Influence of sodium intake and sociodemographic, lifestyle and anthropometric variables on blood cholesterol of hypertensive women

Influência da ingestão de sódio e de variáveis sociodemográficas, de estilo de vida e antropométricas no colesterol sérico de mulheres hipertensas

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ABSTRACT

The restriction of sodium intake, one of the pillars of antihypertensive treatment, has been associated with the increase in cholesterol levels. Given this, we hypothesize that a sodium intake restriction may increase cholesterol levels in hypertensive women. The present study aimed to evaluate the influence of sodium intake, sociodemographic, lifestyle and anthropometric variables on the blood cholesterol levels of hypertensive women. This was a cross-sectional study with hypertensive and nondiabetic women aged 20 to 59 years, recruited from the primary healthcare units of Maceio, Alagoas, in the Brazilian Northeast. Sodium intake was estimated by the 24-hour urinary excretion of sodium; and blood cholesterol was estimated by capillary blood. Age (years), education level (<4 or ≥4 years), race (white or nonwhite), smoking and alcohol consumption were evaluated. The weight, height and waist circumference were measured and body mass index, conicity index and waist-to-height ratio were quantified. The percentage of body fat was measured using a tetrapolar bioelectrical impedance device. The relationship between blood cholesterol and other variables was assessed by multiple regression analysis. A significance level of 5% was used in the final model. This study included 165 hypertensive women. In linear regression, blood cholesterol was directly proportional to age (p<0.001), education level (p=0.01) and race (p=0.04). These variables, as well as sodium intake (p = 0.07) and conicity index (p = 0.12), were included in the multiple regression analysis. Sodium intake (p=0.03) and age (p=0.001) were related, in an inverse and a direct way, respectively, to the blood cholesterol in the hypertensive women studied.

Keywords: Age, Anthropometry, Cholesterol, Hypertension**,** Obesity.

RESUMO

A restrição da ingestão de sódio, um dos pilares do tratamento anti-hipertensivo, tem sido associada ao aumento dos níveis de colesterol. Diante disso, levantou-se a hipótese de que a ingestão de sódio influencia os níveis de colesterol de mulheres hipertensas, independentemente de outros fatores associados. Trata-se de um estudo transversal realizado com mulheres hipertensas e não diabéticas, na faixa etária entre 20 e 59 anos, recrutadas em unidades básicas de saúde de Maceió, Alagoas, situada no Nordeste do Brasil. A ingestão de sódio foi estimada pela excreção urinária de sódio de 24 horas; e o colesterol sérico foi mensurado por coleta de sangue capilar. Foram avaliados idade (anos), escolaridade (<4 ou ≥4 anos), raça (branca ou não branca), tabagismo e consumo de álcool. O peso, a estatura e a circunferência da cintura foram aferidos e o índice de massa corporal, índice de conicidade e razão cintura/estatura foram calculados. A porcentagem de gordura corporal foi medida usando um dispositivo de impedância bioelétrica tetrapolar. A relação entre o colesterol sérico e as outras variáveis em estudo foi avaliada por meio de análise de regressão múltipla, adotando-se um nível de significância de 5% no modelo final. Este estudo incluiu 165 mulheres hipertensas. Na análise de regressão linear, o colesterol sérico foi relacionado à idade (p<0,001), escolaridade (p=0,01) e raça (p=0,04). Essas variáveis, assim como o consumo de sódio (p=0,07) e o índice de conicidade (p=0,12), foram incluídas na análise de regressão múltipla. As variáveis que permaneceram no modelo final foram ingestão de sódio (p=0,03) e idade (p=0,001). A ingestão de sódio e a idade foram as variáveis que influenciaram o colesterol sérico de mulheres hipertensas.

Palavras-chave: Idade, Antropometria, Colesterol, Hipertensão, Obesidade.

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INTRODUCTION

Systemic arterial hypertension (SAH) is a multifactorial clinical disease considered a serious public health problem [1], which substantially increases the risk of developing other cardiovascular diseases (CVD) [2]. These diseases are one of the leading causes of death in the world [3].

Among the risk factors associated with CVD are those considered non-modifiable, such as age, gender and genotype, and those considered modifiable, such as dietary, smoking, stress, weight gain and sedentary lifestyle [4]. One of these main risk factors is cholesterol, whose high serum concentrations are associated with the development of endothelial dysfunction and atherosclerosis [5].

Since most hypertensive individuals present hypercholesterolemia and this condition further increases the risk of CVD [6,7], the knowledge of the factors that influence blood cholesterol in hypertensive women is an important measure to prevent or retard these diseases in this group.

It is known that diet and lifestyle are factors that contribute to the increase of levels of blood cholesterol [7]. Considering that reducing sodium intake is one of the pillars of antihypertensive treatment [8,9,10] and given that the restriction of this micronutrient has been associated with an increase in cholesterol levels [11].

Given the above and the fact that 24-hour urine collection is considered the gold standard for estimating sodium intake [12], the present study aimed to evaluate the influence of sodium intake and sociodemographic, lifestyle and anthropometric variables on blood cholesterol of hypertensive women.

METHODS

This cross-sectional study, conducted between January and September 2015, included 165 hypertensive and nondiabetic women aged 20 to 59 years recruited from primary healthcare units of the city of Maceio, capital of the state of Alagoas in the Brazilian Northeast. Pregnant women and women with genetic or acquired malformations were not included because an anthropometric assessment would not be possible. Women taking lipid-lowering medication were excluded.

The sample size was estimated using the software Epi Info version 6.04, with the following parameters: level of significance of 95% (1-α), a study power of 80% (1-β), ratio of 1:1, considering exposure (hypercholesterolemia) and relative risk equal to 1.5. Based on these criteria, the necessary sample was around 165 women, whose selection was for convenience, and acquisition was by adhesion.

Sociodemographic, anthropometric, biochemical, and blood pressure data were collected. The self-reported races were grouped as white and nonwhite. Education level, based on full years of formal education, was classified as very low (<4 years) and low (≥4 years).

Anthropometric assessment consisted of measuring weight, height, and waist circumference (WC). The measurements were performed twice, by the same researcher, and averaged. New measurements were performed when the two weight, height, and WC measurements, differed by more than 100 g, 0.5 cm, and 0.3 cm, respectively.

Weight and height were measured as originally recommended by Lohman et al. [13], using the electronic portable scale Lider® model P200M (maximum capacity of 200 kg and accuracy of 50 g) and the portable stadiometer Seca® and its inelastic metric tape measure (length of 2 m, graduated to 0.1 cm). Body mass index (BMI) was calculated by dividing weight by the square of the height. Using the cut-off points provided by the World Health Organization (WHO) [14], women with BMI below 25.0 kg/m^2 were categorized as "without excess weight," and those with BMI equal to or above 25.0 kg/m^2, as "with excess weight."

WC was measured by the inelastic metric fiberglass tape measure Sanny®, with a length of 150 cm, graduated to 0.1 cm, at the midpoint between the lowest rib and the iliac crest at the end of a normal expiration [14]. The waist-to-height ratio (WHtR) and the conicity index (C index) were calculated. C index was given by the formula: C index = WC(m)/[0,109 x√(weight(kg)/height(m))]. These indices have been described as the best anthropometric predictors of cardiovascular risk [12]. Women with WC≥80cm [14], WHtR≥0.50 [15] and C index ≥1.18 [16] were considered at risk of developing metabolic complications associated with obesity.

The percentage of body fat (BF) was calculated by the body composition assessment software CompCorp® based on body resistance and reactance was measured by the tetrapolar bioelectrical impedance device RJL model 101-A, as recommended by Lukaski et al.[17]. To indicate above-average body fat levels, the Gallagher et al. [18] classification was used.

Capillary blood was collected by disposable microcuvettes between 08:00 h and 10:00 h after a twelve-hour fast using Accu-Check® (Roche®) test strips and the portable monitor Accutrend GTC® (Roche®), which measures cholesterol in the 150 to 300 mg/dL range. The results were obtained immediately with the reading of the device and interpreted according to the V Brazilian Guidelines on Dyslipidemias and Prevention of Atherosclerosis [19], considering altered cholesterol levels above 200mg/dL.

To determine sodium intake, the participants were asked to collect urine during a full 24-hour period, starting with the second urine on day one and ending with the first urine on day two. Urine was collected in a 5 L container provided by the researchers. When done, the participants returned the containers to their primary healthcare unit. The women were asked not to change their diets during the 24-hour urine collection period.

The analysis consisted of (1) measuring urine volume using a 1000 mL beaker; (2) collecting one 0.5 mL aliquot of urine using 1 ml pipettes and pipette pump; (3) placing the aliquot in one 6 mL test tube; (4) measuring sodium concentration using the ion-selective electrode Iselab®, with automatic aspiration, a built-in printer, and automatic calibration and cleaning systems.

The urine samples of patients who failed to collect one or more urinations, containers with less than 500 mL of urine, and urine collected outside of the 23-25-hour period were discarded, as they were considered incomplete and/or inappropriate [20].

The biochemical marker of sodium intake is the 24-hour urinary sodium excretion (24hUNaE), as more than 90% of the ingested sodium is excreted in the urine [21]. The 24hUNaE is given by the formula: 24hUNaE (mmol/L) = 24-hour urine volume (mL) x excreted Na (mmol) / 1000. 24hUNaE in mmol/L was converted into mg/L by multiplying it by sodium's molar mass (Na = 23 g).

Blood pressure (BP) was measured as recommended by the VII Joint National Committee of Hypertension [22] by the automatic digital device Omron® model HEM 705 CP, validated as instructed by international protocol. In cases where there was a difference greater than 5 mmHg between two measures of systolic blood pressure (SBP) or diastolic blood pressure (DBP), a third one was performed, neglecting the most discrepant. The value adopted for the analyses was the result of the average of the two valid measures. Values of SBP ≥140 mmHg and of DBP ≥ 90 mmHg were considered as high blood pressure levels [22].

Statistical analyses were performed by the software Epi Info version 6.04 (CDC/WHO, Atlanta, GE, USA) and by the software SPSS version 13.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test checked the normality of the continuous variables. Since these variables had normal distribution, they were expressed as mean and standard deviation. The proportions and their respective 95% confidence intervals were also calculated (95%CI).

Linear regression analysis was performed between blood cholesterol and sodium intake (g), age (years), education level (<4 years or ≥4 years), race (white or nonwhite), smoking (smoker and non-smoker), alcohol consumption (does not use, sporadic use and daily consumption), BMI (kg/m²), WC, WHtR, C index and BF. This analysis aimed to evaluate the relationship between blood cholesterol (dependent variable) and the other variables (independent variables) and to select those to be used in multiple regression analysis at a level of 20% significance. Variables with a significance level of 5% ($p<0.05$) were considered significant for the final model.

This study was sponsored by a scientific research-funding agency owned by the state and complied with human research rules established by Resolution n. 466/2012 of the National Health Council. The study was approved in 2013 by the Research Ethics Committee of the Federal University of Alagoas (CAAE: 19203313.2.0000.5013). All women who agreed to participate in the study signed a consent form after being informed of the possibilities of risk and discomfort associated with the procedures.

RESULTS

A total of 191 hypertensive women were assessed. Of these, 18 (9.4%) were excluded because their 24-hour urine collections were incomplete, and 8 (4.2%), because their blood cholesterol data were missing. Hence, the study included 165 hypertensive women, aged 28 to 59 years (48.7±7.7).

There was a predominance of nonwhite race (n=138; 83.6%) and educational levels higher than 4 years (n=103; 62.4%). The majority reported that they were not smokers (n=148, 89.7%) or alcohol users (n = 129, 78.2%) (Table 1).

The use of antihypertensive medication was reported by 156 (94.5%) (Table 1). Nevertheless, 75 (45.5%) presented elevated SBP and DBP and 133 (80.6%) had a higher sodium intake than recommended. Biochemical tests revealed that 80 (48.5%) had altered cholesterol levels. Anthropometric evaluation and body composition assessment showed that 134 (81.2%) were overweight according to BMI, and 115 (69.7%) had elevated BF levels (Table 2).

In linear regression (Table 3 and Figure 1), blood cholesterol was directly proportional to age ($p<0.001$), education level ($p=0.01$) and race ($p=0.04$). These variables, as well as sodium intake ($p = 0.07$) and conicity index ($p = 0.12$), were included in the multiple regression analysis.

From the multivariate analysis (Table 4), an adjusted R^2 coefficient of 0.14 ($p <0.001$) was found. The variables that remained in the final model were sodium intake ($\beta= -3.30$, $p = 0.03$) and age ($\beta= 1.43$, $p = 0.001$).

Table 1. Sociodemographic, lifestyle and clinical data of hypertensive women.

Variables	n	%	95% CI
Age (years)			
45 to 59	118	71.5	63.9 - 78.1
20 to 44	47	28.5	21.9 - 36.1
Race			
Nonwhite	138	83.6	76.9 - 88.8
White	27	16.4	11.2 - 23.1
Education level			
Very low	62	37.6	30.3 - 45.5
Low	103	62.4	54.5 - 69.7
Smoking			
Yes	17	10.3	6.3 - 16.2
No	148	89.7	83.8 - 93.7
Alcohol consumption			
Daily consumption	10	6.1	3.1 - 11.2
Sporadic use	26	15.8	10.7 - 22.4
Does not use	129	78.2	70.9 - 84.1
Use of antihypertensive medication			
Yes	156	94.5	89.6 - 97.3
No	9	5.5	2.7 - 10.4

n - number of individuals; 95%, CI - 95% confidence interval.

Table 2 – Blood pressure, biochemical and anthropometric data of hypertensive women.

Variables	n	%	95%CI
Systolic blood pressure (SBP)			
Altered (SBP≥140mmHg)	75	45.5	37.8 - 53.4
Normal	90	54.5	46.6 - 62.2
Mean ± Standard Deviation		141.1mmHg ± 22.9	
Diastolic blood pressure (DBP)			
Altered (DBP≥90mmHg)	75	45.5	37.8 - 53.4
Normal	90	54.5	46.6 - 62.2
Mean ± Standard Deviation		87.7mmHg ±13.2	
Sodium (Na) intake			
Altered (Na>2g/dia)	133	80.6	73.6 - 86.2
Normal	32	19.4	13.8 - 26.4
Mean ± Standard Deviation		3.7g ± 1.9	
Blood cholesterol (C)			
Altered (C≥200mg/dL)	80	48.5	40.7 - 56.4
Normal	85	51.5	43.6 - 59.3
Mean ± Standard Deviation		202.7mg/dL ± 41.3	
Body mass index (BMI)			
With excess weight (BMI≥25.0kg/m²)	134	81.2	74.2 - 86.7
Without excess weight	31	18.8	13.3 - 25.8
Mean ± Standard Deviation		30.8kg/m² ± 6.4	
Waist circumference (WC)			
With risk (WC≥80cm)	146	88.5	82.4 - 92.7
Without risk	19	11.5	7.2 - 17.6
Mean ± Standard Deviation		96.0cm ± 14.0	
Waist to height ratio (WHtR)			
With risk (WHtR≥0.50)	152	92.1	86.6 - 95.6
Without risk	13	7.9	4.4 - 13.4
Mean ± Standard Deviation		0.62 ± 0.1	
Conicity index (C index)			
With risk (C index≥1.18)	142	86.1	79.6 - 90.8
Without risk	23	13.9	9.2 - 20.4
Mean ± Standard Deviation		1.28 ± 0.1	
Body fat (BF)*			
With risk	115	69.7	62.0 - 76.5
Without risk	50	30.3	23.5 - 38.0
Mean ± Standard Deviation		36.5% ± 8.2	

n - number of individuals; 95%CI - 95% confidence interval; *Gallager et al. (2000)[16].

Table 3 – Simple linear regression analysis between blood cholesterol and independent variables.

	Blood cholesterol (mg/dL)			
Independent variables	β	**95%CI**	**p**	**R^2**
Sodium intake (g)	-2.91	-6.11 – 0.29	0.07	0.01
Age (years)	1.76	0.96 – 2.53	<0.001	0.10
Education level*	17.03	4.13 – 29.93	0.01	0.03
Race (white or nonwhite)	17.49	0.47 – 34.51	0.04	0.02
Smoking (yes or no)	-0.68	-21.6 – 20.29	0.95	-0.01
Alcohol consumption**	-0.19	-15.63 – 15.24	0.98	-0.01
Body mass index (kg/m²)	-0.20	-1.19 – 0.80	0.70	-0.01
Waist circumference (cm)	0.14	-0.32 – 0.60	0.54	-0.00
Waist to height ratio	27.44	-39.07 – 93.94	0.42	-0.00
Conicity index	45.27	-11.49 – 102.03	0.12	0.01
Body fat (%)	0.02	-0.77 – 0.82	0.96	-0.01

*Classified as <4 or ≥4 full years of formal education; **Classified as does not use, sporadic use and daily consumption.

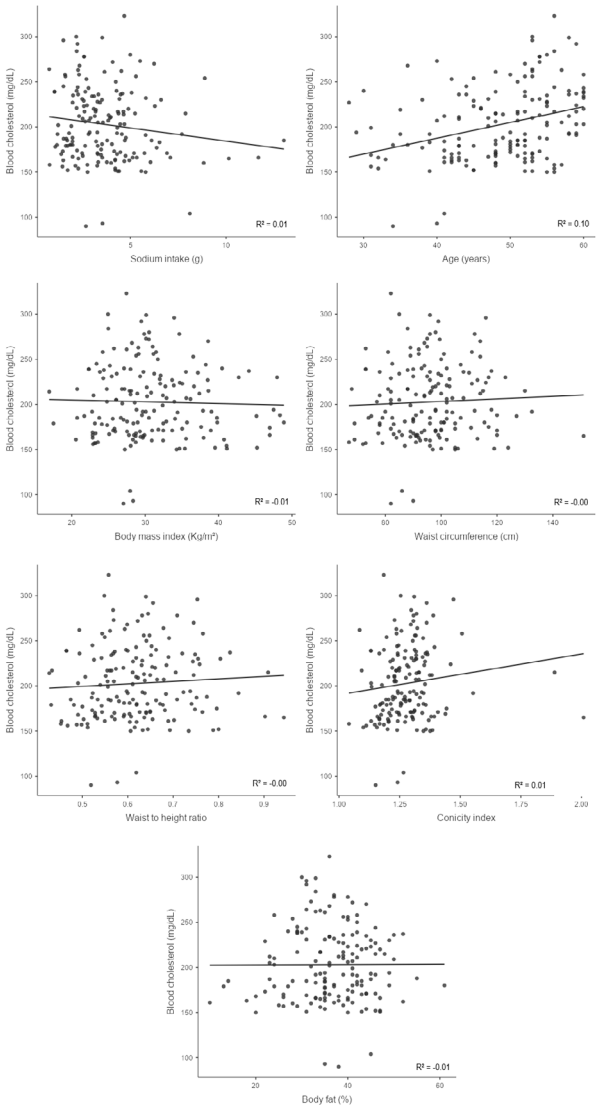

Figure 1 - Simple linear regression analysis between blood cholesterol and continuous variables.

Table 4 – Multiple linear regression analysis between blood cholesterol and independent variables.

	Blood cholesterol (mg/dL)		
Independent variables	β	**95%CI**	**p**
Sodium intake (g)	-3.30	-6.37 - -0.23	0.03
Age (years)	1.43	0.61 - 2.24	0.001
Education level*	12.91	-0.005 - 25.82	0.05
Race (White or nonwhite)	12.08	-4.14 - 28.30	0.13
Conicity index	23.46	-30.81 – 77.72	0.39

*Classified as <4 or ≥4 full years of formal education

Adjusted R^2 for the model = 0.14 (p<0.001)

DISCUSSION

The findings show that sodium intake and age had an influence on blood cholesterol of hypertensive women. The direct relationship between age and blood cholesterol is already well documented in the literature and is explained by different mechanisms [23]. With aging, there is a decline in the rate of bile acid synthesis, an increase in the number of mediators that aid in the absorption of cholesterol in the intestine and oxidative stress, which favors the increase of blood cholesterol [24].

Because the participants were already hypertensive women, where hypertension *per se* is a cardiovascular risk factor [25] and it is known that the prevalence of CVD increases with age [26], special attention needed to be given to the relationship found.

An inverse relationship between sodium intake and blood cholesterol, as evidenced in this study, has been described in meta-analyses [11,27]. In these, it was observed that the limited intake of sodium reduces body water content and increases the levels of epinephrine, renin and angiotensin, aiming at the correction of low plasma volume. However, these hormones inhibit insulin, causing insulin resistance [11] and, consequently, hyperinsulinemia, which compromises lipid metabolism and promotes an increase in cholesterol levels [28,29].

Insulin resistance is known to be a marker of multiple metabolic abnormalities frequently associated with SAH. This condition is common in individuals with excess weight and accumulation of abdominal fat [28], the condition of the majority of the hypertensive women investigated. This homogeneity of the sample may have compromised the occurrence of a statistically significant relationship between the anthropometric indices evaluated and the blood cholesterol.

Although cholesterol is a lipid that plays important roles in the body, in excessive levels and abnormal metabolism, it favors the development of CVD [7]. Aiming at the reduction of blood pressure and consequently the prevention of cardiovascular outcomes, sodium restriction is one of the pillars of antihypertensive therapy [8,9,10]. However, if this restriction favors the increase of blood cholesterol, which, in turn, is also associated with the development of CVD, would the hypertensive patient be benefiting, in fact, from this restriction?

A low sodium diet, despite being advocated for over a century [24], is still one of the major challenges of antihypertensive therapy. Restricting the use of sodium in food alters the palatability and the pleasure of eating [31], which may lead to reduced dietary and nutritional deficiencies.

Our findings agree with the positive relationship already elucidated in the literature between age and blood cholesterol and reinforce the need for further studies to elucidate the metabolic effects of sodium restriction in antihypertensive treatment and to explore the need for this restriction.

The main limitation of the present study is the fact that only hypertensive individuals were evaluated, making it impossible to compare the data found with those of normotensive individuals.

CONCLUSION

In conclusion, sodium intake and age were related, in an inverse and a direct way, respectively, to the blood cholesterol in the hypertensive women studied.

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