Dietary sodium sources in hypertensive patients

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Abstract

Background: Reducing dietary salt intake is the method recommended by the experts as the non-pharmacological treatment of hypertension. The purpose of this study was to evaluate the amount of dietary sodium intake by hypertensive patients and to analyze the factors affecting sodium intake. The frequency of consumption of dietary products with high sodium content was also analyzed.

Material and methods: We recruited for the study 60 patients with uncomplicated chronic hypertension, between 40 and 80 years old. A proprietary questionnaire was used during the study. The first part of the questionnaire included questions about gender, age, body weight, body height. The second part was a questionnaire on the frequency of consumption of sodium-rich products. It included 6 food groups. Another component of the study was a 24-hour dietary recall collected from two working days and one holiday. Analysis of the patient's diet was carried out using ALIANT software. The database was created in Microsoft Excel and statistical analyses were performed using SPSS version 28.

Results: In the study group, all respondents exceeded the salt intake standards recommended by scientific societies. The amount of sodium intake among men was significantly higher than in women ($p = 0.011$). There was no correlation between age, body mass index, place of residence or education and daily sodium intake. Among sodium-containing foods, patients most frequently consumed pizza, with 76.67% of respondents consuming it once a month or more often. The most commonly used condiment was table salt, used by 95% of respondents.

Conclusions: Patients suffering from uncomplicated hypertension do not achieve the target of dietary sodium restriction to the values recommended in scientific guidelines. As dietary sodium intake standards are exceeded, hence the need for more intensive nutrition education among hypertensive patients.

Key words: dietary intake; hypertension; salt; sodium; sodium-rich foods

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Introduction

Cardiovascular disorders (CVD) are the most significant cause of premature deaths worldwide [1]. Among the main CVD risk factors is hypertension, which increases the risk of numerous diseases such as ischemic heart disease, stroke, heart failure, hypertensive retinopathy and kidney failure. CVD prevention to minimize or eliminate their risk is based on the promotion of lifestyle medicine [2–5]. Hypertension therapy, on the other hand, is based primarily on pharmacotherapy, but non-pharmacological management, consisting of reducing sodium intake, reducing alcohol intake, avoiding smoking, normalizing body weight, introducing an appropriate diet and regular physical activity, is also an

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important element in the treatment of hypertension [6–8].

A significant role in the prevention and treatment of hypertension is therefore played by an adequate diet.

Dietary sodium restriction is one of the main pillars of non-pharmacological management. Sodium, as the main cation of the extracellular space of the body, ensures the proper volume of the body fluids and adequate perfusion of organs. Under physiological conditions, with a decrease in extracellular fluid volume (ECV, extracellular volume) caused by a limited sodium supply, a number of compensatory mechanisms are activated: primarily activation of the renin–angiotensin–aldosterone system (RAA) and release of vasopressin. These mediators, acting together, cause vasoconstriction, increased thirst, and reduced renal excretion of water and sodium. Conversely, with increased sodium supply, the initial increase in thirst (caused by an increase in ECV osmolality) causes a transient elevation in arterial pressure with inhibition of the RAA system. This translates into increased diuresis and natriuresis in the kidney, leading to the restoration of normal volume and normal osmolality [9].

Excessive sodium intake along with impaired renal excretion of sodium is one of the main hypotheses for the development of primary hypertension. A meta-analysis of 167 intervention studies implementing a low-sodium diet showed a decrease in blood pressure in hypertensive patients by 5.48 mm Hg systolic and 2.75 mm Hg diastolic pressure [10]. A prospective observational study in normotensive subjects showed a 1.7 mm Hg increase in systolic blood pressure for each additional 100 mmol of 24-hour urinary sodium excretion [11].

International scientific societies, among them the European Society of Cardiology and the European Society of Hypertension (ESC-ESH) and the Polish Society of Hypertension, published guidelines in 2015 and later confirmed in 2019 recommended dietary salt intake below 5–6 g/d. [12, 13]. Recommendations from the World Health Organization (WHO) go even further, proposing to reduce dietary salt intake to below 5 g/day for the entire adult population [14]. The amount of sodium (Na; in grams) is converted to table salt (NaCl; in grams) using the formula: amount of sodium [g] × 2.5 = amount of salt [g].

In Poland, about 10 million people suffer from hypertension, with more than 7 million patients having it poorly controlled. The main reasons for this are attributed to lack of patient education, non-adherence to recommendations, reduction of doses of hypotensive medications, as well as abandonment of lifestyle changes – including a low-sodium diet. This is particularly relevant in the Polish population characterized by a very high intake of table salt. A low-sodium diet is aimed at lowering blood pressure in patients already diagnosed with hypertension, and a nutritionally balanced diet has a beneficial effect on the entire human body, based on two key principles [15]: cessation of salted foods and avoidance of processed and sodium-rich foods.

The purpose of this study was to evaluate the amount of sodium intake with diet by patients with hypertension and to analyze the factors affecting sodium intake. The secondary objective of the study was to assess the frequency of consumption of dietary products with high sodium content by hypertensive patients.

Material and methods

Sixty regular patients (23 men and 37 women) of the Hypertension Outpatient Clinic of the First Department of Cardiology, Interventional Electrocardiology and Hypertension at the Jagiellonian University Medical College were recruited for the study. Patients with uncomplicated hypertension between 40 and 80 years old were included.

A proprietary questionnaire was used during the study. The questions in the questionnaire were personally completed by the interviewer based on an individual interview with the patient.

The first part of the questionnaire included questions about gender, age, body weight, body height. The second part was a questionnaire on the frequency of consumption of sodium-rich products. It included 6 groups of products: Meat, fish, eggs (group 1), Milk and its products (group 2), Fats (group 3), Other sources of fats: nuts, seeds of grains (group 4), Sugar and its products (group 5), Fast food and snacks (group 6), for which an eight-point scale was used to assess the consumption of a specific portion of the product: "I do not consume", "once a month or less often", "2–3 times a month", "1–2 times a week", "3–4 times a week", "5 or more times a week", "daily", and "several times a day".

Another component of the survey was a 24-hour dietary recall collected from two weekdays and one holiday. The interviewer personally obtained information on foods and beverages consumed on the day before the survey. Data from the following two days were sent by patients via email or collected by the interviewer by phone. Analysis of the patient's diet was conducted using ALIANT software.

The database was created using Microsoft Excel from Office 365, and statistical analyses were performed using SPSS version 28. In the analyses of patients' adherence to current recommendations for reducing sodium intake, 2000 mg/d was taken as the target sodium intake according to the guidelines of scientific societies; this is the upper recommended intake limit for the group of respondents in the study, who were in the age range of 40–80 years. Accordingly, the upper norm for dietary salt intake was set at 5 grams/day. The minimum amount of sodium that is necessary for the body to function properly has not yet been determined [15,16].

The study was approved by the Bioethics Committee at the Jagiellonian University, all participants provided informed written consent.

Results

The Tables 1 and 2 show the sodium content of each group of dietary products. Only products with high sodium content are included.

Characteristics of the study group

The study included 60 regular patients of the Hypertension Outpatient Clinic of the First Department of Cardiology, Interventional Electrocardiology and Hypertension of the Jagiellonian University Medical College in Krakow. They were patients with uncomplicated hypertension, between 40 and 80 years old. Twenty-three (38.33%) men and 37 (61.67%) women participated in the study. Table 3. shows the characteristics of the study group. In the study group, the mean age was 60.77 ± 11.65 years. The mean BMI was 29.35 kg/m2 ± 4.41 kg/m^2. Primary education was held by 3 people (5%), vocational education was held by 11 people (18.33%), secondary education was held by 22 people (36.66%), while higher education was held by 24 people (40%). Of the total respondents, 13 people (21.66%) lived in rural areas, 9 people (15%) lived in a city < 100 thousand residents, while 38 people (63.33%) lived in a city > 100 thousand residents.

Of the 60 patients participating in the study, 24 (40%) of them were < 60 years old, 36 (60%) were ≥ 60 years old. BMI was normal (< 25 kg/m^2) in 8 (13.33%) subjects, overweight (BMI > 25 kg/m^2 but ≤ 30 kg/m^2) was present in 31 (51.67%) subjects, while obesity BMI > 30 kg/m^2 was present in 21 (35%) subjects.

Dietary sodium intake in the study group

The average sodium intake of the entire surveyed group was 4739.45 mg/day, with a minimum sodium intake of 2524 mg/d and a maximum of 12288 mg/d. All subjects exceeded the daily sodium

Table 1. Sodium content of different foods [17]

Groups of products	Sodium content [mg/100 g]	
	Minimum	Maximum
Fatty pork meats	610	1596
Sausages, wieners, frankfurters	548	1159
Fish (including smoked)	30	5930
Yellow cheese	585	1368
Melted and moldy cheeses	966	1860
Seasonings		
Maggi	22780	22800
Vegeta	56900	61900

Table 2. Sodium content of fast-food products [17]

Groups of products	Sodium content [mg/100 g]	
	Minimum	Maximum
Hamburger, cheeseburger	414	589
Kebab	603	1097
Pizza	375	719
Hot-dogs	1090	1264
Chips, sticks, crackers	690	1093

Table 3. Characteristics of the study group (n = 60)

Characteristics of the study group		
Characteristics	**Mean**	**SD**
Age (years)	60.77	11.65
BMI (kg/m2)	29.35	4.41
Characteristics	**Number**	**%**
Gender		
Male	23	38.33
Female	37	61.67
Education		
Primary	3	5
Vocational	11	18.33
Secondary	22	36.66
Higher	24	40
Place of residence		
Rural	13	21.66
Small town < 100 k residents	9	15
Large city > 100 k residents	38	63.33

SD — standard deviation

intake standard recommended by European scientific societies (2000 mg/day).

The average sodium intake in the study group corresponds to an intake of 11.85 grams of table salt per day. The patient with the lowest sodium intake in the study group took in 6.30 grams of salt per day, while the patient with the highest sodium intake took in 30.72 grams of table salt per day.

Analysis of factors affecting sodium intake

In order to distinguish factors affecting sodium intake, the study group was divided into subgroups: by age (≤ 60 years of age and > 60 years of age), gender (women, men), BMI (< 25 kg/m^2, ≥ 25 kg/m^2 and > 30 kg/m^2), education (primary, vocational, secondary and higher education) or place of residence (rural, small town < 100 thousand residents, large city > 100 thousand residents). Descriptive statistics assessed the mean, median, standard deviation. Statistical significance was determined using Student's t-test, setting $p < 0.05$ as statistically significant.

Sodium intake by age group (n = 60)

In the age group < 60 years old, the median sodium intake was 4329 mg, with a mean of 4587.8 mg ± 1971.4 mg, while for the age group 60 years old or higher, the median was 4336 mg, with a mean of 4847.8 mg ± 1669.6 mg. No significant difference was found between age groups ($p = 0.46$).

Among women, the median sodium intake was 3921 mg, with a mean of 4294.4 mg ± 1435.3 mg, while among men, the median was 5020 mg and the mean was 5455.5 mg ± 2086.1 mg (Fig. 1). The amount of sodium intake among men was significantly higher than in women ($p = 0.011$).

Sodium intake by BMI (n = 60)

In the appropriate weight group, the median sodium intake was 5046 mg, with a mean of 5043.4 mg ± 1461.8 mg; in the overweight group, the median sodium intake was 4328 mg, with a mean of 4633.5 mg ± 1500.3 mg; and for obese patients, the median was 3983 mg, with a mean of 4780 mg ± 2295.9 mg. There were no differences in sodium intake according to BMI category ($p = 0.523$).

Sodium intake by education (n = 60)

In the group with primary education, the median sodium intake was 3087 mg, with a mean of 3183 mg ± 269.2 mg; in the group with vocational education, the median was 5112 mg, with a mean of 5452.6 mg ± 2658.7 mg; for the group with secondary education, the median was 4411 mg, with a mean of 4963.5 mg ± 1622.8 mg; and for the group with higher education, the median was 4165 mg, with a mean of 4401.8 mg ± 1417.1 mg. There were no significant differences in sodium intake according to education level ($p = 0.101$).

Sodium intake by place of residence (n = 60)

In the group living in a rural area, the median sodium intake was 3965 mg, with a mean of 5087.1 mg ± 2681 mg; in the group living in a small city (< 100 thousand residents), the median was 4735 mg, with a mean of 5115.1 mg ± 1409.9 mg; and for the group living in a large city (> 100 thousand residents), the median was 4328.5 mg, with a mean of 4531.6 mg ± 1492.2 mg. There were no differences in salt intake according to place of residence ($p = 0.503$).

Analysis of the frequency of consumption of sodium-rich foods

Among the sodium-rich foods, patients most often consumed pizza, once a month or more often by 76.7% of respondents. The most commonly used condiment was table salt, by 95% of respondents.

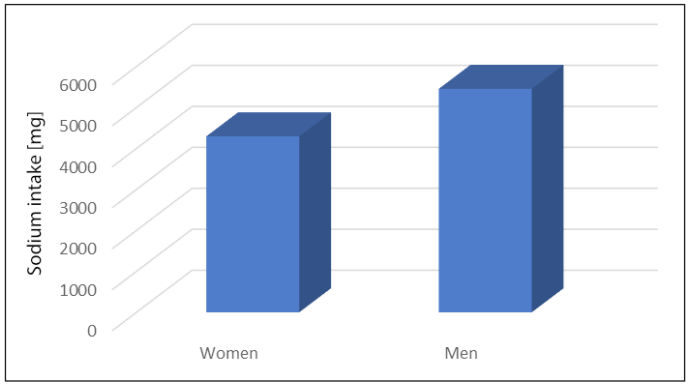

Figure 1. Sodium intake by gender (n = 60)

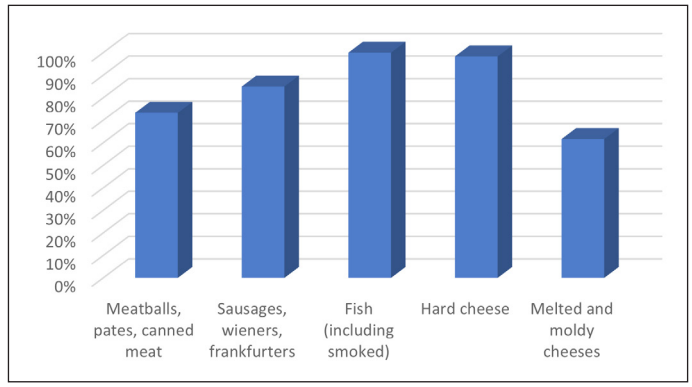

Figure 2. Consumption of selected food products (n = 60)

Meatballs, pates, canned meat and bacon were consumed once a month or more often by 73.33% of respondents. Sausages, wieners, and frankfurters were consumed once a month or more often by 85% of respondents. Fish (including smoked fish) once a month or more often was consumed by 100% of respondents. Hard cheeses once a month or more often were consumed by 98.33% of survey participants.

Melted and moldy cheeses were consumed once a month or more often by 61.67% of respondents (Fig. 2).

Among fast food products, hamburgers and cheeseburgers were consumed once a month or more often by 21.67% of respondents. Kebabs once a month or more often were consumed by 20% of respondents. Pizza once a month or more often was consumed by 76.67% of respondents. Hot dogs once a month or more often were consumed by 16.67% of survey participants. Chips, sticks, crackers once a month or more often were consumed by 48.33% of survey participants (Fig. 3).

Table salt as a seasoning was used by 95% of respondents. Maggi and maggi-like was used by 51.67% of respondents. Vegeta and vegeta-like spice was used by 51.67% of respondents. Herbs as a seasoning were used by 66.67% of respondents (Fig. 4).

Adding salt to food

Adding salt to dishes was practiced by 76.67% of respondents. Soups were salted by 56.67% of respondents. Second dishes were salted by 68.33% of respondents. Pasta was salted by 35% of respondents. All hot dishes were salted by 36.67% of survey participants. Salads, on the other hand, were salted by 36.67% of respondents.

Storage of the salt shaker

The salt shaker on the table where meals are eaten was stored by 40% of respondents. In the room where meals are eaten (but not on the table), the salt shaker was stored by 10% of respondents. In the kitchen on open shelves, the salt shaker was stored by 33.33% of respondents. The salt shaker in a closed cabinet was stored by 33.33% of respondents.

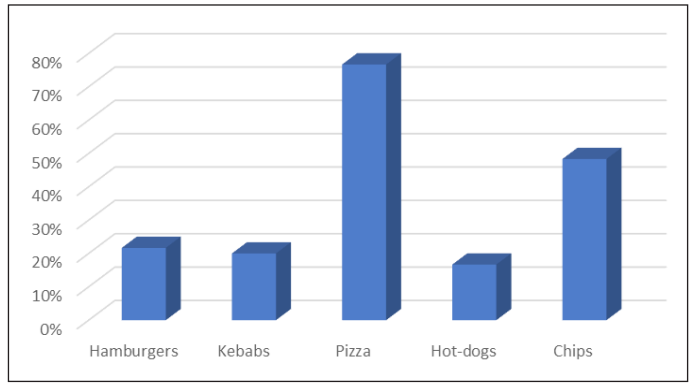

Figure 3. Consumption of selected fast food products (n = 60)

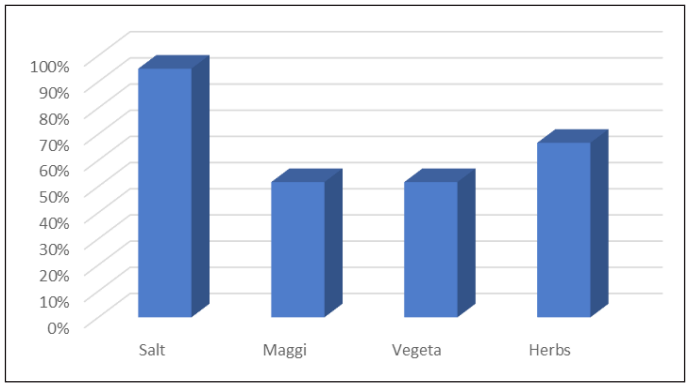

Figure 4. Use of selected seasonings (n = 60)

Discussion

The current study assessed adherence to dietary sodium intake standards recommended by European scientific societies in hypertensive patients, finding that excess sodium intake was common. In addition, assessing the sources of sodium in the diet of hypertensive patients, we found very frequent consumption of products with a high sodium content, especially fast-foods, as well as the subjects' habitual salting of the food they consumed.

Reducing excessive sodium consumption is one of the most important elements of recommendations for non-pharmacological management of hypertension. Such guidelines come from both experts of the Polish Society of Hypertension [12] and European researchers [13].

The benefits of sodium restriction in hypertension are supported by a wealth of literature based on numerous observational and interventional studies, as well as clinical experience.

Excessive consumption of sodium-rich products is particularly noticeable in populations living in developed countries. The salt in the diet of their populations comes mainly from processed foods, since the process of manufacturing these foods results in a significant increase in the salt content of these products. The correlation between excessive salt consumption and the incidence of diseases such as hypertension, left ventricular hypertrophy, and stroke has been the subject of a number of studies demonstrating the benefits of reducing salt intake with the diet [18].

Research by Eaton and Konner estimated that salt intake with food in human ancestors did not exceed 1 g/d of sodium chloride. These findings suggest evolutionary adaptation of humans to a diet now defined as low-sodium [19, 20].

The current average sodium intake worldwide is 3.95 g/d, which translates to about 10 g of table salt. Salt consumption varies in European countries, with salt intake in Poland, especially in men, being high [21]. In our population, the amounts consumed by hypertensive patients were above the average intake typical of Western Europe (about 4.2 g/d sodium, i.e., about 10.5 g NaCl) [22].

When analyzing factors affecting sodium intake, we evaluated gender, age, body mass index, place of residence and education level. Of the factors analyzed, only male gender was significantly associated with higher sodium consumption.

The INTERSALT study, which was one of the first large epidemiological studies conducted in international collaboration to evaluate the association of salt intake with blood pressure values, described that salt intake showed a significant correlation with an increase in blood pressure with age. This association was more pronounced in women than in men. Four of the INTERSALT study sites had very low sodium excretion, low blood pressure and little or negligible increase in blood pressure values with age; these were rural sites from areas far from civilization [23].

It is reasonable to infer that habitually high salt intake may be responsible for much of the increase in systolic and diastolic blood pressure with age observed in most populations worldwide [24].

Unhealthy eating behaviors were observed both in our own study and in a study by Wadolowska et al. conducted in a group of young women – rarely did the subjects restrict high-fat foods, sugar and sweets, but also fats as well as the amount of food consumed. Based on these observations, it can be assumed that there is a high prevalence of this type of behavior in the Polish population, regardless of age and gender [25].

A lower tendency to reduce the consumption of high-calorie and high-sodium foods may indicate a low interest in a quality diet and a strong preference for foods with high palatability.

French et al. made similar observations in their study, indicating that higher frequency of fast food consumption was more prevalent in women who exhibited behaviors that favored a low restrictive diet. The study also observed a lower likelihood of restricting starchy foods (bread, cereals or potatoes). In this context, not restricting the consumption of unhealthy foods is a potential cause of excessive energy consumption, especially with regard to fat intake and sugars consumed with the diet [26]. Numerous studies have highlighted the link between low restraint and overweight and obesity, which may consequently contribute to the development of many diseases [27, 28].

Also, other researchers have found no tendency in groups of obese patients to reduce their intake of fast food, sweets, as well as meat or its products, which may mean that self-regulatory behavior is not present among these individuals.

In the study by Domaradzki et al. men were significantly more likely to consume fried foods, canned foods, sweets, and sodas compared to women [29].

Diets specifically recommended for hypertension include the DASH diet and the Mediterranean diet.

The DASH diet is a specially designed dietary regimen promoted by the U.S. National Heart, Lung and Blood Institute (NHLBI) to prevent or control hypertension. This diet consists of plenty of fruits and vegetables combined with low-fat dairy products with reduced saturated and total fats and low cholesterol, with adequate amounts of whole grains, nuts and fruits, as well as poultry and fish. Red meat, sweets and sugary drinks are excluded from the DASH diet. One of the pillars of this diet is also the fact of limiting the intake of both table salt and salt-rich products [30, 31].

It has been shown that such a diet can lower systolic blood pressure by 5.5 mmHg and diastolic blood pressure by 3 mmHg. The DASH diet with minor changes in the daily diet not only meets the body's daily nutrient requirements, but also assists in various regulatory processes and provides other benefits such as weight loss [32].

Haghighatdoost et al. found that the DASH diet has the ability to provide a feeling of satiety, and because it is healthy, it can be followed for life. In addition, they found it to be an effective way to improve and control various components of the metabolic syndrome (blood pressure, lipid levels and insulin resistance) due to its rich nutritional profile, i.e., high calcium, magnesium and fiber content with relatively little saturated fat and a balanced adequate amount of protein [33].

The effect of dietary modification of the traditional dietary pattern on our bodies is similar to that of expensive prescription drugs. The study's interventions included changes in oil intake (which should not exceed 16 mL per person), sugar (not to exceed 10% of daily caloric intake) and salt (less than 5 g salt/day) [34], as recommended by the WHO [35]. Even if the reduction in average per capita intake of these products is less than ideal, it is sufficient to improve many of the risk factors that often coexist in hypertensive patients, such as dyslipidemia and glucose intolerance [34].

Despite the numerous known health benefits, most people's diets do not allow them to incorporate all these natural ingredients into their food due to various disease barriers or limitations. Reasons for non-adherence to DASH include people's cultural preferences, limited availability, lack of time to prepare DASH meals, and the higher cost of DASH food ingredients that low-income populations cannot afford [36].

In contrast, the Mediterranean diet, abundant in minimally processed plant-based foods, rich in monounsaturated fats from olive oil, but lower in saturated fats, meat and dairy products, appears to be an ideal dietary model for cardiovascular health. Greater dietary compliance with the traditional Mediterranean diet is associated with better cardiovascular health outcomes, including clinically significant reductions in the incidence of coronary heart disease, ischemic stroke and total cardiovascular disease. The Mediterranean diet can be adapted to a wide range of geographic conditions by tailoring it to individual characteristics, such as dietary and cultural preferences and health conditions [37].

The Mediterranean diet, based on fruits, vegetables, olive oil and fish, is widely recommended for people at risk for cardiovascular disease [38].

Liang et al. investigated whether metabolic signatures of multiple plasma metabolites characterize adherence and metabolic response to the Mediterranean diet, and whether such a metabolic signature is associated with cardiovascular disease risk in 1859 participants in the PREDIMED study. The findings were confirmed in 6868 participants of the US Nurses' Health Studies and Health Professionals Follow-up Study (NHS/HPFS). The authors observed significant metabolic variation in relation to dietary adherence, with nearly one-third of the metabolites studied significantly associated with the Mediterranean diet [39, 40].

In conclusion, in the group of hypertensive patients, we found that the standards of sodium intake

recommended by scientific societies were exceeded. Analysis of the frequency of intake of high-sodium foods also indicates that the diet of hypertensive patients significantly deviates from the recommended DASH diet or the Mediterranean diet.

Conclusions

Hypertensive patients do not adhere to dietary sodium restriction to the values recommended by European Society of Hypertension and Polish Society of Hypertension guidelines.

Of the factors studied that affect sodium intake, only relationship with gender was observed, with men showing higher levels of sodium intake. Neither age nor other factors like body mass index, education or place of residence showed significant relationship with increased sodium intake. This is probably due to very high sodium intake in the studied group.

Sodium intake standards with diet are exceeded, indicating the need for in-depth nutrition education for these patients. Hypertensive patients are unaware of the presence of sodium in foods, so information about the need to avoid foods high in sodium should be repeated at each medical visit.

Data availability

Data available from the corresponding author on the justified request.

Ethics statement

The study was approved by the Bioethics Committee at the Jagiellonian University; all participants provided informed written consent.

Author contributions

D.S. and K.S.S. designed the project. B.P., B.K. and K.S.S. recruited the study patients. D.S. and W.O. collected and analyzed dietary data. M.R. and K.S.S. supervised statistical analyses. D.S. wrote first draft of the manuscript. All authors provided critical reading of the manuscript.

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Conflict of interest

None declared.

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