, no significant difference was observed between the ages of the two groups in this study: non-obese (44.3 ± 9.1) vs. obese (45.3 ± 8.7).

The correlation between the positivity of abdominal obesity and pressure parameters (SBP and DBP) was significant. Moreover, obesity was significantly associated with BP levels in women who had mean SBP and DBP values of higher than those of non-obese women.

To establish the odds ratio of a woman with abdominal obesity developing SAH, a logistic regression analysis was performed. Table 1 shows that abdominal obesity was associated with increased odds of an obese woman developing SAH.

It was found that the lipid ratios TC/HDL-c and LDL-c/HDL-c had a direct relationship with increasing obesity. Likewise, TG/HDL-c, which has a correlation with insulin resistance (IR), obtained the highest statistical difference with an odds ratio of approximately 82% higher in obese women compared to non-obese women, as presented in Figure 2. It was also observed that obese women had significantly higher values of lipid parameters compared to non-obese women. By contrast, a significant decrease in HDL-c values was observed in the group of obese women when compared to non-obese women, as presented in Table 2.

To evaluate whether waist-to-height ratio (WHtR) would be an ideal anthropometric parameter to analyze the correlation between abdominal obesity and cardiovascular risk, ROC curve analysis was performed. The best cutoff point for the anthropometric parameters was verified; thus, it was also possible to assess the parameter with the highest correlation in the identification of SAH in women, as shown in table 3.

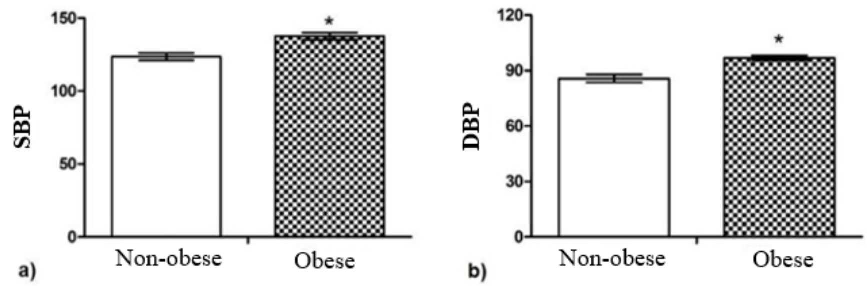

Figure 1 – Difference between blood pressure levels of women with and without abdominal obesity
SBP - Systolic Blood Pressure; DPB - Diastolic Blood Pressure.
Source: the author

Table 1 – Odds ratio of a woman with abdominal obesity developing SAH

Parameters	Odds Ratio	CI	P-value
SAH	2.9	1.1 – 4.2	0.0086*

**p<0.05. CI: confidence interval; p: significance level; SAH: systemic arterial hypertension.*
Source: the author

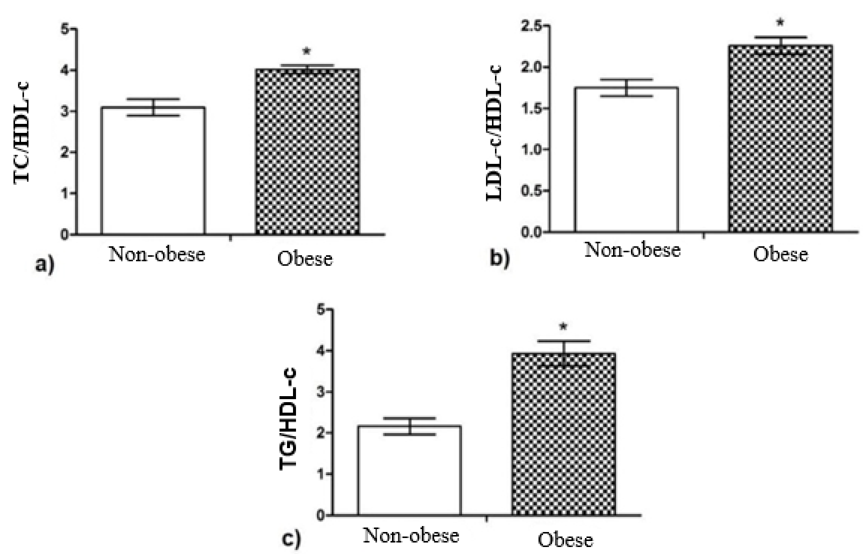

Figure 2 – Lipid ratios in womwn with presence and obsence of abdominal obesity.
All analyses were adjusted for the variable sex. TC (total cholesterol). TG (triglycerides). LDL-c (low density lipoprotein cholesterol). HDL-c (high-density lipoprotein cholesterol).
Source: the author

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Table 2 – Clinical and laboratory parameters obtained with the group of obese and non-obese women

	PARAMETERS	STANDARD DEVIATION (±)	P-value
SBP			
Obese	137.5 mmHg	2.5 mmHg	<0.0001*
Non-obese	123.6 mmHg	2.5 mmHg	
DBP			
Obese	96.8 mmHg	2.5 mmHg	0.0459*
Non-obese	85.7 mmHg	85.7 mmHg	
Lipid Ratio TC/HDL-c			
Obese	4.02	1.4	0.0005*
Non-obese	3.10	0.6	
Lipid Ratio LDL/HDL-c			
Obese	2.26	1.0	0.0084*
Non-obese	1.75	0.6	
Lipid Ratio TG/HDL-c			
Obese	3.93	0.7	<0.0001*
Non-obese	2.16	0.5	
Total Cholesterol			
Obese	155.01	12.7	<0.0001*
Non-obese	143.5	13.8	
LDL-c			
Obese	87.7	12.9	0.0056*
Non-obese	81.0	6.1	
Triglycerides (TG)			
Obese	152.4	21.1	<0.0001*
Non-obese	100.0	11.1	
HDL			
Obese	38.5	9.0	<0.0001*
Non-obese	46.3	7.7	

**p<0,05. Comparisons performed using unpaired Student's t-test. p: significance level; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; HDL-c: high-density lipoprotein; LDL: low-density lipoprotein; SAH: systemic arterial hypertension.*
Source: the author

The ROC curve showed that the best anthropometric parameter, having the best ratio between sensitivity and specificity to identify SAH in this population, was the waist-to-height ratio (WHtR) (Figure 3) with a cut-off point equal to 59, corresponding to the ratio between the waist circumference (WC) and the height of the individual, as shown in Table 3.

The correlation between the WHtR and the BP parameters as well as the lipid parameters, TC, TG, LDL-c, and HDL-c was performed. It was verified that the correlation between WHtR and SBP and DBP was positive and significant p<0.0001. Among the lipid parameters, the correlation was also positive and significant. However, the only variable that did not correlate positively was HDL-c in Table 4.

Table 3 – Relation between the anthropometric parameters investigated to obtain a cutoff point that predicts the early identification of SAH

Parameters	AUC	CI (±)	Sensitivity	Specificity	P-value
Waist circumference	0.695	95%: 0.590 to 0.788	*	*	0.001
Waist-to-height ratio	0.707	95%: 0.602 to 0.798	67.6% (95% CI: 50.2% to 82.0%)	74.1% (95% CI: 60.3% to 85.0%).	0.005
Waist-to-hip ratio	0.664	95%: 0.558 to 0.760	78.4% (95% CI: 61.8% to 90.2%)	55.6% (95% CI: 41.4% to 69.1%);	0.0048
Body Mass Index	0.667	95%: 0.561 to 0.763	45.9% (95% CI: 29.5% to 63.1%)	85.2% (95% CI: 72.9% to 93.4%)	0.0049

*AUC: area under the curve; CI: confidence interval; p: significance level *: measure not applicable.*
Source: the author

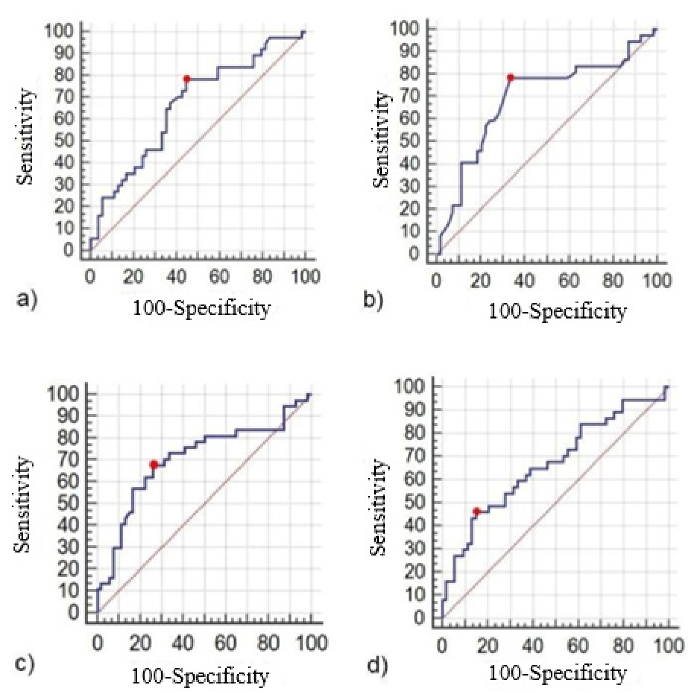

Figure 3 – ROC curve plots related to the relationship between the anthropometric parameters os SAH.
Source: the author

Table 4 – Pearson's correlation between WHtR and blood pressure levels, total cholesterol, triglycerides, LDL-c, and HDL-c

Parameters x WHtR	Value of r
SBP (mmHg)	r = 0.465* (0.287 to 0.614)
DBP (mmHg)	r = 0.276* (0.132 to 0.377)
TC (mg/dL)	r = 0.330* (0.133 to 0.502)
TG (mg/dL)	r = 0.443* (0.261 to 0.595)
LDL-c (mg/dL)	r = 0.195* (0.120 to 0.385)
HDL-c (mg/dL)	r = -0.133* (-0.330 to 0.075)

**p<0.05. All analyses were adjusted for the variable of sex. SBP: Systolic Blood Pressure. DBP: Diastolic Blood Pressure. TC: Total Cholesterol. TG: Triglycerides. LDL-c – Low: density lipoprotein cholesterol. HDL-c: High density lipoprotein cholesterol.*
Source: the author

Discussion

Several epidemiological studies provide evidence for the connection between obesity and several comorbidities, and there is a clear correlation between excess weight, especially fat in the visceral region, and the occurrence of CVD. SAH stands out in this group of diseases associated with obesity, since the increase in body fat, especially abdominal fat, is pointed out as a relevant risk factor for hypertensive disease.[17-21]

In Latin America, the prevalence of overweight individuals is around 40%. When dealing specifically with obesity, studies point to a greater variability among Latin American populations, which is between 9.9% and 35%.[17,18]

In Brazil, the scarcity of population studies corroborates the lack of specific data to the reality of each region. This is due to the fact that the country has a great social diversity among its regions, which is reflected in eating habits, lifestyles, and especially in population health.

According to this study, it was noticed that abdominal obesity was quite predominant among women. In line with this research, a study conducted in 2006 with 1,800 individuals residing in the state of Pernambuco showed that 51.9% of adults of both sexes were obese, with a prevalence of 69.9% in women.[22]

Many studies have suggested that not only the amount of fat, but especially the pattern of fat distribution, may be associated with cardiovascular risk. Excess fat located in the abdominal region is considered the main risk factor for the development of other metabolic abnormalities.[19-21]

In obesity, there is an increase in adipocyte volume due to a higher concentration of triglycerides. This is due to the inability of adipocytes to store fatty acids beyond their biological limit, thus leading to a release of free fatty acids (FFA) into the bloodstream, which may culminate in their deposition in organs, such as the liver, as well as in skeletal muscles. This factor is closely linked to an IR profile.[19] Moreover, IR is also directly related to the increase in BP, for in healthy people, it has a vasodilator effect, but the increase in its concentration can increase BP through its action on sodium reabsorption in the renal tubule.[23]

The presence of abdominal obesity is also capable of promoting alterations that are directly related to SAH. The obese women in this study had significantly higher SBP and DBP values than the non-obese women. The pathophysiological mechanisms that favor the development of SAH in obesity are complex and multifactorial.[23]

According to Loskutoff et al.,[24] adipose tissue is associated with the deregulation of circulatory homeostasis through the action of plasminogen activator inhibitor 1 (PAI-1), which is increased in overweight and obese individuals due to the greater expression of its mRNA in adipose tissue, as well as angiotensinogen, which has high serum levels in individuals with abdominal obesity due to its greater synthesis in adipocytes. High levels of angiotensinogen may serve as a substrate for the renin-angiotensin system (RAS), thus generating a high production of angiotensin II and triggering several mechanisms that are linked to the elevation of BP, either by direct effects on the kidneys or by sympathetic action.[25,26]

Marchi-Alves et al.,[27] in turn stated that high levels of leptin, a peptide hormone secreted mainly by adipocytes, positively modulates systemic blood pressure levels. The concentrations of this hormone are directly proportional to the fat cell volume and increase in proportion to the rise in body fat percentage. Leptin acts, among other ways, by increasing the sympathetic tone in the kidneys, adrenals, and heart, which can trigger BP elevation.

This study identified that women with abdominal obesity are approximately three times more likely (OR=2.9; p=0.0086) to develop SAH than non-obese women. This data confirms that the expansion of adipose tissue in the abdominal region is an important factor in the pathophysiology of SAH.

To strengthen the analysis of cardiometabolic risk, an analysis of lipid ratios allows one to establish some predictive parameters for CVD development.[28] With the likely onset of abdominal obesity-induced IR, the lipid ratios of TC/HDL-c and LDL-c/HDL-c, and Castelli indices I and II, respectively, all predictors of cardiovascular risk, were significantly high in obese women. These data suggest a direct and significant relationship between abdominal obesity and a rise in circulating lipids in plasma. In line with these results, the TG/HDL-c ratio was 82% higher in obese women than in non-obese women.

This fact confirms that the obese group is more likely to develop metabolic diseases, since with a higher concentration of triglycerides, with a reduction in the HDL-c levels, the individual will be more predisposed to being insulin resistant and hypertensive as a direct and indirect consequence.

In recent years, there has been a growing interest in an anthropometric method called waist-to-height ratio (WHtR) as an index to assess adiposity. This method has been proposed as an anthropometric measure to assess central adiposity, as it is strongly associated with cardiometabolic risk factors and because of its relationship with mortality, regardless of body weight.[29] Meta-analysis studies by Savva et al.,[30] and Ashwell et al.,[31] have shown that WHtR has a greater predictive ability for cardiovascular and metabolic risk than the classic anthropometric indicators, BMI, WC, and WHR.

According to the results of the ROC curve analysis, the anthropometric parameter with the highest correlation was WHtR, showing a higher value of area under the curve (AUC 0.707), followed by WC (AUC 0.695), BMI (AUC 0.667), and WHR (AUC 0.664). The WHtR showed a sensitivity value equal to 67.6%, a specificity of 74.1%, and a WHtR cutoff point=0.59.

Thus, a cut-off point of WHtR ≥0.50 has been proposed to predict the risk of CVD as well as diabetes for both sexes. Furthermore, some authors claim that WHtR may be the most useful clinical tool for the global detection of abdominal obesity and for screening cardiometabolic risk in adults and children.[32,33] However, in Latin America, there is a scarcity of major studies assessing the correlation between WHtR and cardiometabolic risk.

Thus, the results of this study corroborate the meta-analyses by Savva and Ashwell,[30,31] indicating WHtR as a better predictor of cardiovascular risk than classical indicators. The definition of cut-off points for anthropometric indicators that stand out for their operational simplicity and good accuracy in detecting at-risk individuals is of great use in health services, since they enable the early identification of health risks in specific population groups, and are also very useful in the use of epidemiological research.[29] However, there is a need to develop more studies with different approaches that can contribute to the construction of scientific knowledge on the problem posed in this study. Furthermore, the development of studies involving a larger number of volunteers (a limitation observed in this study) may contribute significantly to a greater understanding in this area.

Conclusion

The increase in waist circumference is positively associated with the presence of SAH, as well as with the presence of dysregulated lipid parameters, corroborating the increase in cardiovascular risk. This is a worrisome factor, since obesity was present in 62.6% of the women. In addition, it was possible to establish the waist-to-height ratio as a more specific anthropometric indicator that has a better correlation in predicting cardiometabolic risk than the classic parameters, which can contribute to the early diagnosis of CVDs.

Author contributions

Conception and design of the research: Cavalcanti, IML, Araújo TFS. Acquisition of data: Cavalcanti, IML,

Araújo TFS. Analysis and interpretation of the data: Cavalcanti, IML, Araújo TFS, Tenório PP, Nascimento CR. Statistical analysis: Cavalcanti, IML, Araújo TFS. Writing of the manuscript: Cavalcanti, IML, Araújo TFS, Tenório PP, Nascimento CR. Critical revision of the manuscript for intellectual content: Cavalcanti IML, Araújo TFS, Tenório PP, Nascimento CR.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Universidade Federal do Vale do São Francisco under the protocol number CAAE 62537316.3.0000.5196. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

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