Estimated 24 Hour Urinary Sodium and Potassium Excretion in a Population of Moroccan Adults

Mohamed idrissi (idrissom@gmail.com)
joint research unit in nutrition health and environnement, RDC nutrition https://orcid.org/0000-0003-2168-5910

Naima Saeid
Ibn Tofaïl University-CNESTEN,Joint Research Unit in Nutrition, Health and Environment, RDC-Nutrition AFRA/IAEA, Rabat-Kénitra- Morocco

Samir Mounach
Ministry of Health and Social Protection, Division of Non-Communicable Diseases, Rabat, Morocco

Hicham El Berri
Ministry of Health and Social Protection, Division of Non-Communicable Diseases, Rabat, Morocco

Ayoub Al Jawaldah
World Health Organisation (WHO), Regional Office for the Eastern Mediterranean (EMRO), 7608 Cairo, Egypt)

Fadoua Rahhaoui
Ministry of Public Health and Social Protection, Division of Non-Communicable Diseases, Rabat, Morocco

Fatima-Zahra Mouzouni
Ministry of Health and Social Protection, Division of Non-Communicable Diseases, Rabat, Morocco

Anass Rami
Ibn Tofail University- CNESTEN, Joint Research Unit in Nutrition, Health and Environement, RDC-Nutrtion AFRA/IAEA, Rabat-Kenitra, Morocco

Kaoutar Benjeddou
Ibn Tofaïl University-CNESTEN, Joint Research Unit in Nutritin, Helath and Environment, RDC-Nutrition AFRA/IAEA, Rabat- Kenitra, Morocco

Houria Lahmam
Ibn Tofail University-CNESTEN, Joint Research Unit in Nutrition, Health and Environment, RDC-Nutrition AFRA/IAEA, Rabat-Kenitra, Morocco

Hasnae Benkirane
Ibn Tofial University-CNESTEN, Joint Research Unit in Nutrition, Health and Environment, RDC-Nutrition AFRA/IAEA, Raba- Kenitra, Morocco

Mohammed Elmzibri
Ibn Tofail University-CNESTEN, Joint Research Unit in Nutrition, Health and Environment, RDC-Nutrition AFRA/IAEA, Rabat-Kenitra, Morocco

Khalid El Kari
Ibn tofail University-CNESTEN, Joint Resarch Unit in Nutrition, Health and Environement,RDC-Nutrition AFRA/IAEA,Rabat-Kenitra, Morocco
Abdallah Bagri
Hassan First University, Faculty of Sciences and Technology, Laboratory of Biochemistry, Neurosciences, Natural Resources and Environment, Integrative and Computational Neuroscience unit, Settat, Morocco
Hassan Aguenaou
Ibn Tofail University: Universite Ibn Tofail
Latifa Belakhel
Ministry of Health and Social Protection, Division of Non-Communicable Diseases, Rabat, Morocco

---

Research

Keywords: 24-h urinary excretion, Sodium, Potassium, Blood pressure.

Posted Date: December 29th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1146806/v1

Version of Record: A version of this preprint was published at Archives of Public Health on April 20th, 2023. See the published version at https://doi.org/10.1186/s13690-023-01053-y.

Abstract

Background: Excessive sodium (Na) intake and low potassium (K) intake are associated with adverse cardiovascular health outcomes. Morocco lacks data on actual Na and K intake in adults. The aim of this study was to estimate the mean intake of Na and K in a Moroccan population of adults using the 24-h urinary excretion and to examine their association with blood pressure (BP). *Methods:* A total of 371 adults, who participated in the urinary validation sub-study of the STEP-wise Survey-Morocco-2017-2018, have complete data on demographic, anthropometric and blood pressure and have provided a valid 24-h urine collection according to the standard protocol of the World Health Organization (WHO). *Results:* The mean 24-h urinary sodium excretion was 2794 mg (SD, 1394) and the median was 2550 mg (IQR, 1780-3726). The mean 24-h urinary potassium excretion was 1898 mg (SD, 1044) and the median was 1640 mg (IQR, 1170-2410). Sodium excretion was between 3000 and 5000 mg/day in 31% of participants, < 3000 mg/day in 64%, and > 5000 mg/day in only 5%. No significant association of urinary sodium or potassium with blood pressure was found. *Conclusion:* Sodium intake in the studied population of Moroccan adults was higher than WHO recommendation and was comparable to levels reported in countries from Eastern Mediterranean Region. The vast majority of participants had a sodium intake < 5000 mg/day, with only 5% were above this level. Potassium intake was in the range of 1000 to 3000 mg/day. Within these ranges, there was no association between sodium or potassium intake and blood pressure. This information is crucial to help implement the national strategy to reduce sodium intake as a cost-effective intervention to prevent chronic disease in Morocco.

Background

Non-Communicable Diseases (NCDs) are the leading cause of mortality. Globally, they were responsible for 71% of the 57 million deaths that occurred in 2016 [1]. NCDs reduce economic output and alter the health and well-being of people around the world. Unhealthy diet is one of the key modifiable behavioral risk factors for NCDs and represents a major contributor to chronic disease development [2]. The WHO sixth global target for controlling and preventing NCDs stipulates a 25% reduction in the prevalence of hypertension in 2025 [3], The integration of salt reduction into the WHO targets is not coincidental; high salt intakes can in fact lead to heart disease (cardiac failure and myocardial infarction), stroke, renal failure, dementia, and blindness [4]. Different types of studies have established a clear association between excessive sodium (Na) intake and hypertension [5–8]. In this context, the objective of WHO's fourth global target was dedicated to reducing the average Na (salt) intake of the population by 30% (WHO, 2020) [9], with the possibility for each country to set a voluntary target, Morocco has adopted a strategy aimed at reducing the population’s salt intake by 10% in 2029 [10].

It is important to note that K intakes also play a determining role in Blood Pressure (BP) regulation; studies have indicated that high K intake alleviates the negative effects of excessive Na consumption on BP [11–12], especially in individuals with hypertension [13]. To effectively tackle the burden of NCDs, the WHO has recommended 2000 mg/day of Na (≈5g/day of salt) as the maximum intake [14], and 3510 mg/day of K as the adequate intake for adults [15]. Furthermore, some investigators have claimed that

using the Na/K intake ratio is more important to health than measuring the amount of either one separately, and have recommended a Na/K ratio of ≤ 1 for proper health benefits [14]. In Morocco, 80% of premature deaths are attributed to NCDs [16]. However, only a few studies have estimated Na and K intake using 24-h urine collection [17] [18], which is considered as the gold-standard for the assessment of Na intake [19]. This information is crucial to help The Moroccan Ministry of Health implement the national salt reduction strategy and make actions to promote K intake as a key measure for the prevention and control of NCDs in the country. In this context, and based on the WHO guidelines [20], the Moroccan Ministry of Health conducted the STEPwise Survey-Morocco-2017-2018 to update the national data on risk factors for NCDs. We aim here first to estimate the intake of Na and K by using 24-h urine collection. Second, we examined the relationship of the estimated intake of Na and K with the level of BP in this Moroccan population of adults.

Material And Methods

Study design and population

Data were derived from a National cross-sectional study representing a subsample recruited for the urinary validation sub-study within the national survey on NCDs risk factors, the STEPwise Survey-Morocco-2017-2018. Very briefly, the STEPwise Survey-Morocco-2017-2018 was conducted at the national level using the WHO STEPwise guidelines [20]. The field work was conducted from March 01, 2017, through June 03, 2017. The selection of eligible subjects was based on the country's most recent census data, the 2014 National Census [21]. The WHO STEPs sampling design was based on a stratified three-stage cluster sampling procedure (cluster, household, and individual). A list of randomly selected clusters was identified in each region, and households were then randomly selected from each cluster. Using a computer program, one eligible adult was randomly selected from each household. The same sampling design was used for the urinary validation sub-study. We screened 825 adults (594 from urban areas, 231 from rural areas) from 33 clusters of the North West region of Morocco to determine their willingness and eligibility to provide 24-h urine collection and participate in the sub-study. Individuals with self-reported renal dysfunction or on a salt-free diet, and women in menstruation period were excluded from this study. The study was approved by the Biomedical Research Ethics Committee of the Faculty of Medicine and Pharmacy in Rabat-Morocco. All participants signed their consent before participating in the study.

Data collection

All data at the field were collected by a trained staff constituted by nutritional students from the Joint Research Unit in Nutrition and Food-Rabat and nurse and physician from the ministry of health of Morocco. Staff members were trained before the start of the survey.

The standard protocol and instrument of the STEPwise approach to surveillance survey were used for data collection and urinary measurements with the supervision of the ministry of health of Morocco.

Demographic and health characteristics

Data regarding demographic characteristics, health behaviors, and current drug use to treat hypertension, diabetes, and high cholesterol were collected by a health professional staff, using an electronic system for data entry, with a standardized questionnaire [20]. Education attainment was categorized into three subgroups according to the number of years spent in school (never been in school, ≤ 9 years, and > 9 years). Data on salt reduction, smoking, alcohol consumption and drug use (antihypertensive, anticholesterol, and antidiabetic) were based on self-reported information according to the standard questionnaire used in the STEPwise Survey-Morocco-2017-2018. The answer was dichotomized into "yes" or "no".

Anthropometric and blood pressure measurements

Height and weight were measured according to standardized protocols [22]. Body mass index (BMI: estimated as weight in kilograms divided by height in meters squared) was used to classify individuals into four BMI categories as: a) underweight (< 18.5 kg/m^2), b) normal weight (18.5–24.9 kg/m^2), c) overweight (25.0–29.9 kg/m^2) and d) obese (≥ 30.0 kg/m^2) [23]. Three brachial systolic blood pressure (SBP) and diastolic blood pressure (DBP) records were obtained and then averaged to determine mean BP values for each participant. BP was measured in participants in the sitting position using a calibrated digital sphygmomanometer (Digital Automatic Blood Pressure Monitor, DABPM Spengler ES 60), with the appropriate cuff sizes. Before BP measurements, participants were allowed to rest for at least 5 min [20]. Hypertension was defined as individuals with SBP ≥ 140 mmHg or DBP ≥ 90 mmHg, or have declared they use antihypertensive drugs [24].

Twenty-four-hour urine collection

Trained staff members presented to each consenting participant detailed oral and written instructions on 24-h urine collection with a kit containing all collection equipment according to WHO standard protocol [25]. All participants were asked to collect 24-h urine during the weekend, starting the collection on Saturday morning and finishing on Sunday morning. The first morning urination was discarded and then urine was collected over the ensuing 24-h period, including the first void of the next morning. Participants recorded the starting and end time of the collection period. The specimens were transported to the laboratory in thermoelectric coolers. The importance of collecting the last void and trying not to lose any drops was emphasized. Participants were asked to keep the samples in a cool, dark place away from direct sunlight. Once the collection was returned, the total volume was registered by laboratory technicians and four 5 ml aliquots were obtained after shaking. Immediately, the specimens were frozen: two aliquots were kept at -21° for Na, K and creatinine analysis, while the other two aliquots were stored at -80° at the “laboratories of Joint Research Unit in Nutrition and Food-Rabat” as a backup. A valid 24-h urine collection was defined as: (1) total urine volume 400 ml ≤V≤ 3600 ml; (2) loss of not more than one drop; (3) period of collection within 22 hours and 26 hours [26].

Urinary analysis

Urine specimens were analyzed to assess Na and K excretion using inductively coupled plasma mass spectrometry *(ICP-MS; Thermo Scientific XSERIES2*), and creatinine excretion by Jaffe Method using the Cobas C311 (Roche diagnostic, Meylan-France). Urinary measurements of Na, K, and creatinine showed low analytical imprecision with a coefficient of variation of 1.5%, 2.5%, and 1.2%, respectively. An international reference material (Seronorm TM Trace Elements Urine) was used to control and validate the measurements of Na and K. The total concentration of Na, K, and creatinine excretion during 24 hours was standardized by multiplying the concentration of analyte by the total volume of urine.

Statistical analysis

Basic demographic and health characteristics of the participants were examined overall and by gender. Twenty-four-hour urinary sodium excretion (24-hUNa) and 24-h urinary potassium excretion (24-hUK) were assessed for the entire sample and after stratifying by age, educational level, geographic area and BMI. Continuous variables were presented as the mean (±standard deviation (SD)) and median (inter-quartile (IQR)). Categorical variables were reported as percentages (95% confidence interval (95% CI)). The Student's t-test for independent samples, the Mann-Whitney U test, or One-Way Analysis of Variance (ANOVA) test were used to compare the means for continuous variables according to the case. For categorical variables, Pearson's χ^2 test was used. The percentages of the population with Na excretion < 2000 mg/day, K excretion ≥ 3510 mg/day, and Na-to-K ratio excretion ≤ 1 were calculated. All values were estimated using the bootstrap test. Two sensitivity analyzes were performed. First, to assess the impact of a further potential incomplete 24-h urine collection on the outcomes, the analysis was replicated after excluding participants whose 24-h urinary creatinine excretion (24-hUCrea) was outside the range of 3 to 25 mmol for women and 6 to 30 mmol for men [27]. Second, to examine the potential effect of antihypertensive drugs, including diuretics, on 24-hour urinary Na and K excretion, analyses were repeated after excluding all participants who reported the use of antihypertensive drugs.

Multiple linear regression analysis was used to examine the relationship of 24-hUNa or 24-hUK and BP. In addition to 24-hUNa and 24-hUK, factors known to be associated with BP including age, sex, and BMI [28–30] were used to adjust the relationship. Data from linear regression analysis were presented as regression coefficient (β) with 95% CI and corresponding p values. All statistical tests were two-tailed, a p value < 0.05 was used for test significance. Statistical Packages for the Social Sciences 21 and Excel 2019 for data analysis and presentation were used.

Results

Participant’s flow

Out of 463 adults who agreed to participate, 46 did not finish the 24-hour collection and another 46 were excluded for different reasons (Figure 1). The remaining 371 adults constituted the final study sample (Figure 1).

Characteristics of the studied population

Overall, more than half of the participants (50.9%) were between 18 and 49 years old and 69.5% were from urban areas (Table 1). Only 4 participants were underweight, therefore underweight subjects were excluded from the calculation of the BMI category. The population was divided into normal weight, overweight, and obese with prevalence of 31.8%, 37.7%, and 30.5% respectively. Of the total sample, 96.0% reported not reducing salt in their diet, 11.4% were current smokers and 1.7% reported being current alcohol drinkers. Hypertensive subjects represented 31.0%, but only 17.8% reported to take antihypertensive medications. Eighteen percent of participants were diabetic and only 3.9% used medications for diabetes. Finally, 1.1% used anti-cholesterol medications (Table 1).

Table 1
Characteristics of the study population by gender

Characteristics	Overall (n=371)	Men (n=132)	Women (n=239)	P value
	% (95% CI)	% (95% CI)	% (95% CI)	
Age, years				
18-49	50.9 (46.1-56.1)	44.6 (36.0-53.3)	54.4 (48.2-60.8)	
50-94	49.1 (43.9-53.9)	55.4 (46.7-64.0)	45.6 (39.2-51.8)	0.073[a]
Education attainment				
Never been in school	53.6 (48.3-58.6)	50.0 (41.3-58.8)	55.6 (49.2-61.9)	
≤ 9 y	31.7 (26.9-36.7)	29.4 (21.5-37.6)	32.9 (26.9-39.0)	
> 9 y	14.7 (11.1-18.3)	20.6 (13.8-28.1)	11.5 (7.6-15.8)	0.067
Geographic area				
Urban	69.5 (65.0-74.1)	63.2 (55.3-72.1)	72.6 (66.9-78.0)	
Rural	30.5 (25.9-35.0)	36.2 (27.9-44.7)	27.4 (22.0-33.1)	0.080
BMI				
<18.5[c]	-	-	-	
18.5-24.9	31.8 (25.3-37.4)	48.4 (36.7-60.3)	22.8 (15.9-30.1)	
25.0-29.9	37.7 (32.9-42.6)	36.2 (28.0-44.5)	38.6 (32.5-44.8)	
≥30.0	30.5 (25.9-35.0)	15.4 (9.4-21.9)	38.6 (32.5-44.8)	<0.001
Salt reduction	4.0 (02.2-06.2)	0.8 (0.01-2.5)	5.8 (3.0-8.9)	0.019
Curent cigarette smoking	11.4 (8.3-14.7)	12.7 (7.0-18.8)	10.7 (7.0-14.9)	0.566
Current alcohol use	1.7 (0.3-3.3)	0.9 (0.01-2.7)	2.2 (0.5-4.5)	0.389

BMI, body mass index.

Values are percentages (95% confidence interval; 95% CI) for categorical variables, mean ± (standard deviation; SD) for continues variables.

All values were calculated using bootstrap test.

Comparison between men vs. women was done using: Pearson x^2 test for categorical variables [a], Student's t-test for interdependent samples for continues variables [b].

There were only 4 subjects in the thin category, therefore they were not included in the BMI category analysis [c].

Characteristics	Overall (n=371)	Men (n=132)	Women (n=239)	P value
	% (95% CI)	% (95% CI)	% (95% CI)	
Hypertension	31.0 (26.4-35.6)	32.6 (24.6-40.7)	30.1 (24.4-36.2)	0.625
Diabetes	18.1 (13.9-22.6)	10.4 (4.9-16.7)	22.5 (16.8-28.5)	0.010
Drug use				
Antihypertensive	17.8 (13.9-21.9)	10.1 (5.1-15.5)	21.9 (16.8-27.4)	0.005
Anticholesterol	1.1 (0.3-2.2)	0.8 (0.01-2.7)	1.3 (0.01-2.9)	0.689
Antidiabetes	3.9 (2.0-6.2)	1.6 (1.2-0.01)	5.1 (2.5-8.1)	0.105
	Mean (SD)	Mean (SD)	Mean (SD)	
Urinary measurements				
Creatinine (mg/day)	1096± 421	1264±465	1005±365	<0.001[b]
Urine volume (ml/day)	1360±600	1280±580	1400±620	0.045

BMI, body mass index.

Values are percentages (95% confidence interval; 95% CI) for categorical variables, mean ± (standard deviation; SD) for continues variables.

All values were calculated using bootstrap test.

Comparison between men vs. women was done using: Pearson x^2 test for categorical variables [a], Student's t-test for interdependent samples for continues variables [b].

There were only 4 subjects in the thin category, therefore they were not included in the BMI category analysis [c].

Twenty-four-hour urinary sodium excretion

Overall, the mean 24-hUNa was 2794 ± 1394 mg with a median of 2550 mg. There were no significant differences in 24-hUNa between genders (p=0.077); 2962 ± 1426 mg in men and 2702 ± 1301 mg in women, which is equivalent to 7.5 ± 3.6 g/day and 6.9 ± 3.3 g/day of salt intake respectively (Figure 2). According to age groups, the mean of 24-hUNa was significantly higher in individuals aged 18 to 49 years (2949 ± 1351 mg) compared to individuals aged 50 years old and over (2633 ± 1335 mg) (p= 0.026) (Table 2). There were no significant differences in 24-hUNa when categorizing the data by geographic area, BMI, and educational level (Table 2).

Table 2
Mean and median 24-hour urinary sodium and potassium excretion by gender

	Overall (n=371)		Men (n=132) Women (n=239)			
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Mean sodium excretion (mg/day) Overall	2794 (1349)	2550 (1780-3650)	2962 (1426)	2665 (1875-3807)	2702 (1301)	2470 (1720-3520)
Creatinine range ¥	2847 (1372)	2615 (1840-3714)	3064 (1410)	2847 (2046-3852)	2738 (1343)	2513 (1732-3578)
Age, y						
18-49	2949 (1351)	2790 (1932-3815)	2956 (1202)	2990 (2080-3740)	2945 (1425)	2700 (1820-4000)
50-94	2633 (1335)	2390 (1695-3325)	2966 (1612)	2530 (1735-3855)	2427 (1089)	2325 (1647-2985)
	0.026[a]	0.007[b]	0.966[a]	0.578[b]	0.002[a]	0.009[b]
Education, y						
Never been in school	2882 (1383)	2696 (1837-3685)	3071 (1451)	2994 (2106-3737)	2790 (1345)	2615 (1740-3654)
≤9 y	2509 (1273)	2217 (1506-3311)	2544 (1377)	2212 (1423-3579)	2492 (1229)	2222 (1553-3165)
>9 y	2884 (1394)	2611 (1768-3966)	3116 (1471)	2683 (1907-3958)	2661 (1304)	2417 (1571-3996)
	0.052[c]	0.028[d]	0.159[c]	0.104[d]	0.283[c]	0.230[d]
Geographic area						
Rural	2905 (1538)	2616 (1694-3825)	3054 (1648)	2767 (1688-4092)	2798 (1459)	2587 (1696-3687)
Urban	2735 (1300)	2508 (1763-3558)	2849 (1267)	2571 (1867-3597)	2681 (1306)	2549 (1702-3520)
	0.275[a]	0.556[b]	0.432[a]	0.602[b]	0.548[a]	0.842[b]
BMI						
<18.5[e]	-	-	-	-	-	-

	Overall (n=371)		Men (n=132) Women (n=239)			
18.5-24.9	2977 (1566)	2695 (1731-3922)	3036 (1608)	2767 (1780-4015)	2905 (1529)	2632 (1611-3877)
25.0-29.9	2787 (1355)	2599 (1727-3682)	2949 (1422)	2695 (1831-3830)	2706 (1321)	2477 (1678-3483)
≥30.0	2742 (1205)	2513 (1980-2573)	2819 (834)	2524 (2205-3360)	2726 (1274)	2513 (1842-3640)
	0.310[c]	0.206[d]	0.415[c]	0.367[d]	0.337[c]	0.214[d]
Mean potassium excretion (mg/day) Overall	1898 (1046)	1640 (1170-2410)	1966 (1118)	1775 (1092-2525)	1861 (1004)	1610 (1200-2290)
Creatinine range¥	1946 (1065)	1669 (1224-2452)	1995 (1050)	1871 (1336-2441)	1922 (1074)	1610 (1189-2479)
Age, y						
18-49	1931 (1052)	1660 (1190-2470)	1902 (1066)	1640 (1080-2380)	1945 (1048)	1700 (1280-2500)
50-94	1864 (1042)	1610 (1110-2315)	2024 (1168)	1870 (1095-2575)	1766 (948)	1580 (1132-2077)
	0.537[a]	0.457[b]	0.536[a]	0.259[b]	0.167[a]	0.078[b]
Education						
Never been in school	1952 (1069)	1750 (1282-2458)	1892 (981)	1847 (1318-2246)	1981 (1111)	1643 (1263-2572)
≤9 y	1745 (964)	1517 (1031-2345)	1776 (1153)	1458 (856-2336)	1729 (867)	1544 (1095-2351)
>9 y	1801 (935)	1542 (1115-2257)	1993 (1041)	1919 (1295-2739)	1617 (796)	1391 (1046-1976)
	0.201[c]	0.201[d]	0.715[c]	0.450[d]	0.094[c]	0.174[d]
Geographic area						
Rural	2072 (1157)	1788 (1366-2498)	1982 (1112)	1841 (1341-2292)	2136 (1192)	1788 (1368-2696)
Urban	1831 (1013)	1598 (1103-2367)	1842 (1024)	1659 (1056-2341)	1825 (1011)	1533 (1115-2381)
	0.044[a]	0.063[b]	0.469[a]	0.559[b]	0.044[a]	0.057[b]

	Overall (n=371)		Men (n=132) Women (n=239)			
BMI						
<18.5[e]	-	-	-	-	-	-
18.5-24.9	1933 (1141)	1633 (1067-2269)	1849 (1052)	1649 (1055-2220)	2032 (1242)	1595 (1122-2750)
25.0-29.9	1883 (1094)	1634 (1176-2525)	1942 (1092)	1696 (1214-2597)	1854 (1099)	1477 (1157-2479)
≥30.0	1973 (970)	1729 (1318-2498)	2083 (1039)	1906 (1370-2645)	1950 (959)	1696 (1280-2421)
	0.387[c]	0.277[d]	0.465[c]	0.509[d]	0.470[c]	0.342[d]

BMI, body mass index.

¥Twenty- four-hour creatinine excretion range was 3-25 mmol for women and 6-30 mmol for men [27] (n=355).

Comparison between groups was done using: Student's t-test for interdependent samples [a], Mann-Whitney test [b],

One-Way Analysis Of Variance (ANOVA) [c], and kurskal-walis test [d].

[e] Only 4 subjects were thin, therefore estimation of sodium and potassium according to BMI wasn't calculated for this category.

Table 3. Multiple linear regression analysis to assess relationship between urinary sodium and potassium to systolic and diastolic blood pressure.

	SBP (mmHg)		DBP (mmHg)	
Variables				
Urinary sodium (mg/day)	-0.001 (-0.03, 0.0003)	P=0.112	-0.001 (-0.002, 0.0004)	P=0.193
Urinary potassium (mg/day)	0.002 (-0.0002, 0.004)	P=0.069	0.001(-0.0001, 0.003)	P=0.072
Values are β coefficient and 95% confidence interval (95% CI) for systolic				
blood pressure (SBP) and diastolic blood pressure (DBP).				
SBP and DBP were used as dependent variables and age, sex,				
body mass index, urinary sodium and urinary potassium as independent variables.				

Twenty-four-hour urinary potassium excretion and sodium-to-potassium excretion ratio

Mean 24-hUK in the total sample was 1898 ± 1046 mg and the median was 1640 mg. There were no significant differences by gender, (1966 ± 1118 mg and 1861 ± 1004 mg, respectively) (p=0.357) (Figure 3). According to the age groups, the mean of 24-hUK excretion was 1931 ± 1052 mg in individuals aged 18 to 49 years and 1864 ± 1042 mg in individuals aged 50 years and over (p=0.537) (Table 2). No significant differences were observed between groups defined by the level of educational or BMI. However, a significant difference was recorded when categorizing data by geographic area (p=0.044). The 24-hUK excretion was higher in rural areas (2072 ± 1157 mg/day) than in urban areas (1831± 1013 mg/day) (Table 2). The Na/K excretion ratio was equal to 1.7 ± 0.9 and like Na and K, there was no significant difference between men and women (1.8 ± 1.1 and 1.6 ± 0.8 respectively) (Figure 4).

Sensitivity analysis:

The mean 24-hUNa, 24-hUK, and Na/K excretion ratio remained unchanged after excluding participants with creatinine excretion outside the range of 3 to 25 mmol/day for women and 6 to 30 mmol/day for men [27], and after exclusion of participants reported to use antihypertensive drugs.

Distribution at different intake levels and adherence to WHO recommendations of sodium and potassium intake

When categorizing participants according to the level of intake, overall, 5.0% of the participants had 24-hUNa > 5000 mg; Na excretion was between 3000 and 5000 mg in 31%, and in 64%, Na excretion was < 3000 mg (Figure 2). About two-third of adults (69.3%) had a 24-hUNa above the upper limit set by the WHO (2000 mg/day), with no significant differences between men and women: 72.0% versus 67.8%, respectively (p=0.403) (Figure 5). Overall, 8.4% achieved adequate K as recommended by the WHO (≥ 3510 mg/day), 67.7% had their 24-hUK ranging between 1000-3000 mg (Figure 2). No significant

difference was observed by gender (Figure 5). For the Na/K excretion ratio, only 15.1% of adults showed a ratio ≤1. Additionally in this case, no significant difference was observed between men and women (p=0.530) (Figure 5).

Relationship of 24-urinary sodium and potassium to blood pressure

The multiple linear regression analysis showed an absence of a relationship between 24-hour urinary sodium and potassium excretion and BP, after adjustment for potential confounders (sex, age, and BMI).

Discussion

The objective of the present study was to estimate the intake of Na (salt) and K by using 24-hour urine collection and to examine their relationship with BP in Moroccan adults. It was carried out in the spring to avoid the effect of seasonal variations on the estimated intakes of Na and K. Indeed, dietary Na excreted in the urine is underestimated by losing more than the normal fraction (approximately 4 to 12.7 mmol / day) due to the hot climate [31] and BP is mainly affected by seasonal variations in winter and summer [32] [33].

Results of this study showed that mean 24-hUNa was above the upper limit of 2000 mg/day (≈5g/day of salt), and mean 24-hUK was below the recommended adequate intake of 3510 mg. Since nearly 90% of Na consumed is excreted via urine [34] [35], Na intake in this study may be estimated at 3100 mg/day (2794 mg/0.90=3104 mg). This greatly exceeds the upper limit of Na intake of 2000 mg/day recommended by the WHO. Few data on Na intake in Moroccan adults were published. A pilot study carried out on a convenience-based sample of 132 of Moroccan adults reported an estimate that is similar to ours (2960 mg in men and 2769 mg in women) [16]. An Estimate of Na intake of 3620 mg was observed in a cohort of Moroccan women of childbearing age using two 24-hour dietary recalls [36]. Although repeated measurements were collected from the same participant (to account for day-to-day intraindividual variation in Na intake), Na intake in that study was less reliable compared to that found in our study, knowing the well-established measurement errors of dietary surveys [37]. Hence, our estimate using 24-hour urinary excretion, the currently recommended method for estimating Na intake, is a reliable assessment for Na intake in the Moroccan population. We have shown that the majority (69.3%) of adults consume more than 2000 mg/day of Na, highlighting the relevance of implementing the national strategy to reduce the salt intake of the Moroccan population by 10% by 2029 as a voluntary target adapted by the country to fight against NCDs [10].

Sodium intake in the Eastern Mediterranean Region, reported in two systematic reviews [38] [39] was high. The mean Na intake in the current study was within the range reported in the first systematic study published by Al Jawaldeh and colleagues [38]. In that study, the highest estimate of Na intake was observed amongst adult men and women from Jordan (4100 mg/day), men from Lebanon (4800 mg/day), and women from the Republic of Iran (3900 mg/day). In the second systematic study, Powles J and colleagues reported a sodium intake of 3920 to 4200 mg/day in the Middle East and North Africa

region and 4200 mg/day in Morocco [39]. This is a much higher Na intake compared to our findings, however, in the review by Powles et al, the approach used to estimate Na intake in the Moroccan population was unclear.

Mean 24-hUK was 1898 mg. Potassium excretion is subject to large fluctuations, with only a fraction of 77% of dietary K being excreted in urine [40]. Accordingly, mean K intake in this study may be about 2460 mg/day (1898 mg / 0.77 = 2465 mg). Even with such correction, the estimated K intake is still far below 3510 mg/day; the adequate level of K intake recommended by the WHO. Besides, only 8.4% of adults were consuming the recommended 3510 mg/day of K. This corroborates the results of previous studies showing low commitment of individuals to K intake recommendations [30] [17]. Indeed, in Mexican healthy adults, only 2.3% of participants met the recommendations for dietary K [30] and in a Moroccan cohort, only one participant had a K intake above the cut-off set by the WHO to reduce the risk of chronic disease [17].

The vast majority of adults (84.9%) in our study did not meet the recommended Na/K intake ratio ≤ 1. This imbalance in the intake of Na and K may be a reflection of dietary behavior and the current food consumption patterns in Morocco. In fact, a nutritional transition has been observed in the country over recent decades [41]. It concerned on the one hand, a diet which is increasingly based on processed foods (rich in Na and poor in K), in particular in urban regions such as the region of Rabat-Salé-Kénitra [41] and on the other hand, a decrease in the consumption fruits and vegetables. The STEPwise Survey-Morocco-2017-2018 showed that 76.3% of Moroccan adults consume less than 5 portions per day [21]. A WHO/ Food and Alimentation Organization report [42], recommended to consume this amount of fruits and vegetables as a minimum requirement to prevent major diseases such as cardiovascular diseases and certain types of cancers on the basis of the high density of K and other nutrients that more than 5 portions may contain. This suggest that simultaneously with Na reduction strategies, it will be relevant to take measures to promote K intake at the population level; by increasing the individual's awareness of the importance of consuming fruits and vegetables and by making these types of foods more affordable.

We did not find a significant relationship between urinary Na or K and BP, even after adjustment for potential confounders. This result is consistent with findings from several other cross-sectional studies that also suggested an absence of a significant relationship between Na and K excretion with BP [43–45] [30]. In contrast, others suggested a direct association of BP with Na and K intake [46–48] [29] [49]. These contradictions could be explained by the lower range of both estimated K and Na shown in our study. Urinary K excretion in our study was low (1898 mg, equivalent to 2465 mg per day of K intake using the generally adopted conversion factor of 1.3) and ranged between 1000 and 3000 mg/day. This range showed no association with SBP in a recent study based on data from the Dietary Approaches to Stop Hypertension–Sodium trial [50]. Similarly, Filippini and colleagues [51] performed a meta-analysis based on 32 studies and found a U-shaped relationship between 24-hUK excretion and BP levels, with the presence of an association at low and high level but not at the intermediate level of K intake.

Additionally, our population was consuming a relatively low Na level. The K effect on lowering BP is shown to be more pronounced in subjects with high levels of Na intake [13]. The Prospective Urban Rural Epidemiology (PURE) Study [46] and two studies conducted in the Chinese [47] and American [48] population have all shown a direct relationship between high BP and a diet high in Na. Comparing our study with the latter shows that there are differences both in the levels of Na excretion and in the methods used. However, we believe that the excretion level factor would be determining and could largely explain the difference in the relationship between Na excretion and K-arterial pressure. The Na estimate in the aforementioned studies was much higher than in our study (US population: 3650 mg/day, Chinese population: 3838 mg/day, multinational population (PURE study): 4930 mg/day our population: 2794 mg/day). The detailed analysis of the results of the PURE study shows that the slope of the association of Na excretion / BP depended on the levels of excretion. Transposing the excretion levels of 64% of the participants in our study, who had Na excretion below 3000 mg/day, to similar levels in the PURE study, showed the same result: an absence of a significant relationship. Levels of excretion in about a third (31% of the participants in our study with Na excretion between 3000 and 5000 mg/day) corresponded to levels in the PURE study for which a modest association was observed. What further strengthens our hypothesis is the fact that only 5% of our participants had a Na excretion greater than 5000 mg/day, levels for which in the PURE study, there was a stronger slope of association between BP and Na excretion. Methodologically, the Na intake in [47], [48] was estimated using two consecutive urine samples over 24 hours from each individual, whereas in our case only one sample was taken. We performed a comparison in preliminary experiments with a small sample size and found that the small difference in the measurements was not significantly large. This gives the methodological difference less influence than the Na excretion level factor.

The lack of dependence of the estimated Na intake on the BMI is in contradiction with those of some previous studies [52] [53]. The positive association between Na (salt) intake and BMI has generally been observed in developed countries. However, our results are similar to those of a study which showed no association between 24-hUNa and BMI [54]. In addition, a recent cross-sectional study carried out in a cohort of Moroccan women of childbearing age living in the urban areas of the region of Rabat-Salé-Kénitra showed no association between energy intake (assessed using a validated 24-hour multipass dietary recall approach based on the most recent Moroccan food composition table) and BMI [55]. These inconsistencies could be due, on the one hand, to the limit of BMI when used as a tool to assess energy intake or body size among different populations [56] [57] or/and on the other due to differences in basic diet and salt sensitivity in Moroccan adults as well as their clinical characteristics compared to other populations. Salt-sensitive subjects have higher weight compared to salt-resistant subjects [58] [59]. However, the examination of sensitivity to salt in our subjects, which could provide an explanation argument, was not realized.

This study has several limitations. Firstly, 24-h urine collection is still for now the recommended method to estimate Na intake [19]. However, a single 24-h urine collection does not count for the intrapersonal variation in Na excretion. According to some authors, multiple 24-h urine collections are necessary to accurately assess habitual Na intake [60] [19]. However, this approach is more cumbersome for

participants knowing the highly documented difficulty for participants to collect a complete and valid 24-h urine collection [60–62]. This study primarily aims to estimate the mean Na intake of population. If provided by an appropriate number of individuals, a single 24-h urine collection would compensate the intrapersonal day-to-day Na excretion variation and safely estimate the mean population intake. Secondly, we collected the 24-hour urine samples during week-end in order to facilitate participation, however, 42% of adults refused to participate in the study or to collect the 24h urine sample (probably due to its cultural/psychological burden; people could find it embarrassing to bring the jar to their work place and keep collecting urine all 24-hour period). We did not examine the impact of differences in basic characteristics between the final sample and the firstly recruited population on Na and K intake level, but the final sample remain adequate for estimating Na and K intake in a group of subjects [21] [45]. Finally, the sample size was sufficient for an accurate estimate of the mean Na and K intake, but was modest for examining the association between Na or K and BP.

Besides the aforementioned limits, this study used the 24-h urine collection known as the most accurate method to estimate Na intake, with the adoption of a rigorous protocol to minimize the risk of under-collection and overcollection and exclusion of invalid 24-h urine samples based on doubtful urinary volume, inacceptable collection period and the loss of more than one void. Our findings will help to enrich and fill the existing gaps in the national database with accurate information, which can help to implement the national strategy to reduce salt intake and promote the high priority of potassium intake in health programs.

Conclusion

Sodium intake was higher whereas potassium intake was lower than the WHO recommendations in the studied population of Moroccan adults. These levels of intake were comparable to those reported in countries from Eastern Mediterranean Region. Estimated Na intake in most (95%) participants was < 5000 mg/day, and the mean K intake was in the range of 1000 to 3000 mg/day. Within this range, no association between Na or K intake with BP was found. One explanation for this finding could be the previously reported “U-shaped” form between Na or K intake and BP that suggests the absence of a relationship at moderate levels of intake. Our findings are interesting in estimating, based on the recommended 24-hour collection method, an overconsumption of Na and a low consumption of K in this population. These findings will enrich the national database with reliable estimates and enable better decision making on Na (salt) reduction strategy and actions of promotion of K intake in the population as a key measure to prevent and control NCDs in the country.

Abbreviations

Na: Sodium

K: Potassium

BP: Blood Pressure

WHO: World Health Organization

NCDs: Non-Communicable Diseases

BMI: Body Mass Index

SBP: Systolic Blood Pressure

DBP: Diastolic Blood Pressure

DABPM: Digital Automatic Blood Pressure Monitor

ICP-MS: Inductively Coupled Plasma Mass Spectrometry

24-hUNa: Twenty-four-hour urinary sodium excretion

24-hUK: Twenty-four-hour urinary potassium excretion

SD: Standard Deviation

IQR : Inter-Quartile

ANOVA: Analysis of Variance

24-hUCrea: Twenty-four-hour urinary creatinine excretion

95% CI: 95% Confidence Interval

PURE: Prospective Urban Rural Epidemiology

Declarations

Ethic Approval and Consent to Participate: The study was approved by the Biomedical Research Ethics Committee of the Faculty of Medicine and Pharmacy in Rabat-Morocco. All participants signed their consent before participating in the study**.**

Consent for Publication: All authors have read and approved the final version of the

submitted manuscript.

Availability of data and material: The data used to support the findings of this study are available from the corresponding author, MI, upon reasonable request.

Competing Interests: All authors declare no conflict of interest.

Funding: The author(s) received financial support for the research, authorship and/or publication of this article from the World Health Organization.

Author's Contributions: M.I; A.R**;** K.B; H.L, F.R and S.Mcollected the data, conducted data analysis and interpreted results, and wrotethe manuscript. M.I; N.S; S.M; K.E.K; A.B, F.R and A.E.H conducted data analysis and interpreted results**.** N.S; A.B; M.E; L.B; H.E.B; F.M;A.A.J, H.B; K.E.K and H.A contributed to conception and design, critically revised the manuscriptgave final approval and agrees to be accountable for all aspects of work ensuring integrity and accuracy.

Acknowledgements: The authors would like to kindly thank WHO for their financial and technical support. We would also like to thank the Epidemiology and Disease Control Department (DELM) for carrying out the field survey. We are grateful for the entire team of the Joint Research Unit in Nutrition, Health and Environment, Laboratory of Biology and Health, FSK, Regional Designated Center of Nutrition (AFRA / IAEA), for carrying out analyzes

References

1. Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000–2016. Geneva: World Health Organization; 2018.
2. World Health Organization. (2018). Noncommunicable diseases country profiles 2018.
3. World Health Organization. (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020. World Health Organization.
4. WHO. Global NCD target: reduce high blood pressure. 2016.
5. He FJ, MacGregor GA. A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. J Hum Hypertens 2009; 23:363–84. https://doi.org/10.1038/jhh.2008.144
6. Strazzullo, P.; D'Elia, L.; Kandala, N.B et al. Salt intake, stroke, and cardiovascular disease: Meta-analysis of prospective studies. BMJ 2009, 339, b4567. https://doi.org/10.1136/bmj.b4567
7. Aburto, N.J.; Ziolkovska, A.; Hooper, L et al. Effect of lower sodium intake on health: Systematic review and meta-analysis. BMJ 2013, 346, f1326. https://doi.org/10.1136/bmj.f1326
8. He, F.J.; Li, J.; MacGregor, G.A. Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomized trials. BMJ 2013, 346, f1325. https://doi.org/10.1136/bmj.f1325
9. WHO. Noncommunicable diseases and mental health. About 9 voluntary global targets. 2020. https://www.who.int/nmh/ncd-tools/definition-targets/en/
10. Ministère de la Santé. 2019. Stratégie Nationale Multisectorielle de Prévention et de Contrôle des Maladies Non Transmissibles 2019 – 2029. http://www.emro.who.int/fr/mor/morocco-news/lancement-de-la-strategie-nationale-multisectorielle-de-prevention-et-de-controle-des-maladies-non-transmissibles.html Accessed 28 March 2021
11. Adrogué, H. J., & Madias, N. E. (2014). Sodium surfeit and potassium deficit: keys to the pathogenesis of hypertension. Journal of the American Society of Hypertension, 8(3), 203–213. https://doi.org/10.1016/j.jash.2013.09.003

12. Adrogué HJ, Madias NE (2007). Sodium and potassium in the pathogenesis of hypertension. *N Engl J Med* **356**, 1966–1978. 10.1056/nejmra064486
13. Aburto, N. J., Hanson, S., Gutierrez, H., et al. (2013). Effect of increased potassium intake on cardiovascular risk factors and disease: systematic review and meta-analyses. Bmj, 346, f1378. https://doi.org/10.1136/bmj.f1378
14. World Health Organization. Guideline: Sodium Intake for Adults and Children. WHO Document Production Services; Geneva, Switzerland: 2012.
15. World Health Organization. Guideline: Potassium Intake for Adults and Children. WHO Document Production Services; Geneva, Switzerland: 2012.
16. World Health Organization. (2019). Noncommunicable Diseases Progress Monitor 2017. Geneva: WHO; 2017.
17. Derouiche, A., El Kardi, Y., Mohtadi, K., & Jafri, A. (2016). Évaluation de la consommation quotidienne de sel chez les adultes marocains. Nutrition Clinique et Métabolisme, 30(2), 110.
18. Saeid N, Elmzibri M, Hamrani A, et al. (2018). Assessment of Sodium and Potassium Intakes in Children Aged 6 to 18 Years by 24 h Urinary Excretion in City of Rabat, Morocco. Journal of Nutrition and Metabolism Volume 2018. https://doi.org/10.1155/2018/8687192
19. Campbell, N. R., He, F. J., Tan, M et al. (2019). The International Consortium for Quality Research on Dietary Sodium/Salt (TRUE) position statement on the use of 24-hour, spot, and short duration (< 24 hours) timed urine collections to assess dietary sodium intake. The Journal of Clinical Hypertension, 21(6), 700–709. https://doi.org/10.1111/jch.13551
20. World Health Organization. (2015). Chronic diseases and health promotion: STEPwise approach to surveillance. STEPS Instrument. [Cited 2012 July 11th] Available from: https://www.who.int/ncds/surveillance/steps/en accessed 18 March 2021.
21. Ministre de la santé du Royaume du Maroc, 2019. Rapport de l'Enquête Nationale sur les Facteurs de Risque communs des Maladies Non Transmissibles, STEPS, 2017 – 2018.
22. World Health Organization. (2018). How to obtain measures of population-level sodium intake in 24-hour urine samples (No. WHO-EM/NUT/279/E). World Health Organization. Regional Office for the Eastern Mediterranean.
23. WHO. Obesity: Preventing and managing the global epidemic. WHO Consultation; 2000. Report No: 894. Geneva, Switzerland. https://accessed 03 January 2021.
24. CDC. National Health and Nutrition Examination Survey: surveys and data collection systems (2010 data). Atlanta, GA: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2012. Available at http://www.cdc.gov/nchs/nhanes.htm. Accessed July 26, 2021.
25. World Health Organization. (2018). How to obtain measures of population-level sodium intake in 24-hour urine samples (No. WHO-EM/NUT/279/E). World Health Organization. Regional Office for the Eastern Mediterranean.
26. Grimes, C. A., Baxter, J. R., Campbell, K. J., et al. (2015). Cross-sectional study of 24-hour urinary electrolyte excretion and associated health outcomes in a convenience sample of Australian primary

schoolchildren: the Salt and Other Nutrients in Children (SONIC) Study Protocol. JMIR research protocols, 4(1), e7. 10.2196/resprot.3994

27. Wenxia Ma and al. Validation and Assessment of Three Methods to Estimate 24-h Urinary Sodium Excretion from Spot Urine Samples in High-Risk Elder Patients of Stroke from the Rural Areas of Shaanxi Province. Int. J. Environ. Res. Public Health 2017, 14, 1211; https://doi.org/10.3390/ijerph14101211
28. Vollmer WM, Sacks FM, Ard J et al. Effects of diet and sodium intake on blood pressure: subgroup analysis of the DASH-sodium trial. Ann Intern Med 2001; 135: 1019–1028. https://doi.org/10.7326/0003-4819-135-12-200112180-00005
29. Intersalt Cooperative Research Group. Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24-hour urinary sodium and potassium excretion. BMJ 1988;297:319e328. https://doi.org/10.1136/bmj.297.6644.319
30. Vallejo, M., Colín-Ramírez, E., Mancía, S. R et al (2017). Assessment of sodium and potassium intake by 24 h urinary excretion in a healthy Mexican cohort. Archives of medical research, 48(2), 195–202. https://doi.org/10.1016/j.arcmed.2017.03.012
31. Inst. Med. Dietary Reference Intake for Water, Potassium, Sodium, Chloride, and Sulfate. Washington, DC: Natl. Acad. Press; 2005.
32. Lewington, S., LiMing, L. I., Sherliker, P., et al. (2012). Seasonal variation in blood pressure and its relationship with outdoor temperature in 10 diverse regions of China: the China Kadoorie Biobank. Journal of hypertension, 30(7), 1383. 10.1097/HJH.0b013e32835465b5
33. Modesti PA, Morabito M, Massetti L, et al. Seasonal blood pressure changes: an independent relationship with temperature and daylight hours. Hypertension 2013; 61: 908–914. 10.1161/HYPERTENSIONAHA.111.00315
34. Institute of Medicine. Institute of Medicine, Panel on Dietary Reference Intakes for Electrolytes and Water: Dietary Reference Intakes for Water, Potassium Sodium, Chloride, and Sulfate.Washington, DC: National Academies Press; 2005.
35. Lerchl K, Rakova N, Dahlmann A, et al. Agreement between 24-hour salt ingestion and sodium excretion in a controlled environment. Hypertension. 2015;66(4):850–857. https://doi.org/10.1161/HYPERTENSIONAHA.115.05851
36. Fatima Barich, Fatima Zahra Laamiri, Souad Benaich, et al. (2019). NUTRITIONAL STATUS OF REPRODUCTIVE AGE WOMEN LIVING IN THE URBAN AREA OF MOROCCO. European Journal of Biomedical and Pharmaceutical sciences (ejbps), Volume 6, Issue 5, 476-483. ISSN 2349-8870.
37. Gibson, R. S., Charrondiere, U. R., & Bell, W. (2017). Measurement errors in dietary assessment using self-reported 24-hour recalls in low-income countries and strategies for their prevention. Advances in Nutrition, 8(6), 980–991. https://doi.org/10.3945/an.117.016980
38. Al Jawaldeh, A., Rafii, B., & Nasreddine, L. (2018). Salt intake reduction strategies in the Eastern Mediterranean Region. *Eastern Mediterranean Health Journal*, *24*(12). https://doi.org/10.26719/emhj.18.006

39. Powles J, Fahimi S, Micha R *et al.* (2013) Global, regional and national sodium intakes in 1990 and 2010: a systematic analysis of 24 h urinary sodium excretion and dietary surveys worldwide. *BMJ open* **3**, e003733. http://dx.doi.org/10.1136/bmjopen-2013-003733
40. Clark, A. J., & Mossholder, S. (1986). Sodium and potassium intake measurements: dietary methodology problems. The American journal of clinical nutrition, 43(3), 470–476. https://doi.org/10.1093/ajcn/43.3.470
41. Euromonitor, *Consumer Lifestyles in Morocco*, Euromonitor International Limited, London, UK, 2012.
42. l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO)/ Organisation mondiale de la Santé (OMS), 2004. Rapport de l'atelier conjoint Fruits et légumes pour la santé.
43. Mente A, Dagenais G, Wielgosz A, et al. Assessment of Dietary Sodium and Potassium in Canadians Using 24 h Urinary Collection. Can J Cardiol 2016;32:319e326. https://doi.org/10.1016/j.cjca.2015.06.020
44. McLean, R., Edmonds, J., Williams, S., Mann, J., & Skeaff, S. (2015). Balancing sodium and potassium: estimates of intake in a New Zealand adult population sample. Nutrients, 7(11), 8930–8938. https://doi.org/10.3390/nu7115439
45. Ware, L. J., Charlton, K., Schutte, A. E et al. (2017). Associations between dietary salt, potassium and blood pressure in South African adults: WHO SAGE Wave 2 Salt & Tobacco. Nutrition, Metabolism and Cardiovascular Diseases, 27(9), 784–791. 10.1016/j.numecd.2017.06.017
46. Mente, A., O'Donnell, M. J., Rangarajan, S., McQueen, M. J et al. (2014). Association of urinary sodium and potassium excretion with blood pressure. New England Journal of Medicine, 371(7), 601–611.
47. Xu, J., Chen, X., Ge, Z., et al (2017). Associations of usual 24-hour sodium and potassium intakes with blood pressure and risk of hypertension among adults in China's Shandong and Jiangsu Provinces. Kidney and Blood Pressure Research, 42(1), 188–200. 10.1159/000475486
48. Jackson, S. L., Cogswell, M. E., Zhao, L., et al (2018). Association between urinary sodium and potassium excretion and blood pressure among adults in the United States: National Health and Nutrition Examination Survey, 2014. Circulation, 137(3), 237–246. 10.1161/CIRCULATIONAHA.117.029193
49. Khaw, K. T., & Barrett-Connor, E. L. I. Z. A. B. E. T. H. (1988). The association between blood pressure, age, and dietary sodium and potassium: a population study. Circulation, 77(1), 53–61.
50. Chaudhary, P., Wainford, R.D. Association of urinary sodium and potassium excretion with systolic blood pressure in the Dietary Approaches to Stop Hypertension Sodium Trial. J Hum Hypertens (2020). https://doi.org/10.1038/s41371-020-0375-8
51. Filippini, T., Naska, A., Kasdagli, M. I., et al (2020). Potassium Intake and Blood Pressure: A Dose-Response Meta-Analysis of Randomized Controlled Trials. Journal of the American Heart Association, 9, e015719.10.1161/JAHA.119.015719
52. Nam, G. E., Kim, S. M., Choi, M. K et al. (2017). Association between 24-h urinary sodium excretion and obesity in Korean adults: a multicenter study. *Nutrition*, *41*, 113–119. 10.1016/j.nut.2017.04.006

53. Lee, J., Hwang, Y., Kim, K. N., et al. (2018). Associations of urinary sodium levels with overweight and central obesity in a population with a sodium intake. *BMC nutrition*, *4*(1), 47. 10.1186/s40795-018-0255-6
54. Larsen SC, Angquist L, Sorensen TI, Heitmann BL. 24h urinary sodium excretion and subsequent change in weight, waist circumference and body composition. PLoS One. 2013;8:e69689. 10.1371/journal.pone.0069689
55. Fatima Barich, Fatima Zahra Laamiri, Slimane Mehdad, et al. "Energy and Macronutrients Intakes among Childbearing Age Women Living in the Urban Area of Morocco: A Cross-Sectional Study", Journal of Nutrition and Metabolism, vol. 2020, Article ID 2685809, 10 pages, 2020. https://doi.org/10.1155/2020/2685809
56. Garrido-Chamorro RP, Sirvent-Belando JE, Gonzalez-Lorenzo M, Martin-Carratala ML, Roche E. Correlation between body mass index and body composition in elite athletes. J Sports Med Phys Fitness. 2009;49:278–284.
57. Vasconcelos FdAGd. Cordeiro BA, Rech CR, Petroski EL. Sensitivity and specificity of the body mass index for the diagnosis of overweight/obesity in elderly. Cadernos de Saúde Pública. 2010;26:1519–1527. https://doi.org/10.1590/S0102-311X2010000800006
58. Rocchini AP. Obesity hypertension, salt sensitivity and insulin resistance. Nutr Metab Cardiovasc Dis. 2000;10:287–94.
59. Omvik P, Tarazi RC, Bravo EL. Regulation of sodium balance in hypertension. Hypertension. 1980;2:515–23.
60. Campbell, N. R., He, F. J., Tan, M et al. (2019). The International Consortium for Quality Research on Dietary Sodium/Salt (TRUE) position statement on the use of 24-hour, spot, and short duration (< 24 hours) timed urine collections to assess dietary sodium intake. The Journal of Clinical Hypertension, 21(6), 700–709. 10.1111/jch.13551
61. Mente A, O'Donnell MJ, Yusuf S. Measuring sodium intake in populations: Simple is best? American Journal of Hypertension. 2015;28:1303–5. https://doi.org/10.1093/ajh/hpv076
62. Cogswell, M. E., Maalouf, J., Elliott, P et al. (2015). Use of urine biomarkers to assess sodium intake: challenges and opportunities. Annual review of nutrition, 35, 349–387. 10.1146/annurev-nutr-071714-034322

Figures

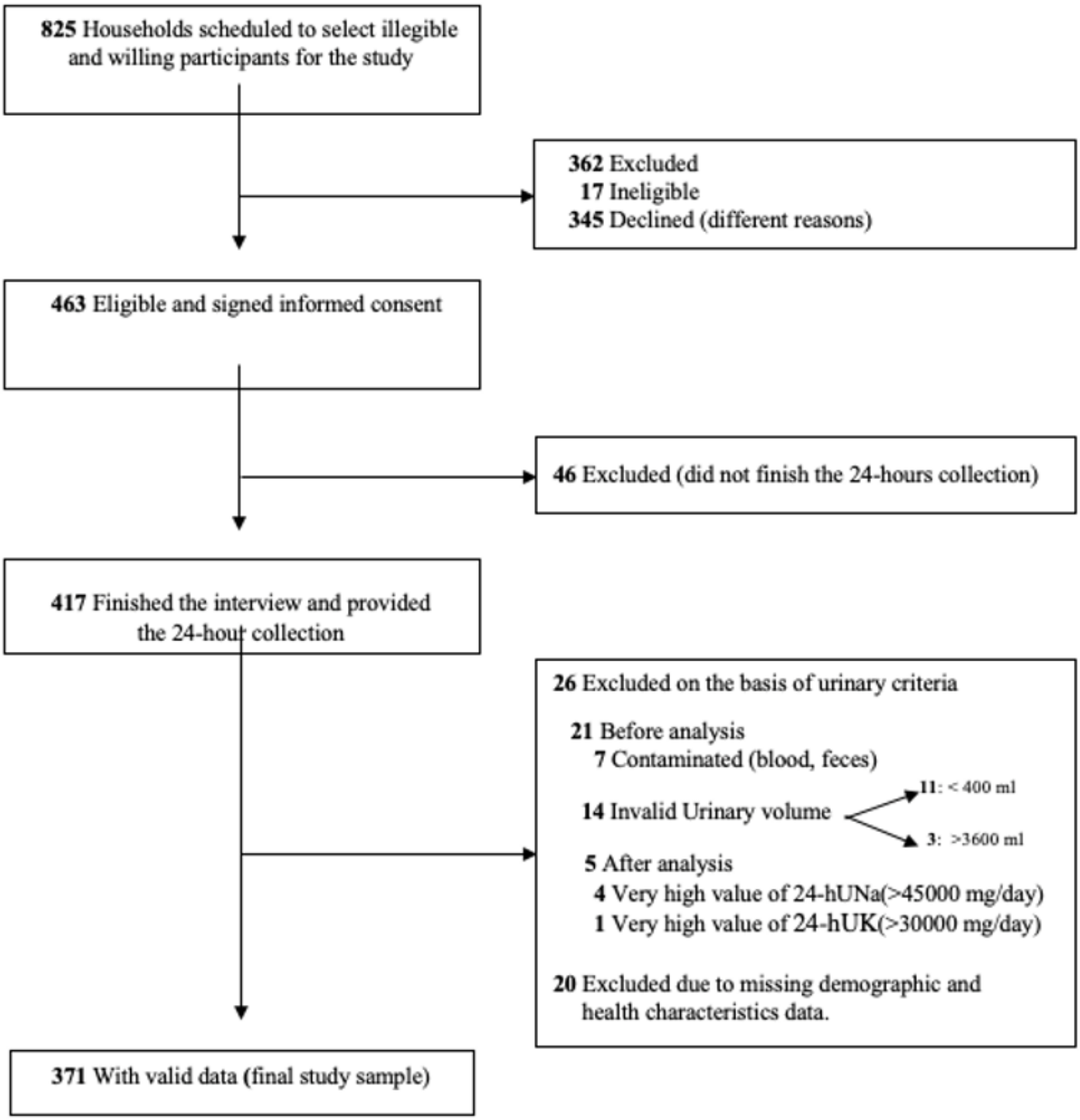

Figure 1

Participant Recruitment Diagram

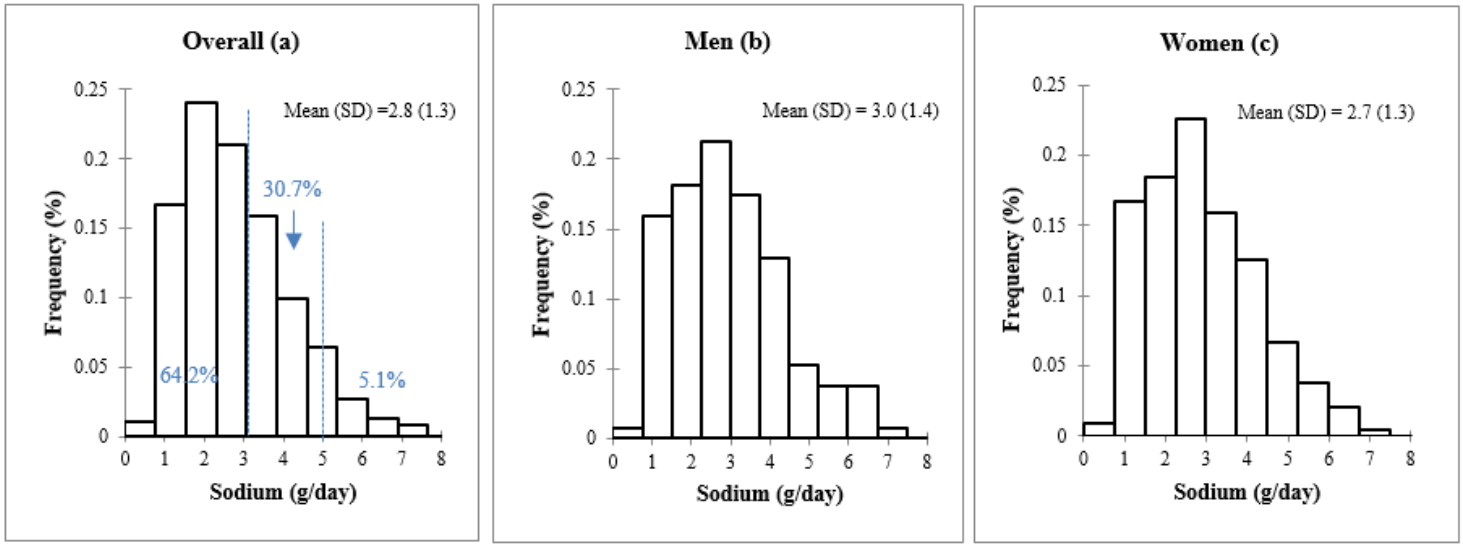

Figure 2

Frequency distribution of 24-hour urinary sodium excretion. (a) Overall, (b) Men, (c) Women. SD; standard deviation, IQR; interquartile range.

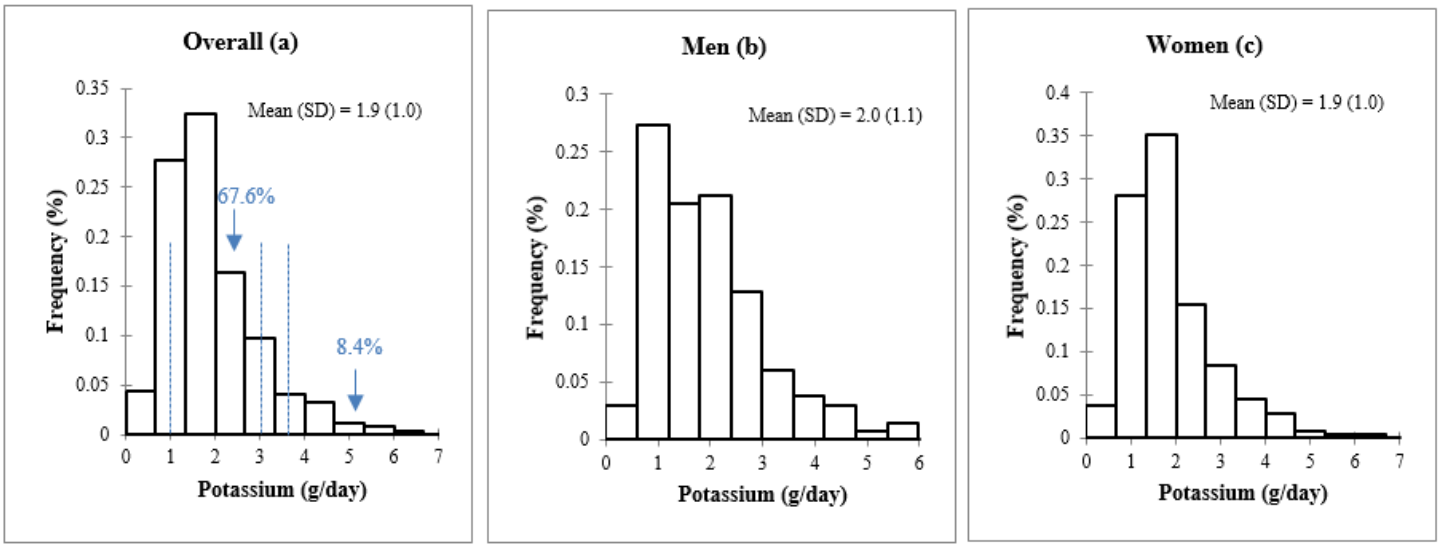

Figure 3

Frequency distribution of 24-hour urinary potassium excretion. (a) Overall, (b) Men, (c) Women. SD; standard deviation, IQR; interquartile range.

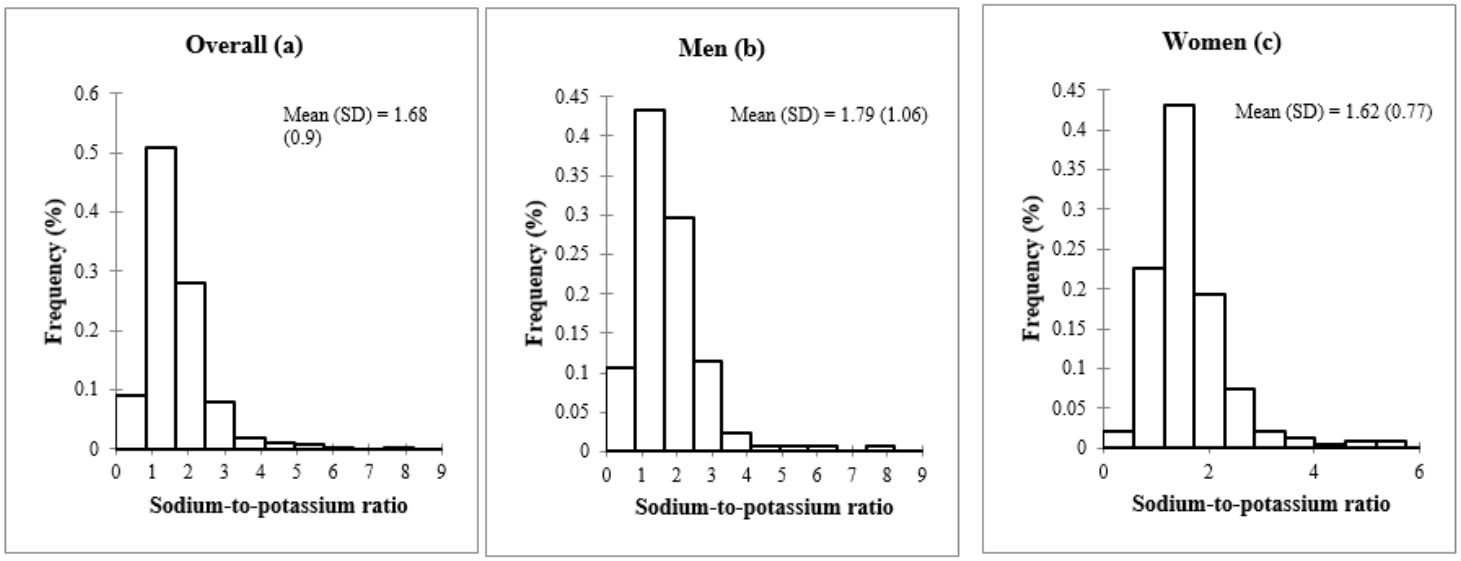

Figure 4

Frequency distribution of 24-hour urinary sodium to potassium excretion ratio. (a) Overall, (b) Men, (c) Women. SD; standard deviation, IQR; interquartile range.

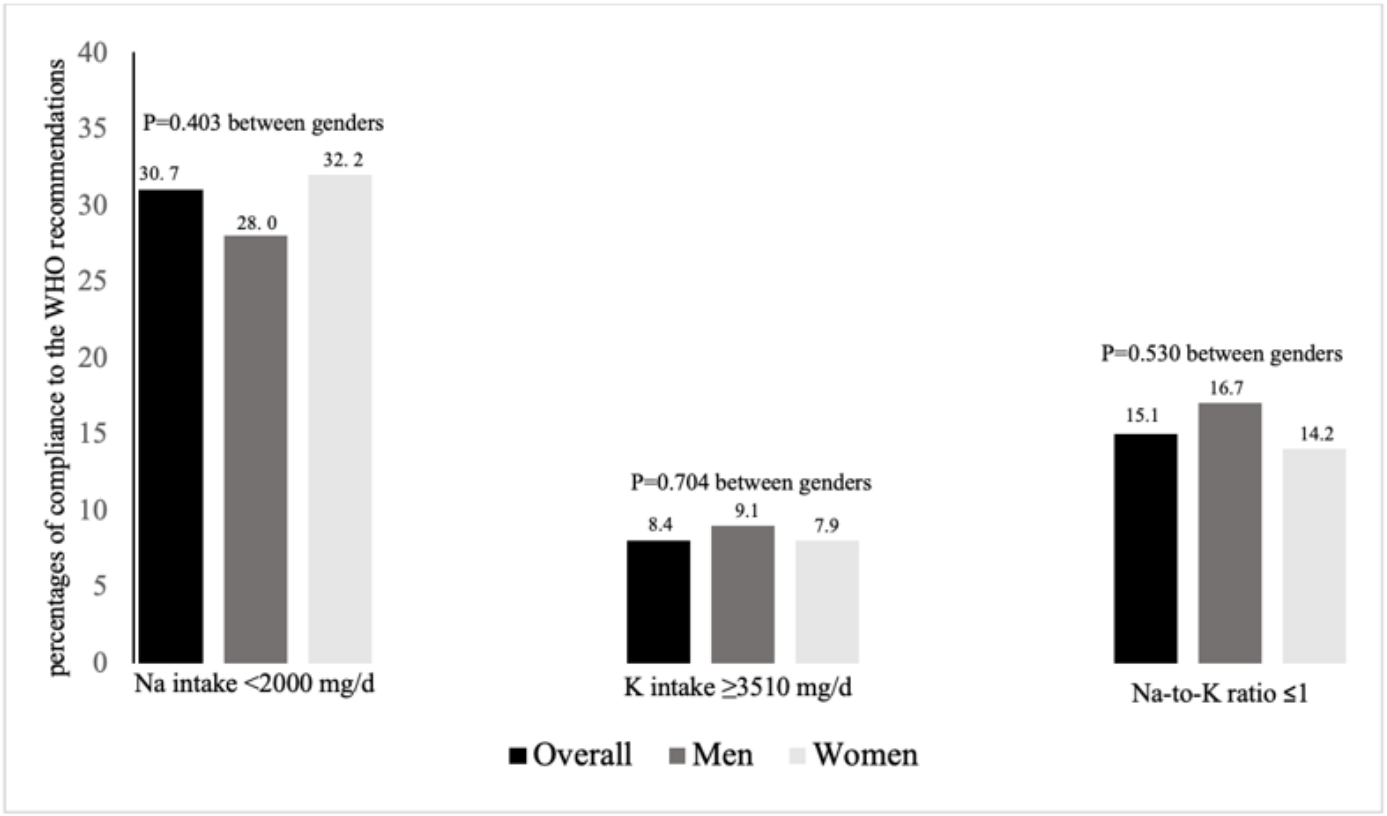

Figure 5

Percentages of adults in accordance with the WHO recommended sodium (<2000 mg/day), potassium (≥3510 mg/day), and sodium-to-potassium ratio intake (≤1), estimated using the 24-h urinary excretion.