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Association between values of anthropometric indicators, Total Antioxidant Capacity and Malondialdehyde in adults: a population-based study

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ABSTRACT

Background: Research regarding the correlation between obesity and oxidative stress is important due to the health complications they entail and elucidating this association through the waist-to-height ratio is of great interest because it is an important anthropometric indicator of cardiovascular and metabolic diseases' risk associated with obesity. The aim of this study was to gain a better understanding of the association between waist-to-height ratio and total antioxidant capacity and malondialdehyde values in adults.

Methods: A cross-sectional population-based study was conducted in 265 individuals from a municipality in northeastern Brazil. Epidemiological data were collected, and anthropometric and biochemical evaluations were performed. To achieve the objectives proposed by the study, linear regression was performed.

Results: In the total sample, more than half of the participants were overweight or obese. The mean value of 54 cm (SD±10) waist-to-height ratio, with the majority of adults (65.28%) presenting with slight elevation waist-to-height ratio. A correlation was found between waist-to-height ratio and BMI with the values of total antioxidant capacity (t= -2.96; p=0.003) and malondialdehyde (t=2.87, p=0.004), as well as LDL (t=3.19, p=0.002), triglycerides (t=3.17; p=0.002).

Conclusion: Abdominal obesity, reflected by a slight elevation in the waist-to-height ratio, corroborated by BMI was indicated as an aggravating factor in oxidative stress increase because it was positively related with malondialdehyde values and negatively with total antioxidant capacity values in this adult population.

KEYWORDS

Anthropometry. Obesity. Antioxidant. Malondialdehyde. Oxidative Stress.

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INTRODUCTION

Oxidative stress is associated with systemic inflammation, endothelial cell proliferation, apoptosis and increased vasoconstriction and therefore is a factor that significantly contributes to endothelial dysfunction. This oxidation reaction causes an increase in the production of reactive oxygen species (ROS), which is associated with low levels of antioxidant enzymes[1].

Several biological mechanisms may be involved in the association between increased adiposity and oxidative stress; among these, the release of inflammatory cytokines by adipocytes may be particularly impactful[2].

Malondialdehyde (MDA) is, among oxidative stress markers, a lipid peroxidation marker universally used as a substitute for antioxidant activity in the body. Accordingly, the progression of atherosclerosis is correlated with oxidative stress and obesity[3], and it can be measured by MDA values[4].

Another oxidative stress marker related to obesity and cardiovascular disease (CVD) is total antioxidant capacity (TAC), which reflects the cumulative action of all antioxidants presented in plasma and body fluids in order to provide an integrated system instead of a simple sum of the measurable parameters of antioxidants. It is considered a tool for medical diagnosis and treatment of various morbidities, including CVD, cancer, diabetes mellitus, obesity and aging[5].

The literature is vast in relation to studies on oxidative stress and obesity[1,5,6]. However, considering the classic anthropometric variables such as body mass index (BMI), waist circumference (WC) and waist/hip Ratio (WHR) already well explored, the waist-to-height ratio (WtHR) stands out as a good indicator of risk for chronic non-communicable diseases (NCD), mainly CVD[7,8,9].

No studies were found on the association between the Waist-to-Height Ratio and oxidative stress in the researched literature, it is expected that the anthropometric indicators will be compared and the WtHR be strongly associated with oxidative stress.

Based on the considerations above, the objective of this study was to analyze the association between BMI, WC, WHR and WtHR with TAC and MDA values in adults.

MATERIALS AND METHODS

Characterization of the study

The present study is derived from a database with multiple objectives. This is a cross-sectional study linked to a population-based research project entitled "The Second Cycle of Diagnosis and Intervention of the Food and Nutritional Situation, and of the Most Prevalent Communicable Diseases of the Municipal Population of João Pessoa/PB."

Ethical issues

This study was submitted and approved by the Research Ethics Committee 'blinded for peer review' under the Protocol 0559/2013, according to the ethical standards for research involving human beings contained in Resolution 466 of December 12, 2012 of the National Health Council/National Research Ethics Committee.

After identifying the residences in randomly selected city blocks located in the east and west areas of the city of João Pessoa, the researchers introduced themselves to the residents, explaining the purpose of the study and requesting their participation. To respect ethical guidelines for research involving humans, the participants residing in the selected households were included in the study only when they had consented to participation by signing the Informed Consent form.

Sample

Given that the population of adults in the east and west areas of João Pessoa is over 10,000 inhabitants according to IBGE Census data in 2010[10], and the sampling fraction was less than 5%, a correction factor for finite population was not necessary. To define the required minimum sample with respect to population parameter estimators, the BOLFARINE and BUSSAB calculation procedure was used to obtain a reliability level of 95%[11].

A single multi-level sampling procedure was used. Due to the presence of heterogeneity in income, which has a direct impact on the relationship between disease prevalence and nutrition[12], stratified sampling was used[13] with the city blocks at the first level. In this level, the neighborhoods/city blocks of the east and west zones of the municipality were ranked by income class into four strata according to information obtained from the IBGE (2010). After stratification, the sample size, or number of representative city blocks per zone, was calculated. Next, the weight of each stratum was calculated as the number of city blocks per zone according by strata, according to the formula defined by Silva, Moraes and Costa[14].

Considering that the average income of adults in the east and west areas was R$2,213.26 (data obtained from "The first cycle of diagnoses and intervention of the food and nutritional situation, and of the most prevalent communicable diseases of the municipal population of João Pessoa/PB" (07/2008-01/2010)), with a standard deviation of R$2,601.93 and a margin of error of R$3,320.00 in income, the minimum sample of adults in João Pessoa necessary to be statistically representative of the eastern and western areas (with a confidence level of 95%) was 265 adults. Thus, a sample of 265 adults distributed across the study area was selected.

Trained teams selected all homes within randomly selected city blocks for study recruitment. The city blocks that had homes or households with persons not consenting to participate were identified, and the number of individuals who refused to participate in each randomly selected house was computed, and the random selection was repeated to minimize losses.

Data obtained from the questionnaire included: socioeconomic and demographic characteristics, epidemiological characterization, an assessment of dietary intake (24 hours of recall), and anthropometric and biochemical evaluations (blood samples were performed at the individual's home and taken after 12 hours of fasting).

The inclusion criteria for this study were as follows: being between: a) 20-59 years of age; b) authorize participation in the study. The exclusion criteria were as follows: prior diagnosis of neuropsychiatric disorders; use of multivitamins and/or mineral supplements, appetite suppressants or steroids; and pregnancy.

Data collection

Home visits were completed and questionnaires were administered by teams of undergraduate researchers enrolled in a nutrition course as master's and doctoral students of the Post-Graduate Program in Nutrition Sciences of the Federal University of Paraíba (UFPB) and trained both at the beginning of data collection and after completion of the pilot study.]

Anthropometric assessment

All anthropometric measurements were conducted by trained students and nutritionists using standard protocols and techniques[15].

A Plenna *Lumina mea* model 02550 digital electronic scale with a capacity of 150 kg and accuracy of 100 g was used to determine weight. Weight measurements were obtained according to *World Health Organization*[15].

A 2-m long measuring tape, developed by the technicians at the Student Assistance Foundation and used in the World Food Program, was used for measuring height. The measuring tape was fixed with tape onto a flat wall with no baseboard in a bright place to allow for an accurate reading. Study participants were instructed to stand with their backs to the wall without bending their knees for the measurements[15].

The waist circumference measurement was performed in triplicate with the aid of an inextensible glass fiber measuring tape with a 0-200 cm scale and resolution of 0.1 cm; the average of the obtained values was used.

Measuring recommendations from the World Health Organization[16] and Ross et al.[17] were followed: the tape was placed along the smallest circumference of the waist without compressing the skin material while the participant stood erect with their feet together, arms relaxed beside the body, and their abdomen relaxed after normal exhalation. Abdominal obesity was defined as Waist Circumference (WC) > 102 cm for men and > 88 cm for women, according to the classification recommended by the NCEP ATP III[18].

The WtHR indicator was based on the quotient of the waist and height measurements in centimeters. The cutoff point used was ≤ 0.5 (no risk), > 0.5 (low risk) and > 0.6 (high risk), as supported by studies conducted around the world in diverse populations as an evaluation tool to identify health risks and related morbidities[9].

Another indicator used to assess nutritional status was the Body Mass Index (BMI) according to the classification of the World Health Organization (WHO)[15] for adults.

Lifestyle

For evaluation of lifestyle, physical activity, alcohol intake, smoking and morbidities were considered. Participants were asked about their practice (yes or no), frequency (number of times per week), duration (minutes) and type of physical activity; information on alcohol consumption (how often they consumed 6 or more doses of alcohol at a time) was also obtained.

Regarding smoking, subjects were asked whether they were smokers (yes or no), if they had smoked in the last six months, or if they were former smokers. If they were former smokers, they were asked when they had stopped smoking; for smokers, the number of cigarettes smoked per day, week or month was collected.

They were also asked about the presence of certain morbidities (hypertension, diabetes, obesity and dyslipidemia); whether they had been diagnosed by a doctor, from either the public or private sector; and if they took medication, with the use of anti-inflammatories and/or aspirin being of particular interest to this research. All information was obtained through the epidemiological characterization questionnaire.

Biochemical Assessment

All subjects were informed of the need to fast for 12 hours prior to blood sampling, and blood samples were collected in the participating households by a properly trained team coordinated by a nurse. Blood collection occurred at the end of the third 24-hour recall. Blood samples were collected into sterile vacuum tubes without anticoagulant, and appropriate protocols for safe use and disposal of sharps were followed.

Evaluation of total antioxidant capacity was conducted through DPPH[19]. The result was expressed as the percentage of antioxidant activity.

For malondialdehyde (MDA) analysis, oxidative activity was quantified based on thiobarbituric acid reactive substances (TBARS)[20,21].

In the lipid analysis, the concentrations of triglycerides, total cholesterol, low-density lipoproteins (LDL-c) and high-density lipoproteins (HDL-c) were determined by turbidimetry. A LabMax 240 premium automatic biochemical analyzer

(Labtest) was used for this analysis. Calibration of the analysis equipment was performed prior to each test sequence with the "Calibra" Labtest calibrator series to assess the accuracy of biochemical marker estimates and verify that they were within the equipment manufacturer's recommended parameters.

Statistical Analysis

A descriptive statistics analysis was completed, which included simple frequencies using position measures such as central tendency and dispersion (average, median, standard deviation and N-%). These data were evaluated for normality using the Kolmogorov-Smirnov test[22]. Statistical analyses of the data were completed using STATA 13 Software. Considering $p<0.05$ as a significant value.

The degree of association among the anthropometric variables of the study was analyzed. Finally, the following linear regression model was used to identify the existence of statistically significant relationships between WtHR and variables used:

$$WtHR = \beta0 + \beta1*Gender + \beta2*Total\ cholesterol + \beta3*LDL + \beta*HDL + \beta5*Triglycerides + \beta6*TAC + \beta7*MDA + \beta8*Income + \beta9*Education\ level + \beta10*Smoking + \beta11*PA$$

The same linear regression model was used to relationships between BMI, WC and variables used.

RESULTS

Sample Characterization

The sample comprised 265 individuals with an average age of 40 years and was predominately female. Regarding socioeconomic data, lifestyle, and morbidity, most individuals had more than ten years of education, received an average of six times the minimum wage at that time (R$ 701,96), did not consume alcoholic beverages, did not smoke, were not physically active, had no morbidities, and did not use medications. Regarding the anthropometric assessment, more than half of the study population was overweight or obese, with a WtHR average of 54 cm (SD±10), and the majority of adults (65.28%) (results not shown) had slight elevated WtHR (Table 1). It is relevant to mention WtHR did not differ significantly by demographic, socioeconomic, or lifestyle characteristics.

Oxidative stress and lipid profile

Table 2 shows that the subjects demonstrated mean values of TAC, MDA and lipid profile in the normal range with the exception of HDL, which was lower than the reference values. For TAC values, all subjects were at the reference range; for MDA, 3.39% were above and 25.28% below the normal range (results not shown).

When the degree of association between anthropometric variables and oxidative stress was calculated, it was observed

Table 1. General characteristics of adults of the east and west regions of João Pessoa.

		Average	SD	Median	N	%
Demographic, Socioeconomic and Lifestyle Characteristics						
Gender	Male				78	30
	Female				187	70
Age	20 – 59 years	40.3	14.3	39.5	265	100
Educational level[1]	Up to complete primary education				48	18.2
	> complete primary education				217	81.8
Family income (R$)[2]		4211.79	5167.97	2000	265	100
Alcohol consumption	Yes				42	15.8
	No				223	84.2
Smoking	Yes				20	7.55
	No				245	92.45

According to the Ministry of Health (2008); [1]Up to complete primary corresponds to 0-9 years of study, and ≥ complete primary education corresponds to more than 10 years of study; [2]Income was based on the dollar value (R$) 3.90 *In accordance with WHO (1999); BMI, body mass index; WC, waist circumference; WHR, waist-to-hip ratio; WtHR, waist-to-height ratio.

Table 1 continuación. General characteristics of adults of the east and west regions of João Pessoa.

		Average	SD	Median	N	%
Demographic, Socioeconomic and Lifestyle Characteristics						
Practice of physical activity	Yes				108	40.75
(150 minutes/week)	Days/week	4.5	1.4	4.5	108	48.0
	Duration of activity/minutes	403	220	360	108	40.75
	No				157	59.24
Morbidities						
	Diabetes				11	4.15
	Hypertension				47	17.73
	Dyslipidemia				7	2.64
	Obesity				59	22.26
Medication						
Anti-inflammatory use	Yes				3	1.13
	No				262	98.87
Aspirin use	Yes				2	0.75
	No				263	99.25
Anthropometric characteristics						
	Weight(kg)	72.88	17.41	72		
	Height (m)	1.62	0.08	1.60		
	BMI (kg/m^2)	27.67	6	27.2		
	WC (cm)	87	19	88		
	WHR (cm/cm)	84	10	80		
	WtHR (cm/cm)	54	10	55		
Nutritional classification *(kg/m^2)						
	Low Weight / normal weight	21.8	2.37	22.36	124	46.8
	Over weight	27.63	1.33	27.62	82	30.94
	Obese	34.63	4.95	32.81	59	22.26
Risk Classification (WtHR **cm/cm)**						
	≤ 0.5	44	0.03	0.44	93	35.09
	> 0.5	54	0.02	0.54	81	30.56
	> 0.6	67	0.05	0.66	91	34.33

According to the Ministry of Health (2008); [1]Up to complete primary corresponds to 0-9 years of study, and ≥ complete primary education corresponds to more than 10 years of study; [2]Income was based on the dollar value (R$) 3.90 *In accordance with WHO (1999); BMI, body mass index; WC, waist circumference; WHR, waist-to-hip ratio; WtHR, waist-to-height ratio.

Table 1b. General characteristics of women of the east and west regions of João Pessoa.

		Average	SD	Median	N	%
Demographic, Socioeconomic and Lifestyle Characteristics						
Gender	Female				187	100
Age	20 – 59 years	44.1	12	39.5	187	100
Educational level[1]	Up to complete primary education				27	14.5
	> complete primary education				160	85.5
Family income (R$)[2]		4292.4	5512	2000	187	100
Alcohol consumption	Yes				28	15
	No				159	85
Smoking	Yes				14	7.5
	No				173	92.5
Practice of physical activity	Yes				75	40.1
(150 minutes/week)	Days/week	4.5	1.4	4.5	75	40.1
	Duration of activity/minutes /week	403	220	360	75	40.1
	No				112	59.89
Morbidities						
	Diabetes				15	8
	Hypertension				52	27.8
	Dyslipidemia				9	4.81
	Obesity				27	14.43
Medication						
Anti-inflammatory use	Yes				3	1.6
	No				3	1.6
Aspirin use	Yes				3	1.6
	No				3	1.6
Anthropometric characteristics						
	Weight(kg)	79.21	14.77	76.8	187	100
	Height (m)	1.63	0.8	1.63	187	100
	BMI (kg/m^2)	25.2	4.4	25.3	187	100
	WC (cm)	94	17.94	95	187	100
	WHR (cm/cm)	81	11	83	187	100
	WtHR (cm/cm)	49	0.6	50	187	100
Nutritional classification *(kg/m^2)						
	Low Weight / normal weight	21.7	2.09	21.8	89	47.6
	Over weight	27.3	1.27	27.6	74	39.6
	Obese	32.1	1.4	31.6	24	12.8
Risk Classification (WtHR **cm/cm)**						
	≤ 0.5	44	0.03	0.44	101	12.83
	> 0.5	55	0.02	55	72	39.13
	≥0.6	60	0.01	60	14	48.66

Table 1c. General characteristics of men of the east and west regions of João Pessoa.

		Average	SD	Media	N	%
Demographic, Socioeconomic and Lifestyle Characteristics						
Gender	Male				78	100
Age	20 – 59 years	32.3	10.45	30	78	100
Educational level[1]	Up to complete primary education				48	61.5
	> complete primary education				217	7,7
Family income (R$)[2]		4018.42	4257	2000	78	92,3
Alcohol consumption	Yes				69	88.5
	No				9	11.5
Smoking	Yes				3	3.84
	No				75	96.15
Practice of physical activity	Yes				42	53.8
(150 minutes/week)	Days/week	4.4	1.3	5	42	53.8
	Duration of activity/minutes /week	73.75	45.48	60	42	53.8
	No				36	46,2
Morbidities						
	Diabetes				0	-
	Hypertension				3	3.84
	Dyslipidemia				1	1.28
	Obesity				0	-
Medication-						
Anti-inflammatory use	Yes				0	-
	No		-		0	-
Aspirin use	Yes				0	-
	No		-		0	-
Anthropometric characteristics						
	Weight(kg)	57.71	13.51	55.95	78	100
	Height (m)	1.63	0.08	1.61	78	100
	BMI (kg/m^2)	21.53	3.37	21.75	78	100
	WC (cm)	71.35	6.46	70.5	78	100
	WHR (cm/cm)	84	10	80	78	100
	WtHR (cm/cm)	43	3	43	78	100
Nutritional classification *(kg/m^2)						
	Low Weight / normal weight	21.33	2.03	21.68	6	7.69
	Over weight	26.71	0.63	27.06	72	92.3
	Obese	-	-	-	0	-
Risk Classification (WtHR **cm/cm)**						
	≤ 0.5	43	3	43	78	100
	> 0.5	-	-	-	-	-
	> 0.6	-	-	-	-	-

Table 2. Oxidative stress and lipid profile values of adults of the east and west regions of João Pessoa.

		Average	Standard Deviation	Median	N*	%
Oxidative stress						
	TAC (%) ’(RV: 34.1 – 94.4%)	41	0.13	42	79	29,81
	MDA (RV: 2.3 a 4.0 µmol/L)	2.76	0.80	2.7	66	24,9
Lipid profile (mg/dL)						
	Cholesterol (desirable RV:<200)	190.05	45.01	183	90	33,96
	LDL (desirable RV: 100 - 129)	113.33	51.59	105.8	71	26,79
	HDL (desirable RV: >60)	43.4	10.88	43	186	70,1
	Triglycerides (desirable RV: <150)	152.49	92	119	104	39,24

Legende: RV - reference values. *risk values.

that WtHR was negatively associated with TAC and positively with MDA (R = -0.2345; p-value = 0.0001 *); BMI obtained the same negative associations with CAT and positive with MDA. For waist circumference, the relationship was as for WtHR and BMI, negative for CAT and positive for MDA, but not significant, presenting only significance for physical activity practice and schooling level (results not shown).

Anthropometric measurements and interaction with the study variables

Multiple linear regression demonstrated a statistically significant relationship between WtHR and both TAC and MDA; when TAC values increased by 1%, WtHR decreased 0.74 cm (p=0.004) cm, and when MDA increased by 1 µmol/L, the WtHR increased 0.09 cm (p=0.005) (Table 3). The results from the lipid profile suggested that when LDL increases by 1 mg/dL, WtHR increases by 0.14 cm, and whn triglycerides increase by 1 mg/dL, WtHR increases by 0.09 cm (table 3).

Table 4 shows that as LDL increases by 1mg / dL, BMI increases by 0.15kg / m² (p = 0.003), when triglyceride increases by 1mg / dL, BMI increases by 0.13kg / m² (p = 0.000), and for MDA, when it increases by 1 µmol / L, BMI also increases by 0.10 kg / m² (p = 0.007).

DISCUSSION

The present study demonstrated that both the average values and the median WtHR of the study population were above the cutoff described in most of the literature and were adequate (0.5)[23,24,2,9]. The values of TAC, MDA, LDL, and triglycerides and education level were all associated with WtHR.

The literature is vast regarding studies on oxidative stress and obesity using anthropometric indicators such as BMI, WC and WHR[1,5,6], according to the classification of the WHO[15,18] for adults. With the WtHR the present study did not find relationships. However, no studies correlating WtHR to oxidative stress have been found in literature, justifying the performance of this unpublished study.

Considering WtHR as a good anthropometric indicator, especially the study by Ashwell, Cole and Dixon[25], which was one of the first to compare anthropometric variables (BMI, WC and WtHR) with computed tomography results and to confirm that WtHR is the best predictor of intra-abdominal fat, and, more recently, because this relationship was considered a good indicator of early risk for several NCD, mainly CVD[7,8,9] and metabolic risk associated with obesity[2,23].

The results of this study support findings by Medeiros et al.[5] suggesting that obesity can cause an increased production of reactive oxygen species and depletion of antioxidant defenses, increasing oxidative stress.

Accordingly, the development of a mild chronic inflammatory condition has shown to play a key role in the development of metabolic complications associated with obesity; similar to other inflammatory processes, adipose tissue is intrinsically linked to oxidative stress[26]. In addition, obesity may contribute to an antioxidant deficit resulting from inappropriate activity of the major antioxidant enzymes[1].

The finding that oxidative stress is induced by obesity, as observed in clinical studies, has established correlations between the final products of free radicals mediated by oxidative stress, including lipid peroxidation products and protein carbonyls, and BMI[27,28] WHR[3], and WtHR, as described in this study.

In another study where total antioxidant capacity was analyzed, an inverse relationship between body fat, visceral obesity and antioxidant defense markers, such as SOD, catalase and GPx, was also observed in obese adult subjects evaluated based on measurements of BMI, waist and hip circumference[29].

Table 3. Multiple regression analysis between WtHR and gender, lipid profile, oxidative stress, socioeconomic data and lifestyle of adults in João Pessoa city.

Multiple regression/number of observations = 265				
Model 1 (WtHR) / R-squared 0.2264				
	Coefficient	**95% CI**	**t statistic**	**p-value***
Gender Female	0.04	-0.0041±0.8739	1.95	0.005*
Total Cholesterol	-0.00	-0.0019±0.0009	-1.79	0.075
LDL – C	0.14	0.0542±0.2289	3.19	0.002*
HDL – C	-0.07	-0.1788±0.3094	-1.39	0.173
Triglycerides	0.09	0.0361±0.1561	3.17	0.002*
TAC	-0.74	-0.1273±-0.2434	-2.96	0.003*
MDA	0.09	0.0292±0.156	2.87	0.004*
Income	0.00	-0.0190±0.0252	0.27	0.785
Education level	-0.07	-0.1236±0.0174	-2.62	0.009*
Smoking	-0.00	-0.0576±0.0544	-0.06	0.956
Practice of Physical Activity	0.00	-0.0449±0.0552	0.11	0.913

*p < 0.05; This model was also completed with the inclusion of the following variables: alcohol consumption; food consumption including calories (1703,91±407,04 cal), total fat (52,95±17,62 g), saturated fat (16,57±6 g), monounsaturated fat (13,07±4,8 g), polyunsaturated fat (14,9±6,37 g); most prevalent non-transmissible chronic diseases; and use of anti-inflammatories and aspirin. Within this model, significant re-

Table 4. Multiple regression analysis between BMI and gender, lipid profile, oxidative stress, socioeconomic data and lifestyle of adults in João Pessoa city.

Multiple regression/number of observations = 265				
Model 1 (BMI) / R-squared 0.1340				
	Coefficient	**95% CI**	**t statistic**	**p-value***
Gender Male	0.02	-0.2922±0.0761	0.88	0.381
Total Cholesterol	-0.00	-0.0020±0.0002	-1.61	0.108
LDL	0.15	0.0531±0.2584	2.99	0.003*
HDL	-0.08	-0.2316±0.0678	-1.08	0.283
Triglycerides	0.13	0.0788±0.1973	4.59	0.000*
TAC	-0.10	-0.1746± -0.0376	-3.05	0.003*
MDA	0.10	0.0283±0.1784	2.71	0.007*
Income	0.01	-0.0149±0.0503	1.07	0.288
Education level	-0.06	-0.1434±0.0111	-1.69	0.093
Smoking	-0.04	-0.1150±0.0349	-1.05	0.294*
Practice of Physical Activity	0.01	-0.0626±0.0980	0.43	0.665

*p < 0.05; This model was also completed with the inclusion of the following variables: alcohol consumption; food consumption including calories (1808±409,37 cal), total fat (56,84±18,18 g), saturated fat (17,62±6,26 g), monounsaturated fat (13,96±5,49 g), polyunsaturated fat (13,86±5,22 g); most prevalent non-transmissible chronic diseases; and use of anti-inflammatories and aspirin.

However, in a study carried out with healthy patients and subjects with coronary diseases, increased TAC was observed in men with coronary artery disease and hypertension, but only in bivariate analyses. After adjusting for common cardiometabolic risk factors, these associations were not detectable. Instead, positive correlations of TAC with overweight and obesity rates in both groups and positive relationships between blood pressure and lipid levels in coronary patients with metabolic syndrome were found. One possible explanation for these results might be that during the course of many diseases, a lower TAC value may be caused by a depletion of the antioxidant barrier as an effect of long-term oxidative stress[30].

Adipose tissue represents a preferred storage location for natural antioxidant compounds, such as fat-soluble vitamins (e.g., Vitamin A, Vitamin E or carotenoids). Nonetheless, people with obesity as evaluated based on BMI usually have relatively low levels of TAC[26]. Relationship with BMI was found in the present study, as well as with WtHR in detecting risk regarding increased oxidative stress. In this sense, even with WtHR values (little high) for the majority of the study population that presented oxidative stress values according to reference standards, there is the onset of risk for NCD and CVD[7,8,9].

The literature suggests that increased levels of malondialdehyde decrease membrane fluidity and viscoelasticity and deform erythrocytes in obese individuals, which may be responsible for initiating complications such as diabetes, hypertension, or hyperlipidemia[31]. With higher malondialdehyde levels reflecting an increase in free radicals, there is evidence of oxidative stress conditions[32].

In a review article, Vincent and Taylor[27] observed that peroxidation of lipid markers, such as malondialdehyde, is found to be elevated in the plasma of obese individuals, with obesity diagnosed based on different anthropometric indicators such as BMI and waist circumference in clinical studies. In addition, the hyperlipidemia observed in obese individuals contributed and, more importantly, amplified systemic oxidative stress for population with mean and median BMI compatible with overweight.

Regarding the relationship between physical activity and WC, a cohort of Swiss adults who practiced physical activity showed a relationship inversely associating obesity with WC[33]. Regarding schooling, in research with a population of Chinese adults, it was observed that the educational level was inversely proportional to WC[34], both results are similar to the present study, corroborating the study by Schienkiewitz et al.[35], who found that obesity is more common among people with a low level of education compared to those with high education levels. Based on a literature review, it was observed that these relations are still little studied.

A study in which WtHR was analyzed as an early indicator of health risk noted that an WtHR ≥ 0.5 classified the participants as being at 'increased early risk' of health[9], considering the cited study, in relation to the present study, the variable WtHR presented that more than half of the population (65.28%) had only "low risk" (WtHR ≥ 0.5) and 34.33% had an WtHR below the reference values, i.e. <0.5 "without risk"[36].

WtHR as a good predictor of risks was supported by the results of other studies[33,34], as well as the results in this study, which detected the relationship between oxidative stress in adults with mean and median WtHR values slight elevated, as well as BMI.

In conclusion, we have demonstrated that abdominal obesity, as reflected by slight elevated values in WtHR, may be an aggravating factor that increases oxidative stress as indicated by a positive association with MDA values and negative association with TAC values in a population of adults, as well as BMI, although not a measure of direct abdominal fat[33], behaved similarly to the findings of the WtHR.

In interpreting the results, some limitations need to be considered, such as the low prevalence of obese and male subjects, as well as the non-heterogeneity of the data.

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