Ciência & Saúde Coletiva
cienciaesaudecoletiva.com.br
ISSN 1413-8123. v.30, n.8
DOI: 10.1590/1413-81232025308.12622023

Relationship between salt and blood pressure in indigenous and non-indigenous populations

Relação entre sal e pressão arterial em populações indígenas e não indígenas

Relación entre la sal y la presión arterial en poblaciones indígenas y no indígenas

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Abstract *Objective: to compare the effect of salt consumption on blood pressure (BP) of an indigenous and of a non-indigenous population in Brazil. Design: the studies were carried out in the years of 1999-2004 in an urban population of Vitória (n = 1,663), the capital of Espírito Santo State, and in an indigenous population settled in a reserve of Aracruz (n = 663). Salt consumption was evaluated by a 12-hour overnight urine collect. Results: salt consumption (mean ± sd) was very high (12.8 ± 5.7 g/day vs 11.8 ± 5.9 g/day; P < 0.001), respectively, in indigenous and non-indigenous population. Systolic and diastolic BP was lower in the indigenous population (118/75 mmHg).* In multivariate analysis the contribution of fat accumulation evaluated by body mass index (BMI) was the main component contributing to elevate blood pressure in indigenous. *The slope of the systolic BP in the indigenous in the multivariate analysis, salt intake, age and BMI explained 27% of systolic BP and 21% of the diastolic BP in the indigenous group, while these variables explained 17% and 15% in the non-indigenous population. Conclusion: blood pressure itself did not show a statistically significant change with salt intake alone, highlighting BMI as a key factor in to explain the BP variability in indigenous population.*
Key words *Salt, Urine, Blood pressure, Indigenous population, Urban*

Resumo *Objetivo: comparar os efeitos do consumo de sal na pressão arterial (PA) de uma população indígena e não indígena no Brasil. Metodologia: os estudos foram realizados entre os anos de 1999-2004 em uma população urbana de Vitória (n = 1.663), capital do estado do Espírito Santo, e população indígena assentada na reserva indígena de Aracruz (n = 663). O consumo de sal foi avaliado por meio de coleta de urina noturna de 12 horas. Resultados: a média ± dp do consumo de sal foi muito alta (12,8 ± 5,7 g/dia vs. 11,8 ± 5,9 g/dia; P < 0,001), respectivamente, na população indígena e não indígena. A PA sistólica e diastólica foi menor na população indígena (118/75 mmHg). Na análise multivariada a contribuição do acúmulo de gordura avaliada pelo índice de massa corporal (IMC) foi o principal componente que contribuiu para a elevação da pressão arterial em indígenas. A inclinação da PA sistólica nos indígenas na análise multivariada, consumo de sal, idade e IMC explicaram 27% da PA sistólica e 21% da PA diastólica no grupo indígena, enquanto essas variáveis explicaram 17% e 15% no grupo não indígena. Conclusão: a pressão arterial em si não apresentou alteração estatisticamente significativa apenas com a ingestão de sal, destacando o IMC como fator chave para explicar a variabilidade da PA na população indígena.*
Palavras-chave *Sal, Urina, Pressão arterial, População indígena, População urbana*

Resumen *Objetivo: comparar los efectos del consumo de sal sobre la presión arterial (PA) en una población indígena y no indígena en Brasil. Metodología: Los estudios se realizaron entre 1999 y 2004 en una población urbana de Vitória (n = 1.663), capital del estado de Espírito Santo, y en una población indígena asentada en la Reserva Indígena de Aracruz (n = 663). El consumo de sal se evaluó mediante la recolección de orina nocturna de 12 horas. Resultados: la media ± DE del consumo de sal fue muy alta (12,8 ± 5,7 g/día frente a 11,8 ± 5,9 g/día; P < 0,001), respectivamente, en las poblaciones indígena y no indígena. La PA sistólica y diastólica fueron más bajas en la población indígena (118/75 mmHg). En el análisis multivariado, la contribución de la acumulación de grasa, evaluada mediante el índice de masa corporal (IMC), fue el principal factor que contribuyó a la elevación de la presión arterial en la población indígena. La pendiente de la presión arterial sistólica en la población indígena en el análisis multivariado, la ingesta de sal, la edad y el IMC explicaron el 27% de la presión arterial sistólica y el 21% de la presión arterial diastólica en el grupo indígena, mientras que estas variables explicaron el 17% y el 15% en el grupo no indígena. Conclusión: la presión arterial en sí no mostró un cambio estadísticamente significativo con la ingesta de sal únicamente, lo que destaca al IMC como un factor clave para explicar la variabilidad de la presión arterial en la población indígena.*
Palabras clave *Sal, Orina, Presión arterial, Población indígena, Población urbana*

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Introduction

The indigenous populations living in their original way of life, did not add salt the cooking process. Therefore, daily salt intake was very low in these populations (usually < 0.5 g/day of sodium)[1]. This fact was showed in the INTERSALT Study, which was the largest study conducted by the end of the last century aiming to investigate the relationship between salt consumption and blood pressure in different populations[1,2].

From the 52 populations of the five continents included in the analysis, four still lived in their primitive conditions without use of addition salt, and in these four populations, the age-dependent blood pressure increase was very low so that the prevalence of hypertension, if any, was very low[2]. The nutrition transition of these primitive populations has been very fast in Brazil as well as in other countries[3], with the introduction of diet habits, such as salt addition, use of processed and ultra-processed foods and alcohol abuse, etc., thus facilitating the development of several chronic non-communicable diseases (NCDs), such as high blood pressure, obesity, and diabetes which give an important contribution for the morbidity and mortality.

Cardiovascular diseases are the leading cause of mortality around the world and arterial hypertension (AH) is the most important risk factor for cardiovascular deaths[4]. The development of high blood pressure depends of a large number of non-modifiable (genetic traits, sex and age) and modifiable factors including lifestyle-related risk factors such as smoking, excessive consumption of alcoholic beverages, and high sodium intake[5].

Salt consumption is high all over the world, including the indigenous populations that adopted nutrition habits similar to those occurring in the general population[6]. The INTERSALT study showed also that in the populations with high sodium intake (> 5 g/day) there is a linear relationship between the mean salt intake of each population, the mean values of BP and the prevalence of hypertension[2].

The World Health Organization (WHO) suggests a daily intake of sodium of 2 g, equivalent to 5 g of table salt[1]. The great majorities of the studies carried out in indigenous and non-indigenous populations have shown a mean salt intake well above the actual WHO recommendation, especially in Brazil where salty foods are quite appreciated. In a representative sample of the adult Brazilian population included in a National Health Survey (2013), the estimated salt consumption was around 9.34 g/day and less than 5% showed a consumption less than 5 g/day[7]. In this study, salt consumption was estimated based on the sodium/creatinine rate in a spot urine sample.

Study carried out with a representative sample of the population of Vitória, a 12.6 g/day consumption was measured[8], while in an indigenous group established in the reserve of Aracruz, the mean consumption reached 13.7 ± 7.1 g/day (2003).[6] In both these studies salt consumption was calculated based on a 12-hour overnight urine collect used same analysis method to check salt consumption. The Native Brazilian populations did not use salt in the cooking process and the prevalence of AH was almost absent[9].

Over the years, the westernization of the eating habits of these populations may contribute to a progressive increase of BP levels and AH development. BP is complex variable because it depends on factors and studies relating the contribution of these factors to BP levels in populations with different ancestry are very scarce. Our aim in this study was to compare of influence of salt intake and obesity of BP of two population, one living in an indigenous reserve that has adopted a western diet for the last decades and an urban population living in the city of Vitoria.

Blood pressure and anthropometric variables were measured with the same techniques and by the same research group. Importantly, salt consumption was evaluated by the same method previously validated[8] based on a 12-hour overnight urine collect. The study showed that BP of the indigenous seems to be less sensitive to a high salt diet as compared to non-indigenous. Conversely, in the first group, BP levels are more sensitive to fat accumulation.

Material and methods

Populations and samples

Data were collected in two cross-sectional studies. The first, in a representative sample of the urban population (25-64 years old) of Vitória, the capital of Espírito Santo State and the second in adults (> 20 years old) of an indigenous population living in a reserve in Aracruz, north coast of the same state. In Vitória, the data were collected in a representative sample of households (N = 1,663; 1999-2001), selected by a random sample of domiciles[8].

In the indigenous reserve all subjects (>20 years) were invited and from the eligible population (N = 834), 663 (79.5%) attended to the project for data collection (2003-2004)[6]. Both studies were designed to investigate the prevalence and severity of cardiovascular risk factors and were approved by the national and institutional ethics committees UFES (Decision 3123/02) and by the Human Research Ethics Committee (CONEP) (Decision 4559) and all participants signed a written informed consent. In the indigenous population this procedure was carried out with the help of local health personal.

All data were collected following international rules in according with the Declaration of Helsinki. Research protocols were similar in both studies and participants were invited to attend to the University Hospital (urban population of Vitória) or to the Health Unit of the indigenous reserve in a pre-scheduled day. Socio-demographic characteristics (sex, age, schooling, self-reported race/ethnicity) and habits (smoking and alcohol intake) were collected by questionnaires during the visit. Blood sample was collected in fasting condition. All other data were obtained by specific exams during the same visit. All participants were asked to avoid strenuous physical exercise and to not drink alcohol in the 24 h previous to exams.

Anthropometry

Body weight (kg), and height (cm) were collected while the participants were fasting, barefoot and in light clothes, by using an electronic scale (precision of 0.1 kg) and a wall mounted stadiometer (precision of 0.5 cm). Weight classification was based on body mass index (BMI), calculated as the ratio between weight (Kg) to the squared height (m). Subjects were classified as eutrophic (BMI < 25kg/m2), overweight (BMI ≥ 25.0 - 29.9 kg/m2) or obese (BMI ≥ 30kg/m^2 [10].

Blood pressure

Resting systolic and diastolic BP (SBP, DBP) was measured in the left arm in sitting position after a rest period of 5 min. Three readings with 5-10 min intervals were obtained in each subject by using an oscillometric automatic device (Onrom 705CP, Japan). Clinic BP was determined as the mean of the last two measurements. Subjects were classified as hypertensive if blood pressure was ≥140/90 mmHg or in use of anti-hipertensive drugs, including diuretics[11].

Salt consumption

Participants in both studies received previous instructions for an overnight 12-h urine collection in the evening of the clinic visit. Individuals were asked to void as nearly as possible of 7:00 pm in the night before exams. From this moment they were orientated to collect all urine in a plastic bottle (2 liters volume) and to proceed the last collect around 7:00 am next day. The exact time of the last urine void and last collect in the bottle should be annotated in a form in order to calculate the exact interval of urine collect. In the indigenous community the urine collect was guided by trained health professionals attending local health facilities.

When arriving at the local of exams (University Hospital in Vitória or the local health facility in the indigenous reserve) the bottle was delivered to a research assistant to determine the period of urine collect and to measure urine volume in a graduated cylinder with 10 mL precision. A sample (5 mL) was separated and sent to a central laboratory to sodium and potassium dosage. Urinary flow (mL/min) was measured by dividing total urinary volume by the period of urinary collect. Urine collect was considered valid if the volume was ≥ 250 mL and with no report of urine lost[12]. The daily sodium intake was estimated from the 12-h urinary sodium excretion according to a validation study of our group showing that nearly 47% of the 24-h sodium excretion is found in the 12-h overnight urine sample[13]. Salt consumption (g/day) was calculated considering that all urinary sodium comes from NaCl ingestion.

Statistical analysis

Continuous variables are given as means and standard deviations and categorical variables as absolute frequencies and percentages. The goodness-to-fit to a Gaussian distribution was verified by the Kolmogorov-Smirnov test. Differences between groups were assessed using the students t test for independent samples. The chi-square test was applied for categorical variables. The association between BP and urinary sodium excretion (Ur-Na) was performed using Pearson's coefficient, and a multivariate linear regression model was used to test the dependence of BP on the estimated salt intake, and

after adding to the model, in this order, age, and BMI. All statistical analyses were performed using SPSS 22.0 Statistical Package (SPSS, Chicago, IL). Statistical significance was set at $P < 0.05$.

Results

From the indigenous population (N = 663) we removed for this analysis 33 who did not collected 12-h urine, 17 with 12-h urine < 250 mL, 18 with implausible salt consumption (≥ 30g/day), and 15 without data of blood pressure, serum creatinine, or body weight. Others 54 were removed because they were in use of anti-hypertensive drugs, remaining 526 participants in the analysis (see supplementary material, available at: https://doi.org/10.48331/SCIELODATA.JCPZL0). From the 1,663 non- indigenous participants recruited in the Vitória, we removed from the analysis 10 without urine collect, 45 with 12-h urine volume < 250 mL, 50 with implausible salt consumption (≥ 30g/day) and others 25 without data of blood pressure, creatinine or body weight. Others 254 were removed because they were in use of anti-hipertensive drugs, remaining 1,279 participants in the analysis (see supplementary material, available at: https://doi.org/10.48331/SCIELODATA.JCPZL0). Below presents the results of the indigenous and non-indigenous population. The socio-demographic characteristics of the two samples are shown in Table 1.

The sex distribution was similar in both groups and the indigenous group showed lower schooling levels and excessive fat accumulation (overweight and obesity was less prevalent: (44.7% vs 51.9; $p < 0.05$). Regular smoking was similar in the two groups. Hypertension, however, was less frequent in the indigenous population (12.7% vs 30.8%; $p < 0.01$).

Table 2 shows anthropometric, clinical and biochemical characteristics of the groups. The indigenous group was around seven years younger (35.5 vs 43.4 years; $p < 0.001$) than the urban one. BMI was slightly lower in indigenous (25.0 vs 25.7 kg/m^2; $p = 0.009$), while blood pressure (118/75 vs 124/82 mmHg; $p < 0.001$), cholesterol (164.6 vs 211.7 mg/dL; $p < 0.001$), triglycerides (106.7 vs 129. 7 mg/dL; $p < 0.001$), glycemia (89.3 vs 102.0 mg/dL ($p < 0.001$), creatinine (0.7 vs 0.9 mg/dL; $p < 0.001$) and uric acid (4.2 vs 4.7 mg/dL; $p < 0.001$) also showed lower values in indigenous as compared to the non-indigenous ($p < 0.001$). High density lipoprotein (HDL-c) however, showed an opposite picture being higher in indigenous (49.2 vs 44.3 mg/dL; $p < 0.001$).

The general characteristics of the 12-h urine are shown in Table 3. The indigenous group produced a urine with smaller volume (around 14% less) but with higher sodium concentration (154 vs 128 mmol/L; $p < 0.001$). The urinary creatinine concentration was similar in both groups (99.1 vs 102.2 mg/dL; $p = 0.321$) so that the sodium to creatinine ratio was also

Table 1. Sociodemographic and clinical characteristics of the samples according to the population groups (1999-2004).

	Indigenous (Aracruz, ES)	**Non-indigenous (Vitória, ES)**	**P-value**
	(N = 526)	**(N = 1,279)**	
	N (%)	**N (%)**	
Sex			0.954
Male	257(48.9)	623 (48.7)	
Female	269(51.1)	656 (51.3)	
Education			<0.001
≤ 4 years	349(66.5)	557 (43.6)	
4 to 8 years	83 (15.8)	190 (14.9)	
8 to 11 years	87(16.6)	319 (25.0)	
≥ 12 years	6(1.1)	211 (16.5)	
Nutritional status			0.020
Euthophy	291(55.3)	615 (48.1)	
Overweight	163(31.0)	464 (36.3)	
Obesity	72(13.7)	200 (15.6)	
Smoking	145(27.6)	315 (24.7)	0.199
Hypertension	67(12.7)	394 (30.8)	< 0.001

Source: Authors.

Table 2. Anthropometric, clinical and biochemical characteristics of individuals according to the population group (1999-2004).

	Indigenous (Aracruz, ES) (N = 526) M (±SD)	Non-indigenous (Vitória, ES) (N = 1279) M (±SD)	P-value
Age (years)	35.5 (±13.5)	43.4 (±10.5)	< 0.001
Weight (kg)	65.2 (±12.1)	68.6 (±14.0)	< 0.001
Height (cm)	161.2 (±8.9)	163.1 (±9.2)	< 0.001
BMI (kg/m2)	25.0 (±4.3)	25.7 (±4.5)	0.009
SBP (mmHg)	118 (±17)	124 (±19)	< 0.001
DBP (mmHg)	75(±10)	82 (±13)	< 0.001
HR (bpm)	69 (±11)	75 (±11)	< 0.001
Cholesterol (mg/dL)	164.6 (±45.7)	211.7 (±44.9)	< 0.001
HDL-cholesterol (mg/dL)	49.2 (±15.0)	44.3 (±14.8)	< 0.001
Triglycerides (mg/dL)	106.7 (±161.6)	129.7 (±99.3)	< 0.001
Glucose (mg/dL)	89.3 (±14.6)	102.0 (±25.9)	< 0.001
Serum creatinine (mg/dL)	0.7 (±0.2)	0.96 (±0.2)	< 0.001
Uric acid (mg/dL)	4.2 (±1.5)	4.7 (±1.4)	< 0.001

Values are presented as means and (±) standard derivations; N = number of subjects; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate; t test for independent groups.

Source: Authors.

Table 3. Urine characteristics of individuals according to the population group (1999-2004).

12 -hour urine	Indigenous (Aracruz, ES) (N = 526) M (±SD)	Non-indigenous (Vitória, ES) (N = 1,279) M (±SD)	P-value
Volume (mL)	719 (±334)	833 (±420)	< 0.001
Sodium (mmol/L)	154.4 (±58.9)	128.4 (±65.0)	< 0.001
Potassium (mmol/L)	26.9 (±14.4)	30.7 (±20.0)	< 0.001
Creatinine (mg/dL)	99.1 (±59.5)	102.2 (±60.7)	0.321
Creatinine excretion (mg)	607.2 (±335.1)	705.2 (±327.4)	< 0.001
Sodium/creatinine (mmol/mg)	0.20 (±0.13)	0.15 (±0.10)	< 0.001
Potassium/creatinine (mmol/mg)	0.03 (±0.27)	0.03 (±0.33)	0.017
Sodium/potassium ratio (mmol/mmol)	6.7 (±3.2)	4.9 (±3.2)	< 0.001
Urinary Na_{12h} mg)	2,375.0 (±1052.4)	2,182.0 (±1083.8)	< 0.001
Urinary K_{12h} (mmol)	17.0 (±8.0)	22.6 (±14.0)	< 0.001
Salt consumption (g/day)	12.8 (±5.7)	11.8 (±5.9)	< 0.001

Values are presented as means and (±) standard derivations; N = number of subjects.

Source: Authors.

higher in indigenous (0.20 vs 0.15 mmol/mg; $p < 0.001$). The sodium to potassium ratio was higher in indigenous group (6.7 vs 4.9 mmol/mmol) and much above the actual recommendations (~1) in the two groups. The calculated 12-h sodium excretion as well as the estimated salt consumption were both higher in the indigenous group as compared the non-indigenous one (12.8 ± 5.7 vs 11.8 ± 5.9 g/day; $p < 0.01$).

The relationship between systolic and diastolic BP as a function of salt consumption in the models is shown in Table 4. The linear correlation between salt intake and BP increment (mmHg/g) was lower and non-significant in the indigenous ($r = 0.075$) and higher an significant in non-indigenous ($r = 0.14$; $P < 0.01$). In multivariate analysis the contribution of fat accumulation evaluated by body mass index (BMI) was the main component contributing to elevate

Table 4. Results of multiple linear regression between salt intake and blood pressure in indigenous and non-indigenous populations (1999-2004).

Systolic blood pressure					
Indigenous					
	r	**r^2**	**r^2 adjusted**	**F**	**P-value**
Model 1	0.075	0.006	0.004	2.999	0.084
Model 2	0.510	0.260	0.258	180.130	< 0.001
Model 3	0.525	0.275	0.271	10.725	< 0.001
Non-indigenous					
Model 1	0.140	0.020	0.019	25.434	< 0.001
Model 2	0.335	0.112	0.111	133.555	0.001
Model 3	0.410	0.168	0.166	85.700	< 0.001
Diastolic Blood Pressure					
Indigenous					
	r	**r^2**	**r^2 adjusted**	**F**	**P-value**
Model 1	0.111	0.012	0.010	6.561	< 0.011
Model 2	0.385	0.148	0.145	83.3156	< 0.001
Model 3	0.453	0.206	0.201	37.842	< 0.001
Non-indigenous					
Model 1	0.194	0.038	0.037	49.913	< 0.001
Model 2	0.278	0.077	0.076	545.001	< 0.001
Model 3	0.393	0.154	0.152	115.991	< 0.001

Multivariable linear regression model. Significantly different, P value < 0.05. Model 1: Salt and blood pressure. Model 2: Salt, blood pressure, Age. Model 3: Salt, blood pressure, Age, BMI.

Source: Authors.

blood pressure in indigenous. The slope of the systolic BP in the indigenous in the multivariate analysis, salt intake, age and BMI explained 27% of systolic BP and 21% of the diastolic BP in the indigenous group (model 3), while these variables explained 17% and 15% in the non-indigenous population.

Figure 1 presents the slopes of the comparison curves between the indigenous and non-indigenous population for model 3. It was observed that the modulation in systolic blood pressure and specifically BMI were twice as high in systolic blood pressure in the indigenous people compared to the non-indigenous group indigenous (p = 0.01). The BMI beta values for indigenous people are as follows: (0.49 vs 1.03; P = 0.01). The same was observed for diastolic BP (0.59 vs 0.81; p = 0.1), although not statistically significant.

Discussion

In this study, we observed that salt consumption was quite high in almost all subjects were this variable was investigated, independent of the group, that is, either the non-indigenous urban population of Vitória as in the indigenous population living in an indigenous reserved. It is important to emphasize that sodium intake was evaluated by a validated method involving a 12-h overnight urine collect. The other variables (BP, blood biochemical analysis, anthropometry, etc.) were collected by using the same procedures.

Also, regression was performed only in individuals not in use of anti-hypertensive drugs to avoid the influence of the treatment on BP. We observed a tendency towards a linear relationship between the estimated value of salt consumption and SBP when evaluated according to the crude model and after including in the analysis age (because the indigenous group was younger) and BMI was lower.

The significant values found were due to the influence of salt intake on blood pressure, largely modulated by BMI, on systolic blood pressure (p < 0.01). An accurate assessment of sodium intake is not easy when tested in large number subjects. The gold standard method is the 24-h urine collect[13]. However, there are serious inconveniences of this procedure when used in the general population because subjects are generally outside their homes along the day.

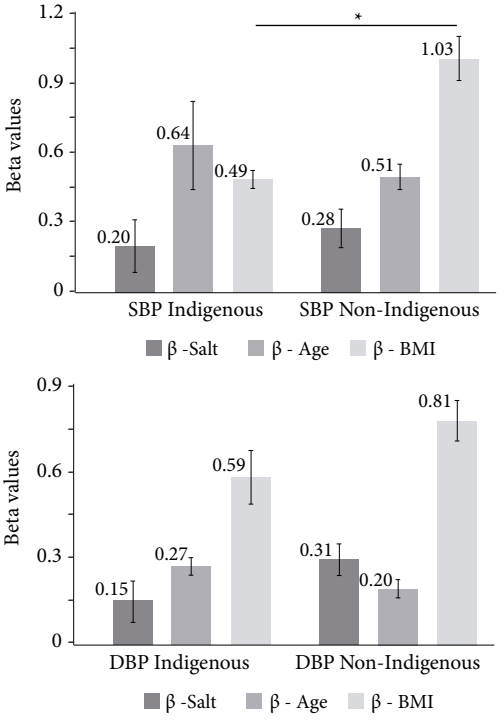

Figure 1. Adjusted beta values for pressure and salt in model 3. Indigenous and non-indigenous population, 1999-2004.

Source: Authors.

Therefore, our group developed several studies to validate the overnight 12-h urine collect to estimate salt consumption and our studies to validate the 12-h overnight urine collect as an alternative method to estimate salt intake[14]. In one of these studies[14] the overnight 12-h urine Na comprised 47% of the 24-h urine, a value that was confirmed in a larger study in the general population of Vitória[8]. Several criteria were used to consider a timed urine collect as 'valid', causing a loss of about 10% participants in the two populations showed in this study, a value lower that it was usual when other methods to evaluate salt consumption, such as spot urine and 24h recall are used[15,16].

To investigate the relationship between salt consumption and blood pressure we also removed from the analysis all subjects in use of antihipertensive drugs, including diuretics, because these drugs would be an important confounder to determinate the association between these two variables. More important, we used the same methods to collect and process the urine and blood pressure data. Therefore, data of these two populations can be compared without important bias interfering in the results.

We observed that in both populations the salt consumption is high and quite above the WHO recommendations of 5 g/day[17]. Similar results have been obtained in other studies in Brazil as well in populations of other countries. In a previous analysis of the data of this same study, Meyerfreund *et al.*[6] (2009), related that the salt intake was similar in the three different groups living in the same reserve of Aracruz (Guarani, Tupinikin and non-indigenous: (11.7 ± 5.3 g/day; 13.7 ± 7.2 g/day and 14.2 ± 7.2 g/day; $P > 0.05$, respectively. Studies carried out through the National Health Survey (PNS-2013) using a spot urine sample found average salt values of 9.34 g/day, being higher in men (9.6 vs 9.5 g/day; $p < 0.05$)[7]. Furthermore, no statistical differences were found according to age groups and education level[7].

Also in Vitória, the assessed salt consumption was 10.4g/day with 24-hour collection[13]. National reports according to data from the Household Budget Survey (POF 2008-2009) revealed high levels of daily salt intake equivalent to 12g/day[17].The relationship between salt intake and blood pressure is well established in the literature[18,19]. However, to date this is the first study to compare the impact of sodium intake with blood pressure in two populations with a high and similar pattern of salt intake but with different ancestry. We discuss here some possible causes for the interference in nutritional status in the pressure of the indigenous and urban population, observed in these groups.

The first point to be considered for interference in nutritional status and effects of salt intake and blood pressure is insulin resistance in obese individuals. Individuals who have a high body mass index tend to have illnesses related to diseases such as cardiovascular complications associated with quality of life[5]. Therefore, there is a relationship between obesity and insulin resistance, which are linked by pathophysiological mechanisms which include low-grade chronic inflammation and association with free fatty acids interfering with insulin signaling[20-22]. Furthermore, mitochondrial dysfunction can also contribute to insulin resistance, through increased hepatic glucose production[20-22]. Increased salt consumption, in turn, tends to worsen these conditions, as it is linked to hypertension[8]. All of these effects lead to greater accumulation of visceral fat, worsening of systemic

inflammation and insulin resistance in obese individuals[5].

Another aspect to be considered is the effect of overweight/obesity on blood pressure. Recent population studies[23,24] have demonstrated the relationship between high salt intake in adults, obesity and blood pressure. High body mass index has been strongly associated with increased salt intake and hypertension. Individuals with a high BMI tend to eat more salt[23], which leads to greater sodium and water retention in the body. This sodium retention, in turn, increases blood volume, increasing blood pressure. Furthermore, individuals with a higher BMI have greater activation of the sympathetic nervous system, which activates the release of catecholamines, such as noradrenaline, increasing blood pressure values[20-22].

This high sympathetic activity in individuals with high BMI causes vasoconstriction of the arteries, increasing peripheral vascular resistance which is associated with excessive salt intake, causing an effect on the arteries, making the smooth muscle more reactive to nervous stimuli, generating pressure reactivity[20-22]. Studies[23,24] observe the combined effects of high BMI and high salt intake and cardiovascular events, such as stroke.

The response of high BMI to blood pressure is also related to the behavior of sodium receptors in the kidneys and genetic variations and sensitivity to salt[25]. Individuals with a high BMI tend to be more sensitive to salt, which means that even small amounts of sodium can substantially increase blood pressure[26]. Although this effect was not directly observed in our study. Therefore, weight management strategies and reduction in salt consumption are necessary to manage hypertension and associated risk factors.

Our study has some limitations. First, sodium intake was not determined with the gold standard 24-hour urinary collect. However, in a previous study[14] the 12-h overnight urine collect was validated to replace the more difficult 24-h collect. The estimated salt intake when using these two urines collect methods is quite similar in studies of our group. Second, sodium intake may be slightly undervalued because we removed from the databank the hypertensive patients in use of antihypertensive drugs and previous studies have shown that hypertensive individuals show a higher salt intake[8,23,25]. Finally, data were recorded at different times (1999-2001 in Vitoria and 2003-2004 in the indigenous population). However, dietary habits remain essentially unchanged in this small period of time and other factors influencing BP were not taken into consideration in this analysis.

Conclusion

The results demonstrate a high salt consumption in both populations (urban and racially mixed and the indigenous), with values above the maximum allowable recommendation being found. No significant relationship was found between salt consumption and blood pressure when used alone, but statistical significance occurred after adding to the model age and BMI. Low influence of salt was observed in the indigenous. In this group, the predominant factor influencing either systolic and diastolic blood pressure is fat accumulation. We can suppose that the blood pressure of the indigenous people is more independent of salt intake because they are more efficient to eliminate sodium in the urine. The fact that we observed a higher sodium/creatinine ratio in the urine of indigenous reinforces this view.

Collaborations

Analysis, interpretation and writing of the work: AS Porto. Interpretation and writing of the work: L Forechi. Interpretation and writing of the work: MDCB Molina. Conception, planning, data collected, analysis, interpretation and writing of the work: JG Mill. All authors approved the final version sent.

Acknowledgments

We thank, first of all, all study participants who were willing to perform the 12-hour urine collection and voluntarily participate in the research. This study was funded by a scholarship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) with the aid of a research grant from Universidade Federal do Espírito Santo (UFES).

Funding

This work was supported by Fapes-CNPq/ PRONEX (No. 24/2018) and CNPq (No. 302518/2019-3).

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Article submitted 08/08/2023
Approved 10/08/2024
Final version submitted 12/08/2024

Chief editors: Maria Cecília de Souza Minayo, Romeu Gomes, Antônio Augusto Moura da Silva, Vânia de Matos Fonseca