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ORIGINAL ARTICLE

Analysis of blood pressure of patients with obesity and its relationship with sodium intake and cardiovascular risk markers: a prospective observational cross-sectional study

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Abstract

Obesity is currently a serious clinical problem, and it is estimated that by 2035, approximately 1.77 billion adults will be overweight 1.53 billion will be obese, and arterial hypertension is one of the most prevalent comorbidities. One of the challenges associated with the correct approach to blood pressure among patients with obesity concerns its correct measurement. An alternative that has been used is measurement using automatic equipment, in addition to the usual positioning on the arm, also the wrist as the measurement site. Cardiovascular risk markers have been evaluated for sodium consumption, and it is considered that there is a strong relationship between excessive consumption and greater risk, including increased arterial stiffness. **Objective:** It was to evaluate whether blood pressure measurements obtained using automatic equipment on the arm and wrist are equivalent in patients with obesity, to analyze sodium consumption through urinary excretion, to evaluate the correlation between sodium consumption and blood pressure, to evaluate the correlation between sodium consumption and cardiovascular risk markers, and to observe markers related to lifestyle and health habits such as alcohol consumption, physical activity, smoking, sleep, work, lipid profile, glycemic profile, and renal function. **Methods:** A total of 47 patients treated at the Nutrology Outpatient Clinic of HCRP-USP in 2022 and 2023 were included. The inclusion criteria were patients aged between 20 and 60 years; both genders; Body mass index greater than 30 kg/m^2. The exclusion criteria were the presence of body deformities that prevented anthropometry and/or blood pressure measurement; the presence of arm circumference greater than that allowed for cuff use; previous bariatric surgery; pregnancy; and Failure to perform the requested laboratory tests. Personal, anthropometric, and laboratory data were collected from each patient. **Results and Conclusion:** Systolic blood pressure did not show any difference between measurements on the arm and wrist. Diastolic pressure was different, being lower on the wrist. 93.6% of patients had a daily consumption greater than 2 g/day, the limit recommended by the WHO. No correlation was found between sodium intake and blood pressure measurements taken on the arm and wrist, as well as correlations between sodium intake and glycemic profile, lipid profile, and renal function. The prevalence of diabetes was similar to that observed in other studies involving patients with BMI > 30 kg/m^2 but was higher than the overall prevalence. The presence of dyslipidemia was higher than the overall prevalence and also higher than other studies involving only patients with obesity. Renal function was preserved in most patients and the few who showed signs of impairment were all diabetic and/or hypertensive.

Keywords: Blood pressure. Obesity. Sodium intake. Cardiovascular risks. Lifestyle. Arm. Wrist.

Introduction

Obesity is currently a serious biopsychosocial problem. Its global prevalence has doubled since 1980, and currently, approximately 42% of the world's population is overweight **[1,2]**. It is projected that by 2035, 1.77 billion adults will be overweight and 1.53 billion will be obese, equivalent to 54% of the population having one of these two conditions **[2]**. In Brazil, according to data from the World Atlas of Obesity, the prevalence in 2024 of adults with a body mass index (BMI) greater than 25 kg/m^2 is 55% **[2]**.

For the patient, obesity represents a risk of affecting practically all organs and systems, with frequent comorbidities such as diabetes, cardiovascular diseases, psychological disorders, and musculoskeletal changes, among others **[1]**. Hypertension is one of the most prevalent disorders among obese individuals **[3]** and, in addition, it is often considered the comorbidity that poses the greatest health risks to patients **[4]**. It is believed that 75% of the incidence of hypertension is related to obesity **[3]**. Data from 2008 showed that 40% of the world's adult population had hypertension, with 1 billion cases without adequate control and an annual increase of 400 million cases since 1980, leading to 9.4 million deaths per year **[3]**.

In the kidneys, obesity increases sodium reabsorption and impairs natriuretic pressure as it activates the renin-angiotensin system, in addition to altering the dynamics of forces within the renal parenchyma. Abnormally high levels of renin activity, angiotensinogen, angiotensin II, and aldosterone have been demonstrated in patients with obesity, despite the volume expansion and sodium retention observed in these patients **[5]**. In chronic cases, changes in renal structure are also observed, leading to functional impairments in the nephron that culminate in more hypertension **[6]**. In the central nervous system, obesity increases the activity of the sympathetic nervous system, through hyperstimulation of peripheral α1 and β-adrenergic receptors **[3]**.

The free fatty acids produced in the diet of obese individuals increase the αadrenergic sensitivity of the vessels, leading to their hypertonia. Additionally, the sensitivity of baroreceptors is impaired in obesity **[3]**. The adipose tissue of patients with obesity produces pro-inflammatory adipokines, such as leptin, TNF-alpha, resistin, and interleukin-6, in addition to reactive oxygen species, favoring endothelial dysfunction and damaging the kidneys **[3]** and, additionally, producing reduced amounts of adiponectin **[5]**. The insulin resistance in most obese individuals reduces the production of nitric oxide, which would have a vasodilatory effect **[5]**. One of the challenges associated with the correct approach to blood pressure concerns its accurate measurement, which involves the use of cuffs with adequate diameters **[7]**. This fact, among patients with obesity, already leads to some difficulties, since the professional would need to perform frequent cuff changes, depending on the patient being treated, and, almost always, the professionals do not even have different cuffs available. Additionally, systolic and diastolic pressures measured by the auscultatory method can be difficult to obtain in patients with severe obesity, due to the muffling of noise.

An alternative that has been used to facilitate this measurement, especially in patients with obesity **[8]**, is measurement using automatic equipment, which can be placed on the arm in a similar way to conventional equipment. Another possibility is to use the wrist as the measurement site **[9]**, since this site has a circumference with much less variability than the arm, almost always allowing the use of a single cuff even in patients with significantly different weights. Validation studies have been conducted for these devices, especially for home self-monitoring **[10,11]**, showing a good correlation with the usual measurement. The search for more accurate measurement methods is essential since it is believed that only half of hypertension cases are detected and, in the case of patients with obesity, the measurement itself brings a series of additional difficulties **[3]**.

Ge et al. **[12]** demonstrated a higher risk of metabolic syndrome as sodium intake increased. Afsar **[13]** demonstrated better cognitive function with lower sodium intake. A Korean study published in 2017 and conducted by Nam et al. **[14]** showed a positive association between high sodium intake and obesity, regardless of energy intake, a result similar to that observed by Grimes et al. **[15]** in Australian schoolchildren.

Data from a cohort study published in 2016 showed an association between 24-hour urinary sodium excretion and cardiovascular disease **[16]**. Specifically to arterial hypertension, Lemogoum et al. **[17]** showed in a 2018 publication that sodium intake was the aspect that most influenced the presence of hypertension among pygmies. Liusov et al. **[18]** demonstrated that hypertension was particularly severe in patients who exceeded 180 mmol/day of sodium excretion. Han et al. **[19]** showed a significant increase in the risk of hypertension in the upper quartile of sodium intake in a prospective Chinese study involving 1,668 adults, even after controlling for confounding variables such as age, BMI, smoking, alcohol use, and fruit and vegetable intake.

The average sodium intake in the US is 3.6 g/day, which far exceeds the limits suggested by the US Dietary Guidelines (2.3 g/day) **[20]** and even more than the maximum recommended by the American Heart Association (1.5 g/day) **[21]**, and the relationship between this excess and the prevalence and incidence of arterial hypertension is considered an unequivocal fact.

Despite the existence of individuals who are not sodium-sensitive in terms of blood pressure control, the relationship between the two is undeniable **[17]** and the presence of genetic factors involved is currently recognized, as the relationship between sodium intake and hypertension has a familial component **[22]**. From the point of view of its hypertensive action, there is a certain proportionality between the effect and the amount consumed. Additionally, sodium can lead to endothelial dysfunction and oxidative stress, causing vascular injury, increasing peripheral insulin resistance and directly increasing the activity of the renin-angiotensin system **[16,23]**.

Cardiovascular risk markers have been evaluated for sodium consumption, and it is considered that there is a strong relationship between excessive consumption and increased risk **[24]**. Kapoor et al. **[25]** found that higher consumption was linked to increased triglycerides and LDL and reduced HDL. Additionally, they found a strong relationship with new cardiovascular risk markers, hs-cTnt, and NT-proBNP. A relationship with some mediators has also been demonstrated, with low consumption leading to increased adiponectin and reduced insulin, and high consumption to reduced renin and angiotensin activity **[26]**.

According to a study by Baldrand et al. **[27]**, high consumption increases plasma cortisol and reduces HDL and adiponectin, in addition to being related to hypertension and insulin resistance, considering that, due to these effects, there is an unequivocal correlation with metabolic syndrome. The correlation between high sodium consumption and hyperuricemia has also been demonstrated, even in the absence of hypertension **[28]**.

In the case of patients with obesity, in general, total food consumption is high and, even if the diet has a healthy profile, the total sodium consumed will probably be high in absolute numbers. Although this is a plausible theory, few studies demonstrate this relationship between total intake and blood pressure levels in patients with obesity. In this context, 24-hour urinary sodium excretion is a recognized method for estimating intake objectively, without incurring the errors observed in dietary surveys.

The arterial hypertension of patients with obesity, its adequate measurement, and its relationship with sodium intake are aspects that still deserve further scientific exploration, and the present study was designed to collaborate on these issues, with the objectives of evaluating whether, in patients with obesity, the blood pressure measurements obtained with automatic equipment on the arm and wrist are equivalent; sodium consumption through urinary excretion; the correlation between sodium consumption and blood pressure; the correlation between sodium consumption and markers of cardiovascular risk; and markers related to lifestyle and health habits, such as alcohol consumption, physical activity, smoking, sleep, work, lipid profile, glycemic profile, and renal function.

Methods

Study Design

This study followed a prospective observational and cross-sectional model, following the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) rules (Attached 1). Available at: https://www.strobe-statement.org/checklists/.
Accessed on: 07/22/2024.

Ethical Approval

The present study was approved by the Ethics Committee of the Clinic Hospital of FMRP-USP under approval number 4.026.175, and informed consent was applied.

Settings

The study was conducted at the Clinic Hospital of FMRP-USP in the Nutrology Outpatient Clinic. Patients with obesity referred by health units in the city of Ribeirao Preto were included.

Eligibility – Inclusion and Exclusion Criteria

Inclusion criteria were patients aged between 20 and 60 years; both genders; body mass index greater than 30 kg/m^2. Exclusion criteria were the presence of body deformities that prevented anthropometry and/or blood pressure measurement; the presence of arm circumference greater than that permitted for cuff use; previous bariatric surgery; pregnancy; failure to perform the requested laboratory tests.

Sample Size Calculation

The sample size calculation was performed using the mean BP data from Liu et al. **[10]**. Considering that BP has a normal distribution and that a difference of less than 5 mmHg between the mean of the BP measurements taken at the wrist and the arm is considered adequate, it was calculated that the study of 40 patients would be sufficient to detect differences above 5 mmHg between the two measurements, with a power of 80% and a type I error of 0.05 (Stata 17 software was used). This value can be considered conservative, based on the ISO 81060-2 standard used for validation of new BP measuring equipment by AAMI/ANSI (Association for the Advancement of Medical Instrumentation/American National Standards Institute), which establishes the cut-off value for differences in measurements between two devices of up to 8 mmHg.

Participants, Measurement, Variables and BIAS

Of the 51 patients referred to the Nutrology Outpatient Clinic who met the inclusion criteria, 4 were excluded, 3 of whom were pregnant, and 1 did not undergo the requested tests. During the initial consultation, personal and anthropometric data were obtained. Blood pressure was also measured using Omron® electronic equipment, model HEM-6181 for the wrist and model HEM-7122 for the arm. The measurement was always taken approximately 15 minutes after the start of the consultation, to minimize the effects of initial stress, seeking to relax and unwind the patient before the measurement. Both measurements were taken with the patient seated, following standardized techniques. The following laboratory tests were also requested: urine collected at home over 24 hours and delivered to an appropriate room in the physical space of the Hospital das Clínicas outpatient clinics: urinary sodium of 24; microalbuminuria (in the material collected over 24 hours); urinary creatinine (in the material collected in 24 hours). In the blood (10 mL collected in a single sample in an appropriate room in the physical space of the outpatient clinics of the Hospital das Clínicas): fasting blood glucose; glycated hemoglobin; lipid profile; hs-CRP; creatinine.

The diagnostic criteria used were blood pressure and the 2023 parameters of the European Society of Hypertension, with values that define hypertension being considered when the systolic blood pressure was greater than or equal to 140 mmHg and the diastolic blood pressure greater than or equal to 90 mmHg **[29]**; blood glucose and glycated hemoglobin: were used to assess the presence of diabetes. Blood glucose was considered normal when below 126 mg/dL and glycated hemoglobin when below 6.5%. Values above this cutoff point were considered indicative of diabetes mellitus, following the guidelines of the World Health Organization **[30]**; microalbuminuria: was used as a marker of renal injury (increased glomerular permeability), with values above 30 mg/24 hours being considered high **[31]**; urinary creatinine: was used to verify whether the patient had collected all the urine produced in 24 hours, to validate the other two tests performed on total urine (microalbuminuria and 24-hour urinary sodium) **[32]**. The value considered adequate was between 630 and 2500 mg/24h **[33,34]**; lipid profile: data from the Update of the Brazilian guideline on dyslipidemia and prevention of atherosclerosis for patients with fasting before the test was used **[35]**: total cholesterol < 180 mg/dL; HDL > 40 mg/dL; triglycerides < 150 mg/dL; and LDL < 130 mg/dL; creatinine: was used to assess renal function. Creatinine increases as the glomerular filtration rate decreases and decreases as filtration increases. The cutoff points used were 1.3 mg/dL (men) and 1.1 mg/dL (women); urinary sodium excretion: was used to obtain salt intake, assuming that urinary sodium excretion reflects 90% of its consumption in the last 24 hours **[36-39]**. This is because it is known that a small amount of ingested sodium is excreted through other routes, such as feces, sweat, saliva, and others **[40]**.

Statistical Analysis

The comparison between blood pressure values in the arm and wrist was performed using the Student's t-test for paired data **[41,42]**. Correlation studies were performed using Spearman's correlation coefficient **[41,42]**. Values above p less than 0.05 were considered significant. Stata 17 software was used.

Results

The general clinical results of the study were summarized and consolidated in Table 1.

Table 1. Personal, anthropometric, blood pressure, and laboratory data (n=47).

Variables	Parameters	Results
Gender	Number and percentage of women	39 (82.9 %)
Age (years)	Mean ± DP	47.4 ± 12.3
BMI	Mean ± DP	43.8 ± 8.3
Systolic blood pressure - arm	Mean ± DP	133.9 ± 20.3
Diastolic blood pressure - arm	Mean ± DP	88.9 ± 11.2
	Prevalence of high blood pressure (arm) All patients Patients taking any antihypertensive medication	28 (59.6%) 20 (42.6%)

Systolic blood pressure – pulse	Mean ± DP	134.4 ± 22.1
Diastolic blood pressure – pulse	Mean ± DP	85.7 ± 13.8
	Prevalence of high blood pressure (pulse) All patients Patients taking any antihypertensive medication	23 (48.9%) 17 (36.2%)
Use of antihypertensive medication	Number and Percentage of Users	26 (55.3%)
Use of alcoholic beverages	Number and Percentage of Users	14 (29.8%)
Smoking	Number and Percentage of Smokers	2 (4.3%)
Physical activity (minutes per week)	Mean ± DP No physical activity Less than 150 minutes per week More than 150 minutes per week	68.9 ± 104.6 29 (61.7%) 5 (10.6%) 13 (27.7%)
Sleep (hours per day)	Mean ± DP Prevalence of less than 7 hours of sleep per night	6.6 ± 2.2 26 (55.3%)
Working	Number and percentagem	26 (55.3%)
Blood Glucose	Mean ± DP Prevalence of altered values (≥ 126 mg/dL)	107.6 ± 28.2 14.9 %
Glycated hemoglobin	Mean ± DP Prevalence of altered values (≥ 6.5 %)	5.97 ± 0.97 19.1 %
Microalbuminuria (mg/24 hours)	Mean ± DP Prevalence of altered values (%)	24.77 ± 62.61 12.8 %
Urine creatinine (mg/24 hours)	Mean ± DP Prevalence of altered values (< 630 or > 2500 mg/24h) (%)	1279.7 ± 646.8 14.9%
Total cholesterol	Mean ± DP Prevalence of altered values (≥ 190)	176.4 ± 35.9 34.0 %
LDL-cholesterol	Mean ± DP Prevalence of altered values (≥ 130)	103.7 ± 27.6 19.1 %
HDL-cholesterol	Mean ± DP Prevalence of altered values (≤ 40)	44.3 ± 9.9 34.0 %
Triglycerides	Mean ± DP Prevalence of altered values (≥ 150)	141.4 ± 55.1 40.4 %
Creatinine	Mean ± DP Prevalence of altered values (> 1.3 men and > 1.1 women)	0.88 ± 0.23 6.4 %
Urine sodium (mg/24 hours)	Mean ± DP Prevalence of altered values (%)	4.651.5 ± 2.425.7
Sodium intake (g/day)	Mean ± DP Prevalence of altered values (> 2.000 mg/day)	5.168.4 ± 2.695.2 93.6 %

Source: Own Authorship.

It can be seen that there is no statistical difference between systolic blood pressure measured on the arm and the wrist (p=0.748), as well as the comparison between diastolic blood pressure measured on the arm and the wrist, is statistically different (p=0.020). The evaluation of the correlation between systolic blood pressure measured on the arm and sodium intake also did not show statistical significance, with p = 0.463>0.05.

The correlation between diastolic blood pressure measured on the arm and sodium intake was evaluated, and it can be seen that there is no correlation between the two variables (p = 0.244>0.05), as well as the analysis of the correlation between systolic blood pressure measured on the wrist and sodium intake was not significant (p = 0.178>0.05). It was observed that the correlation between diastolic blood pressure measured on the wrist and sodium intake was also not significant, with p = 0.156>0.05.

Likewise, the correlations between sodium intake and body mass index (BMI) did not show any statistically significant correlation, with p = 0.988>0.05. Table 2 shows the correlations between sodium intake and some cardiovascular risk markers evaluated in the present study. Sodium intake was not correlated with markers of the glycemic or lipid profile, nor with renal function or inflammatory markers, all with p>0.05.

Table 2. Correlations between sodium intake and cardiovascular risk markers.

Sodium intake versus Types of Analysis	Blood glucose	Glycated Hb	Microal buminuria	TC	TG	LDL	HDL	PCR	Creatinine
Spearman` Rho	0.068	-0.006	0.015	0.073	0.237	0.037	0.043	-	-0.089
DF	45	45	45	45	45	45	45	43	45
p-value	0.648	0.971	0.920	0.624	0.109	0.806	0.774	0.410	0.552

Note: Total Cholesterol (TC); Triglycerides (TG); Polymerase Chain Reaction (PCR); Degrees of Freedom (DF). Source: Own Authorship.

Discussion

Most patients were female (82.9%). This proportion does not correspond to the characteristics of the Brazilian population, in which, according to data from the 2022 IBGE Census, women represent 51.48% **[43]**. On the other hand, in outpatient clinics specializing in obesity with spontaneous demand, it is common for women to seek treatment more often. Data from a study by our group conducted in Ribeirao Preto showed that, among 1,386 patients who attended an obesity treatment service, 71.7% were female **[44]**. Among patients who were candidates for bariatric surgery, a survey conducted in Brazil showed that 83% of patients who sought the service were women **[45]**. The average age of patients was 47.4 years, and most of them were over 35 years old. This was also approximately the average age (46.1) among patients who were candidates for bariatric surgery in the city in the state of Paraná **[45]**. The BMI showed an average of 43.8 kg/m^2. According to the classification recommended by the World Health Organization, this average indicates class 3 obesity **[46]**. Even considering the variation of 1 standard deviation, most patients had a BMI between 35.5 (class 2 obesity) and 52.1 (class 3 obesity).

The average blood pressure in the arm, both systolic and diastolic, was above the cutoff points suggested in the most recent guide of the European Society of Hypertension **[29]**. Using this same reference, the prevalence among all patients was quite high (59.6%), and, even among the 26 patients using antihypertensive medication, a prevalence of 42.6% was observed.

The average blood pressure in the wrist, both systolic and diastolic, was also above the cutoff points suggested in the most recent guide of the European Society of Hypertension **[29]**. Using this same reference, the prevalence among all patients was quite high (48.9%), and, even among the 26 patients using antihypertensive medication, a prevalence of 36.2% was observed.

High blood pressure is quite common among patients with obesity **[3]**, contributing to a large part of the health risks associated with excess weight **[4]**. A study by our group conducted in Ribeirão Preto showed that, among 882 obese adults evaluated, 49.9% had high blood pressure **[44]**. The high prevalence observed even among those being treated with antihypertensive medication can be explained by low therapeutic adherence and insufficient medical monitoring. Data from 2008 showed that, worldwide, there are more than 1 billion cases of high blood pressure without adequate control **[3]**.

It is important to take into account that the measurement methodology did not follow all the recommendations, so it is not possible to consider them as a definitive diagnosis, but rather as a screening. In total, 29.8% of patients regularly consumed alcoholic beverages. No patient was considered an alcoholic and, in all cases, the reported use was concentrated on special occasions and weekends, always in small quantities. According to data from the 2021 VIGITEL survey, in the 27 cities evaluated throughout Brazil, the frequency of abusive consumption of alcoholic beverages in the last 30 days was 18.3%, being higher in men (25.0%) than in women (12.7%) **[47]**. Use is considered abusive when men ingest five or more doses or when women drink four or more doses on a single occasion in the month. No patient in the present study reported use with an abusive profile. Only 2 patients (4.3%) reported being smokers, which is below the national average, which is 9.1% according to the VIGITEL 2021 survey **[47]**. The average number of minutes per week was 68.9 minutes, however, 61.7% did not practice any physical activity. 34 patients (72.3%) had practice considered insufficient, that is, less than 150 minutes per week, a number higher than the national average of 48.2% according to data from VIGITEL 2021 **[47]**. Only 13 (27.7%) practiced at least 150 minutes per week, this percentage being lower than the national percentage, assessed by VIGITEL 2021, which was 36.7% **[47]**.

The average sleep time was 6.6 hours per day, which is below the recommendation for adults: the Sleep Foundation recommends that people between 18 and 64 years of age sleep 7 to 9 hours per night **[48]**. 26 (55.3%) patients slept less than 7 hours a day, which is close to the national prevalence and can be considered a high number, especially when considering the harmful effects of insufficient sleep on obesity **[49]** and blood pressure **[50]**. According to the Sonar-Brasil study, the average sleep time for Brazilians is 7h48, but 22% sleep less than seven hours a night, which is the minimum recommended amount **[51]**.

Although all patients in the study were of working age and able to work, 26 (55.3%) were working, which is in line with the national reality. The most recent data from Brazil, collected by the IBGE, show that 57% of the working-age population was employed in the third quarter of 2023 **[52]**.

The mean blood glucose level was 107 mg/dL and 7 patients had blood glucose levels greater than or equal to 126 mg/dL, defining a prevalence of 14.9% of diabetes using this criterion. Regarding glycated hemoglobin, the mean was 5.97% and 9 patients had values greater than or equal to 6.5%, defining a prevalence of 19.1% of diabetes using this criterion. Considering a patient with one of the two altered criteria as diabetic, 9 patients had glycated hemoglobin levels greater than or equal to 6.5% or fasting blood glucose levels greater than or equal to 125 mg/dL, defining a prevalence of 19.1% of diabetes. A study by our group conducted in Ribeirao Preto showed that, among 882 obese adults evaluated, 19.3% had a diagnosis of type 2 diabetes mellitus **[44]**. A population-based survey conducted in 29 underdeveloped and developing countries showed that among patients with a BMI > 30 kg/m^2, the prevalence of diabetes defined as glycated hemoglobin > 6.5% or fasting blood glucose greater than 125 mg dL was 14.6% between 2008 and 2016 **[53]**.

Only 6 patients presented albuminuria greater than 30 mg in 24 hours, corresponding to 12.8%. Three of these patients had glycated hemoglobin compatible with diabetes and four of them had high blood pressure. Five of them presented high urinary sodium excretion. Creatinine measurement was performed to assess renal function. The mean value observed (0.88) was below the cutoff point and the prevalence of patients with creatininemia considered high was 6.4%, which refers to three patients. Of these, two had high blood pressure and the one with normal blood pressure was diabetic. In the present study, urinary creatinine was used to verify whether the patient had collected the total urine produced in 24 hours, to validate the other two tests performed on total urine (microalbuminuria and 24-hour urinary sodium) **[32]**. The value considered adequate would be between 630 and 2500 mg/24h **[33,34]**. Using this criterion, 14.9% of patients presented results outside the normal range and may have collected 24-hour urine inappropriately. Additionally, urinary creatinine measurement is also used as a marker of renal function **[32]**. Considering that several patients in the present study were diabetic and/or hypertensive, it is possible that some of these patients presented unsatisfactory urinary creatinine values due to renal dysfunction.

Changes in cholesterol metabolism are considered very common among patients with obesity. This was demonstrated in the present study in which 34% presented high total cholesterol, 19.1% with high LDL, 40.4% with hypertriglyceridemia, and 34% with low HDL. Considering dyslipidemic the patient who had any of the fractions with altered values, the prevalence of this condition was 72.3%, representing 34 patients.

A study by our group conducted in Ribeirao Preto showed that, among 882 obese adults evaluated, 33.3% had a diagnosis of dyslipidemia **[44]**. Another Brazilian study that evaluated 96 obese adults found low levels of HDL cholesterol in 58.3% of patients and high triglycerides in 29.2% **[54]**. Among patients who were candidates for bariatric surgery and, therefore, had a more severe case of obesity, a survey conducted in Brazil showed a prevalence of 16.5% of some dyslipidemia **[45]**. Given the WHO recommendation that daily sodium intake should not exceed 2 g **[55]**, 93.6% of patients had a daily intake above this limit. 93.6% of patients had a daily intake above 2 g/day, the limit recommended by the WHO. This percentage is in line with what is observed in the general population. The average consumption value was close to 5g/day, which is much higher than the national average, estimated at around 3.7g/day, demonstrating that, possibly due to the high food consumption characteristic of obesity, the amount of sodium consumed is proportionally higher.

Studies conducted in the general population, regardless of nutritional status, reached similar results, highlighting excessive salt consumption as a global problem. In 1960, Dahl et al. **[56]** analyzed the daily salt consumption of different population groups, observing that American men consumed, on average, 10g/day of salt. Subsequently, the INTERSALT study collected 24-hour urinary sodium excretion data from more than 10,000 adult individuals of both sexes, from 32 countries, and the study indicated that most of the population analyzed had excretion greater than 2.3g/day **[57]**.

More recently, in Brazil, data from the National Health Survey (PNS), using the estimation method based on the sodium/creatine ratio in urine samples, identified that more than 95% of the Brazilian population consumes salt above the recommended 5 g/day. On average, a consumption of 9.34 g/day was observed **[58]**. The PNS also indicated a large variability in consumption among individuals, with values ranging from 1 to 25 g/day **[58]**. These results are in agreement with those observed in the present study.

The relationship between high sodium intake and higher BMI has been studied by several research groups. Murakami et al. **[59]** observed higher average sodium intake, estimated by urinary excretion, in overweight and patients with obesity (BMI ≥ 25 kg/m^2). In the same study, there was no association between intake and abdominal circumference. In children and adults in Korea, self-reported sodium intake was associated with the risk of obesity, regardless of energy intake **[60]**. Similarly, a German study observed an association between increased urinary sodium excretion and increased body adiposity in children and adolescents **[61]**. Increased urinary excretion was also associated with higher BMI in men in Sweden **[62]** and with higher BMI and abdominal circumference in women in Venezuela **[63]**. Due to the study design, it is not possible to conclude which of the two methods leads to more accurate data; however, the measurement taken on the arm is the one classically used and has extensive scientific validation. Therefore, since it is not possible to interchange the measurements, the one taken on the arm should be used preferentially. The data from the present study showed that, regardless of the measurement site, it was not possible to establish a correlation between blood pressure and sodium intake among patients with obesity. Some studies indicate that there may be a positive association between urinary sodium excretion and BP. In the PURE study, it was found that a 1-gram increase in urinary sodium was associated with increases of 2.11 mmHg and 0.78 mmHg in SBP and DBP, respectively **[64]**. Among patients with obesity, Ndanuko et al. found a direct correlation between urinary sodium excretion and SBP and DBP values **[65]**.

On the other hand, Moore et al., observing urinary sodium excretion and SBP and DBP values in 2,632 normotensive individuals, showed that there was no increase in mean SBP and DBP in quintiles of increasing sodium intake. The authors state that contrary to expectations, the mean SBP in each quintile was 134.5, 132.2, 132.3, 130.3, and 128.3 mmHg, respectively. The same was true for DBP values, which ranged from 78.1 to 75.5 mmHg **[66]**. Bonfils et al. **[67]** studied the effects of sodium intake on BP in groups of individuals with severe obesity (BMI>40 kg/m^2) and arterial hypertension, with severe obesity without arterial hypertension, and without obesity or arterial hypertension. As a result, there was no significant difference in BP among the members of the three groups after 5 days of a high-sodium diet.

In the present study, a cross-sectional study was conducted, so it is not possible to establish the effects of sodium consumption over time. Additionally, a significant proportion of the patients were using antihypertensives and/or diuretics, which may have interfered with the results. All patients evaluated had a BMI above 30 kg/m^2, so what the data showed was that, above the cutoff point used to define obesity, the increase in BMI did not lead to greater sodium intake. One of the initial hypotheses that guided the formulation of the investigation was precisely to find out whether, by eating more, patients also increased their sodium intake, in gross values. This hypothesis is based on the premise that the higher the BMI, the higher the consumption **[68]**, which is not necessarily true **[69]**. The expected correlation was not demonstrated. The explanation may lie in the fact that patients with a higher BMI do not always eat more **[69]**. Many factors, such as low metabolic rate and a sedentary lifestyle, can cause a positive energy balance to exist even without necessarily excessive consumption, in gross values. Another factor refers to the fact that some patients may have a high BMI at present, as a result of a positive energy balance in the past, but, at present, the total intake may not be high.

Recent studies have shown that sodium can modulate oxidative stress, and inflammation, alter the autonomic nervous system, and induce dysfunction of the innate and adaptive immune responses, in addition to its action on the renin-angiotensin-aldosterone system. These actions are probably secondary to its action on the pro-inflammatory cytokines IL-6, TNF-α, and IL-17 and the metabolism of essential fatty acids, which may be responsible for its involvement in insulin resistance and diabetes **[70]**. Additionally, excessive sodium consumption impairs renal function **[71]** and may contribute to the onset of dyslipidemia, particularly among patients with obesity **[72]**.

In the present study, sodium intake was not correlated with markers of the glycemic or lipid profile, nor with renal function or inflammatory markers. It should be noted that many patients were using diuretics and medications aimed at treating diabetes, dyslipidemia, and arterial hypertension. Due to the total number of patients in the study, it was not possible to separately analyze those who were using any medication.

Main Conclusions and Limitations:

- Systolic blood pressure did not show any difference between measurements taken on the arm and wrist. Diastolic pressure was different, being lower on the wrist. Considering that measurements taken on the arm are the best studied and most frequently used in different guidelines, the results of this study do not allow us to recommend wrist measurements as a safe alternative for assessment since they can underestimate diastolic pressure and impair the diagnosis of arterial hypertension.
- 93.6% of patients had a daily intake of more than 2 g/day, the limit recommended by the WHO. This percentage is in line with what is observed in the general population. On the other hand, the average intake was close to 5 g/day, which is much higher than the national average, estimated at approximately 3.7 g/day, demonstrating that, possibly due to the high food intake characteristic of obesity, the amount of sodium consumed is proportionally higher.
- No correlation was found between sodium intake and blood pressure measurements taken on the arm and wrist. Since 55.3% of the patients were taking some antihypertensive medication, this fact may have influenced the results. Another relevant aspect is the fact that 93.6% of the patients consumed excess sodium, and it is possible that the hypertensive effect of excess sodium consumption was observed in almost all patients, reducing any possible effect of the variation in consumption correlated with blood pressure values.
- No correlations were observed between sodium consumption and glycemic profile, lipid profile, and renal function. It is also worth noting that 93.6% of the patients consumed excess sodium, and it is plausible that the harmful effects of this consumption had already manifested themselves from the extrapolation of WHO recommendations by the patients. Thus, since almost all of them already had excessive intake, it is possible that increases beyond the limits did not lead to additional problems, losing the possibility of correlation with the markers studied.
- Regarding data on lifestyle habits (alcohol consumption, physical activity, smoking, sleep, work), the patients were very similar to the general population,

except for a sedentary lifestyle, which was higher in the group studied than in Brazilian data for this age group. This sedentary profile may be contributing to the maintenance of obesity among these patients, but, in addition, due to their high BMI, many of them are little or not at all capable of performing physical activities.

- Regarding laboratory data, the prevalence of diabetes was similar to that observed in other studies involving patients with BMI > 30 kg/m^2 but was higher than the overall prevalence. The presence of dyslipidemia was higher than the overall prevalence in the group studied, and also higher than in other studies involving only patients with obesity. With the data studied, it was not possible to explain why this particular group presented such high numbers of dyslipidemia. On the other hand, the pattern was similar to that seen in other studies, with a predominance of hypertriglyceridemia and low HDL. Renal function was preserved in most patients, and the few who presented signs of impairment were all diabetic and/or hypertensive.

Conclusion

It was concluded that systolic blood pressure showed no difference between measurements on the arm and the wrist. Diastolic pressure was different, being lower on the wrist. 93.6% of patients had a daily consumption greater than 2 g/day, the limit recommended by the WHO. No correlation was found between sodium intake and blood pressure measurements taken on the arm and wrist, as well as correlations between sodium intake and glycemic profile, lipid profile, and renal function. The prevalence of diabetes was similar to that observed in other studies involving patients with BMI > 30 kg/m^2 but was higher than the overall prevalence. The presence of dyslipidemia was higher than the overall prevalence and also higher than in other studies involving only patients with obesity. Renal function was preserved in most patients and the few who presented indicators of impairment were all diabetic and/or hypertensive.

CRediT

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Ethical Approval

The present study was approved by the Ethics Committee of the Clinic Hospital of FMRPUSP under approval number 4.026.175, and informed consent was applied.

Informed Consent

It was applicable.

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No additional data are available.

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The authors declare no conflict of interest.

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