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The status of sodium intake and excretion and the primary dietary sources of sodium in Iranian adults, a comprehensive pilot study

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Background Coronary artery disease and hypertension are the leading causes of death and disability worldwide, primarily due to high sodium intake. Therefore, accurate assessment of the status of sodium intake and excretion is crucial. The present study aimed to assess the dietary sodium intake and excretion in Iranian population.

Methods This cross-sectional study was carried out on 150 adults aged 20–65 years in Tehran, Iran. A 24-h dietary recall was used to measure the intake of sodium. A food frequency questionnaire was also used to identify the food items that contributed the highest amount of sodium in the diet. A 24-h urine collection was applied to assess the amount of sodium excretion.

Results The mean of dietary sodium intake and sodium excreted in 24-h urine collections were 3888 ± 2931 mg/day and 125.2 ± 49 mmol/dl, respectively. Sodium intake and sodium excretion were significantly higher in men compared to women ($P = 0.012$ and $P = 0.004$, respectively). Traditional flatbreads were identified as the two main food sources contributing to dietary sodium intake, accounting for 31.2% of the total sodium intake from food sources. The average daily salt intake exceeded the recommended amount (5 g/day) in over 80% of the participants.

Conclusion Sodium intake in a wide range of Iranian adults may be higher than the recommended values. Iranian flatbreads are the primary source of sodium intake In Iranian diets. If be confirmed in future studies, these results could help policymakers make decisions on reducing salt intake to prevent diseases associated with high salt consumption. *Cardiovasc Endocrinol Metab* 14: 1–6 Copyright © 2025 The Author(s). Published by Wolters Kluwer Health, Inc.

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Introduction

Cardiovascular diseases (CVDs) are the leading cause of death globally and more than 17.8 million people died in 2019 due to CVDs [1]. Epidemiological studies indicated that excessive sodium consumption is associated with high blood pressure and its cardiovascular consequences [2–7]. Furthermore, high salt intake has been linked to cerebrovascular diseases, stomach cancer, kidney stones, asthma, and osteoporosis [8]. The United Nations (UN), World Health Organization (WHO), Centers for Disease Control and Prevention, and other organizations have previously demonstrated a significant association between dietary sodium and CVDs [9–11].

Dietary salt consumption varies between 8 and 12 g/day in different populations, which is higher than the recommended amount (<5 g/day). A meta-analysis of randomized controlled trials estimated that reducing dietary sodium intake by 2.0–2.3 g/day, equivalent to 4–5 g/day of salt intake, was associated with a 20–30% reduction in CVDs and a decrease in systolic blood pressure by approximately 2–5 mmHg [12–14]. Despite the recommendations from the WHO and the Iranian Ministry of

Health to reduce sodium consumption, CVDs continue to be the leading cause of death in Iran [15]. Recent studies reported that the mean sodium intake in the Iranian population exceeds the recommended intake, with an average ranging from 3000 to 4600 mg/day [16]. The WHO and the Iranian Ministry of Health recommend a daily sodium intake of less than 85 mmol/day (equivalent to less than 2 g/day). In addition, dietary guidelines for reducing the risk of CVDs recommend a sodium intake of less than 100 mmol/day (equivalent to 2.3 g/day) [13,14].

With the aim of national planning and strategy implementation to reduce salt consumption as the primary source of sodium intake, it is crucial to have accurate and reliable estimates of salt intake. Therefore, the primary objective of this study was to determine the total sodium and salt intakes by 24-h dietary recalls and 24-h urinary sodium excretion. The secondary objective was to identify major food items that have the highest contribution to dietary sodium intake.

Methods

Study design and participants

Participants in this cross-sectional study were selected through convenience sampling from the database of persons who had visited the Iranian National Nutrition and Food Technology Research Institute (NNFTRI) from 22 May to 30 June 2014. Adults between the ages of 20 and 65 years were invited to participate in the study through telephone contacts. Subsequently, appointments were scheduled for participants to meet with trained research assistants. Written informed consent were obtained from all participants.

A total of 102 families residing in 12 districts of Tehran participated in the survey. After providing comprehensive explanations about the study, four families declined to participate. As a result, a total of 197 persons from 98 families were included in this study. The sample size was calculated using OpenEPI online software and the results of a similar study [17]. However, 47 persons from these families expressed their unwillingness to provide urine samples and were consequently excluded from the study. Ultimately, a total of 150 persons aged between 20 and 65 years from 98 families participated in this study. This study adhered to the guidelines outlined in the Declaration of Helsinki, and all procedures involving human subjects were approved by the ethics committee of the NNFTRI under approval number IR.SBMU.NNFTRI.Rec.1393.053561.

In the first visit, weight of the participants was measured with minimal clothes and no shoes with a Seca digital scale with an accuracy of 0.1 kg, and height was measured using a Seca stadiometer with an accuracy of 1 cm. Then BMI was calculated by dividing weight (kg) by height (m^2). The age of the patients was also obtained through interviews.

The 24-h urine collection

A maximum of two adults aged 20–65 years from each household were eligible to participate in the 24-h urine collection. The 24-h urine samples were collected based on the protocols established by the WHO and the INTERSALT study [18,19]. During the first visit, the participants were also instructed to collect their urine sample 1 day before delivering it to the institute. They were instructed to discard the first-morning urine sample after waking up and collect subsequent urine samples until the next morning in a designated container and the container should be kept in a cool and well-ventilated place for storage. In the second visit, the participants gave their urine samples to the research assistants and were asked about specific supplement consumption, intense physical activity, and adherence to urine collection protocols. Subsequently, the urine sample containers were labeled and transferred to the laboratory of nutrition research at NNFTRI. Upon arrival, the urine samples were swiftly measured using 2-L measuring cylinders. The samples were then divided into fresh tubes and stored at a temperature of −20 °C until they were ready for use. Then, concentrations of sodium and creatinine in 24-h urine samples were measured. Urinary sodium concentration was determined using flame photometry [2,20]. Urine creatinine was assessed using a colorimetric assay (Pars Azmoon, Tehran, Iran) and autoanalyzer (Selectra E, Vitalab, Hoogerheide, the Netherlands) [21]. Salt intake was estimated using 24-h urinary sodium excretion (each 17.1 mmol of urinary sodium concentration represented 1 g salt intake) [22].

Dietary intake

On the day of urine sample collection, trained research assistants conducted a 24-h diet recall through a face-to-face interview. Ten days later, a validated form of food frequency questionnaire (FFQ) [23] was administered to each participant. The participants were asked about the frequency of consumption for each food item, using predefined portion sizes or household measures as references. The consumption of each food item was then calculated in g/day. To determine the daily intake of energy and sodium contents for each food item, Iranian food composition table and the United States Department of Agriculture National Nutrient Database for Standard Reference [23] were used. Data collected from FFQ were converted to grams of nutrients using Nutritionist IV software (First Databank Division, the Hearst Corporation, modified for Iranian foods). In addition, during the first and third visits (day 10), the weight of saltshakers and containers were measured to record the amount of salt used in household meal preparation and serving. These data were utilized to calculate the total quantity of discretionary salt consumption. Salt was weighed using a

Table 1 **Age and anthropometric characteristics of the participants**

	Participant			
Variable	Men ($n = 51$)	Women ($n = 99$)	Total ($n = 150$)	*P* value
Age (year)	41.2 (14.2)	42.7 (11.7)	42.2 (12.5)	0.520
BMI (kg/m^2)	25.38 (3.33)	26.03 (4.79)	25.81 (4.33)	0.331
Height (cm)	174.1 (7.4)	159.8 (6.0)	164.8 (9.5)	<0.001
Weight (kg)	76.9 (11.9)	66.5 (12.7)	70.1 (13.3)	<0.001

Table 2 **Daily intake of energy, salt, and sodium, urine volume, and sodium excretion of the participants**

	Participants			
Variable	Men ($n = 51$)	Women ($n = 99$)	Total ($n = 150$)	*P* value
Total energy intake (kcal)	2571 (951)	1882 (609)	2119 (807)	<0.001
Total sodium intake (mg)	4599 (3140)	3515 (2271)	3888 (2631)	0.012
Total salt intake (g)	8.98 (3.90)	6.79 (2.32)	7.53 (3.11)	<0.001
24-h urine volume (ml)	1299 (762)	1467 (809)	1409 (792)	0.180
24-h urine sodium (mmol)	146.6 (61)	113.9 (38)	125.2 (49)	0.004

scale (Soehnle, Backnang, Germany) with a sensitivity of 1 g and expressed in grams per day. Furthermore, persons in the households who were responsible for cooking and food preparation were selected for interviews and the quantities of salt used in food preparation for each meal were recorded. Subsequently, the total amount of consumed salt was divided by the number of household members to calculate the salt consumption per capita [24].

Statistical analysis

The participants were divided into two groups based on their sex and a comparison was then made between the two groups regarding age, anthropometric measurements, daily intake of energy, salt and sodium, urine volume, and sodium excretion using the independent sample *t*-test or the Mann–Whitney *U*-test. The statistical analyses were performed utilizing SPSS (version 20; IBM Corp., Armonk, New York, USA). Significance was determined at *P*-values less than 0.05.

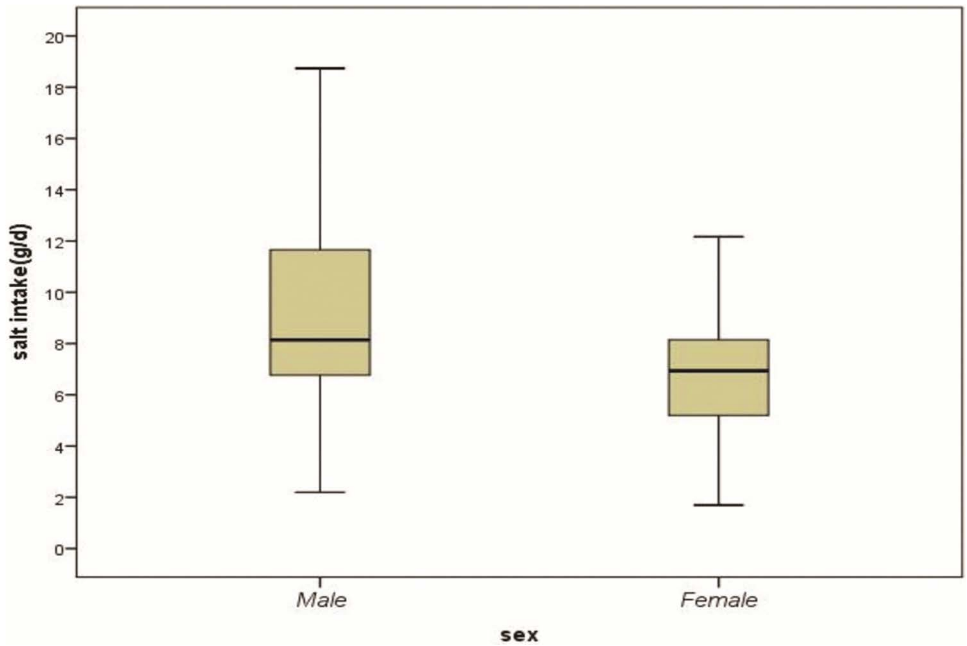
Results

We studied 150 participants with a mean age of 42.2 ± 12.5 years, of whom 66% were women. Table 1 presents the demographic and anthropometric characteristics of the participants categorized by sex. In general, 60% of the samples were collected on weekdays, whereas 40% were collected on weekends. There were no significant differences observed in urine volumes between men and women. Despite similar urine outputs, men had a higher urinary creatinine (1314.3 ± 406.5 vs. 914.5 ± 328.2 mg/day, $P = 0.001$) and sodium (146.6 ± 61 vs. 113.9 ± 38 mg/day, $P = 0.004$) excretion compared to women (Table 2). The majority of participants (80.1%) had daily salt intakes exceeding the recommended value of less than 5 g/day ($P < 0.05$) (Fig. 1). A significant difference in sodium consumption was observed between men and women ($P = 0.012$). The mean intake of dietary sodium was 3888.87 mg/day/person, which corresponds to an average daily salt consumption of 9.88 g. Discretionary salt (salt added when you prepare food) intake with an average consumption of 5.9 g/day, accounts for 53.6% of the total salt intake. Approximately 71.8% of sodium consumption was found to be associated with processed food items including breads (31.2%), cheeses (16.9%), Persian traditional yogurt drinks (Dough) (12%), fast foods and take-away foods (3.8%), commercially processed red meats (4%), cakes and confectionery products (1.7%), and (2.2%) (Table 3). The results from the FFQ indicated that the primary sources of sodium consumption were different types of traditional Iranian flatbreads. According to the highlighted weighing method, the mean discretionary salt consumption in the families was 6.84 g/person/day, and the mean intake of salt added at the table was 0.47 g/person/day.

Discussion

The results of the present study indicated that more than 80% of the participants had daily salt intakes exceeding the recommended values. The main sources of sodium consumption were different types of traditional Iranian flatbreads. Also, about 30% of sodium consumption was found to be associated with processed food items. CVDs are the leading causes of death in Iran, primarily due to the high prevalence of major risk factors such as hypertension and smoking [25]. Hypertension and other conditions are influenced by poor dietary habits, with salt consumption being a key factor that can be modified to improve blood pressure. Epidemiological studies conducted over the past four decades have consistently shown an elevated risk of noncommunicable diseases such as CVDs caused by high sodium intake [26–28]. It appears that by making dietary adjustments and reducing salt intake, individuals can improve their personal diet

Fig. 1



The mean value estimations for sodium intake in the participants ($n = 150$) based on sex. Vertical bars represent 95% confidence interval.

Table 3 The amount of sodium in each food item and its relative to total sodium intake derived from the results of food frequency questionnaire

Food items	Consumer (*n*)	Quantity (g)	Sodium (%)
Bread	150	166	31.2
Cheese	145	27	16.9
Yogurt drink	96	78	12.0
Pickled food	99	9	5.6
Salty snack	69	11	4.7
Milk	120	163	4.6
Meat product	89	11	4.0
Yogurt	138	125	3.9
Sandwich and fast food	109	16	3.8
Biscuit	99	13	2.8
Salted nuts	106	8	2.4
Ketchup	68	3	2.2
Mayonnaise and other condiments	87	5	1.8
Pastry	104	9	1.7

and contribute to better overall health outcomes, such as reducing the risk of hypertension [27].

Furthermore, this study reveals that the estimated salt intake calculated from 24-h sodium excretion was higher in men than in women. Based on 24-h dietary recalls, men consumed more sodium than women, which confirms the correlation between sodium excretion and estimation of sodium intake by 24-h dietary recalls. Data collected in the INTERSALT study on 24-h urinary sodium excretion from 52 population samples across 32 countries revealed that the average sodium intake for over half of the men ranged from 150 to 199 mmol/day, while it ranged from 100 to 149 mmol/day for half of the women in the studied sample, which is in line with the present study. In Middle Eastern countries, a mean urinary sodium excretion of 109.8 mmol/day was reported in Egypt, while sodium excretion values for Saudi Arabia men and women were 153 and 118 mmol/day, respectively [29,30]. Some previous studies on urinary sodium excretion in Iran showed higher sodium excretion compared with those in the present study. For example, results of a survey in Esfahan (2008) indicated higher urinary sodium excretions in men (189.7 mmol/day) than in women (164 mmol/day) [31]. Furthermore, higher sodium excretions had been recorded in Rasht (210 mmol/day) and Sari (188 mmol/day), cities in the north of Iran [32]. In contrast to Japan, the USA, and the UK, which included general concordances of the means from the INTERMAP study, China's dietary sodium estimations were lower than the urinary sodium excretions. However, dietary and urinary sodium excretions were similar in the population studied in Egypt [29,33].

Our results supported the hypothesis that both daily sodium intake and daily salt consumption were statistically higher than the WHO's recommended levels (<5 g/day) [34]. In this study, the mean dietary sodium intake, estimated through 24-h dietary recalls, was about 3900 mg/person/day, equivalent to an average daily consumption of about 10 g of salt. The current findings highlight that more than 50% of the total sodium intake is attributed to discretionary sodium intake. Based on urinary sodium excretion, an assessment of sodium intake in Japanese adults showed that men consumed saltier foods and added more seasoning with discretionary salt than women [18]. Similar results were reported in Somalia and Norway, indicating that adult men consumed more salt than women (8.66 and 7.39 g/day, respectively) [35]. Investigations on dietary recalls and 24-h urinary sodium excretions in Lithgow, Australia, showed that salt intakes were higher than the recommended salt intake by WHO (6.8 and 9 g/day, respectively), and men consumed more salt than women. Similar to the present study, one investigation in the Lithgow population reported that discretionary salt was the primary source of sodium, with cereal and cereal products being the main contributors to salt intake [36]. An assessment of total salt intake in Sao Paulo showed quantities significantly higher than those recommended by the WHO (10.5 and 11.0 g/day, respectively). The major sodium sources were food seasoning and table salt (accounting for 68.2% of total sodium intake). Men were found to be higher salt consumers than women when assessed by using the 24-h urine collection method (11.7 vs. 9.6 g/day; ($P = 0.0001$) [37]. Another study on salt intake in Austria demonstrated an overall median salt intake of 5.0 g/day, which was significantly higher in men than in women (6.1 and 4.6 g/day respectively; $P < 0.001$). The major sources of salt intake were condiments such as table salt (32.6%) and cereals and cereal products (27.0%) [38]. Moreover, commercially processed foods such as various types of bread, cheeses, yogurt drinks, and pickled vegetables, contribute significantly to sodium intake. Sodium was mostly added either by the manufacturers, during cooking, or at the table, with a small proportion of intrinsic sodium usually found in fruits. Similar findings have been reported regarding high salt use in home cooking in China and Indonesian East Java (75.8% and 50% of total salt intake, respectively) [33,39].

This study has several limitations. First, despite the use of a reliable FFQ and 24-h dietary recall administered by trained nutritionists, there remains a possibility of recall bias and self-report bias. Second, Due to the small sample size, it is impossible to generalize the results to the entire Iranian population. Studies with larger sample sizes and using validated laboratory methods to assess sodium intake could be useful in confirming the findings of the present study.

Conclusion

This study provides substantial insights into salt intake within the adult population of Tehran, Iran. These findings indicate that sodium consumption, as determined by 24-h excretion of sodium in urine, is greater than the levels recommended by the WHO. Added salt at the table emerges as a prominent factor in daily sodium intake. Among food items, Iranian flatbreads are the primary source of sodium intake in Iranian diets. If the present findings are confirmed in future large-scale studies, these could help policymakers make decisions on reducing salt intake to prevent diseases associated with high salt consumption, such as CVDs. Involvement of the health sector and food industry in making policies to reduce sodium intake appears to be highly important and effective.

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The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of interest

There are no conflicts of interest.

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