Salt-related knowledge, attitudes, and practices and their relationship with 24-hour urinary sodium and potassium excretions among a group of healthy residents in the UAE: A cross-sectional study

Amjad H. Jarrar[1, 2], Pariyarath S. Thondre [2], Leila Cheikh Ismail[3,4], Helen Lightowler [2], Mo'ath F. Bataineh[1, 5] , Alia K. Al Baloushi , Amira Y. Al Braiki[1], Shaima Al Halabi[1], Joudi Hajouz[1], Usama Souka[1], Fatima Al Meqbaali [1], Lily Stojanovska [1, 6], Habiba I. Ali [1], Johaina T. Idriss [1], Rameez Al Daour [3], Sheima T. Saleh [3], Maysm N. Mohamad [1], and Ayesha S. Al Dhaheri [1]*

[1]Department of Nutrition & Health Sciences, College of Medicine and Health Sciences, United Arab Emirates University, Al Ain 15551, United Arab Emirates

[2]Oxford Brookes Centre for Nutrition and Health, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford

[3]Clinical Nutrition and Dietetics Department, College of Health Sciences, University of Sharjah, Sharjah 27272, UAE

[4]Nuffield Department of Women's & Reproductive Health, University of Oxford, Ox-ford OX1 2JD, UK.

[5]Department of Sport Rehabilitation, Faculty of Physical Education and Sport Science, Hashemite University, Zarqa, Jordon

[6]Institute for Health and Sport, Victoria University, Melbourne, Vic.Australia

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***Corresponding authors:** Ayesha Al Dhaheri; Department of Nutrition and Health, College of Medicine and Health Sciences, United Arab Emirates University, Al Ain 15551, UAE, Tel: 03-7134593, Email: ayesha_aldhaheri@uaeu.ac.ae

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Ethical Standards Disclosure: This study was approved by the University Research Ethics Committee at Oxford Brookes University (UREC), Number: 181168, as well as the United Arab Emirates University (UAEU) Research Ethics Committee (Reference No DVRGS/ 36). This study was conducted according to the stated principles in the Declaration of Helsinki. All participants were asked to read and sign a written "Informed Consent" form.

Abstract

Objective: This study aimed to measure urinary sodium and potassium as a measure of sodium and potassium intake concerning the knowledge, attitude, and practice (KAP) toward sodium intake among a group of healthy residents in the UAE.

Design: A cross-sectional study on a sample of healthy adults in the UAE. In addition to the KAP questionnaire, sodium and potassium excretions, and food records were taken.

Setting: The United Arab Emirates

Participants: A sample of 190 healthy individuals aged between 20-60 years.

Results: The mean (± SD) age of the sample was 38.6 (± 12.5) years and 50.5% were females. The mean urinary sodium and potassium intake were 2816.2± 675.7 mg /day and 2533.3± 615 mg/day, respectively. The means were significantly different compared to the World Health Organization (WHO) recommendation of sodium and potassium, ($p < 0.001$). About 65% of the participants exceeded the WHO recommendations for salt intake, and participants' knowledge classification for health-related issues was fair while food-related knowledge was poor ($P=0.001$). A two-stage stepwise multiple regression analysis revealed that KAP scores were negatively associated with urinary sodium excretion ($r = -0.174$; $p = 0.017$) and those older participants and females had lower urinary sodium excretion ($p<0.001$).

Conclusion: These findings may suggest an increase in the risk of hypertension in the UAE population. Moreover, these findings emphasize the need to establish education and public awareness programs focusing on identifying the sodium contents of foods and establishing national regulations regarding food reformulation, particularly for staple foods such as bread.

Keywords: Urinary sodium; potassium; food related knowledge; sodium sources; UAE

1. Introduction

Non-communicable diseases (NCDs), also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioral factors. The major burden of NCDs is accounted for by diabetes mellitus (DM), cardiovascular diseases (CVDs), cancers, and chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma). These diseases are steadily increasing globally, as documented by the World Health Organization (WHO), and are considered as leading causes of death worldwide (1). NCDs contribute to the death of 41 million people each year, equivalent to 71% of all deaths globally (2). CVDs account for most NCD deaths with 17.9 million annually, followed by cancer (9.3 million), respiratory diseases (4.1 million), and diabetes (1.5 million). Collectively, these four groups of diseases account for over 80% of all premature NCD deaths (2).

In developing countries, CVDs are causes of great concern as it is most commonly attributable to risk factors such as obesity, high blood pressure (BP), lack of physical activity, and smoking (3). Hypertension, which is associated with increased BP, is a major risk factor in the development of CVDs, which are responsible for 62% of strokes and 49% of coronary heart disease (CHD) worldwide (3). Hypertension is a common medical condition; its prevalence increases with age and is estimated to affect 65% of those ≥ 60 years old (6). An estimated 20% of the global population will be ≥ 65 years old by 2023 (4). Therefore, the impact of high BP on mortality among older adults is expected to grow over the coming decades. According to the WHO, CVDs account for 46% of the total deaths in the Kingdom of Saudi Arabia (KSA), 41% in Kuwait, 33% in the Sultanate of Oman, 30% in the UAE, 26% in Bahrain, and 24% in Qatar (5).

Salt is an ionic compound of sodium and chloride. Sodium is an essential nutrient necessary for the maintenance of certain body functions, such as keeping fluid balance and maintaining muscle and nerve functions. According to the WHO, adults should consume less than five grams (just under a teaspoon) of salt per day (6). In the Eastern Mediterranean region, the current salt intake is high, with an average intake of >12 g per person per day (5). These intakes are concerning since high sodium (>2 g/day or >5 g salt/day) and insufficient potassium intake (< 3.5 g/day) can contribute to high blood pressure and increase the risk of heart disease and stroke (2).

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Research has shown that a decrease in salt intake to 6 g predicted a fall in blood pressure of ~7/4 mm Hg in hypertensive and of ~3.5/2 mm Hg in normotensive individuals (7). This decrease in blood pressure is predicted to lead to a 14 % reduction in stroke deaths and a 9 % reduction in coronary artery disease deaths in hypertensive people, as well as a 6 % reduction in stroke deaths and 4% reduction in coronary artery disease deaths in normotensive people (7). Population salt reduction is considered a 'best buy' intervention for the prevention of NCDs (7). Cardiovascular diseases (CVDs) in adults are associated with hypertension, and high sodium intake is a leading cause of hypertension. Conversely, potassium attenuates sodium's negative effects. Increased potassium intake is associated with reduced systolic blood pressure and the risk of developing CVDs (8). WHO has suggested a sodium-to-potassium ratio of approximately 1.00, which will be associated with a low risk for the development of CVDs (3). WHO has recommended different strategies to reduce salt intake at country levels. These include consumer education and awareness, food reformulation, front-of-pack labelling, and salt taxation (9). Although the specific strategies vary in approach, some strategies use a multi-component approach. However, consumer education is the most common intervention therefore, assessing consumer knowledge, attitude, and practice is the recommended approach to set appropriate consumer education programs (10).

The WHO recommends using a 24-hour urinary sodium excretion as the gold standard method to estimate sodium intake as a more practical method in comparison with dietary surveys (11, 12). To date, only one study has used 24-hour urinary sodium excretion as a tool to assess salt intake in UAE in 2015/16 (10). Therefore, this study aimed to measure urinary sodium and potassium excretions according to the Pan American Health Organization (PAHO) /WHO protocol (12), to predict sodium and potassium intakes and to measure the ratio of sodium to potassium intake. Additionally, assess the relationship between urinary sodium and potassium excretions and Knowledge, Attitudes, and Practices (KAP) regarding salt intake.

Materials and Methods

1.1 Study Design

A cross-sectional study was conducted between October 2018 and March 2019 in the UAE. Several methods were used for patient recruitment: email circulation to students, staff, and faculty members of UAE University- Al Ain, University of Sharjah- Sharjah, and Zayed

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University- Abu Dhabi. In addition, posters were displayed (in shopping malls, health centers, hostels, and in the country) and on social media including Snapchat™ and WhatsApp™.

A sample of 297 healthy individuals aged between 20 and 60 years showed interest in participating in the study from the seven Emirates (Western region: Emirate of Abu Dhabi: including Abu Dhabi and Al-Dhafra districts, Northern region: Dubai, Sharjah, Ajman, Ras Al Khaimah, Fujairah and Umm Al Quwain and Eastern region: Al Ain). Only 244 met the following inclusion criteria at screening as self-report, including the age of 20 to 60 years (male and female), non-pregnant and non-lactating, no known chronic kidney disease, renal failure, hypertension with medications and liver diseases, no medical condition(s) or medication(s) known to affect urination and ability to collect 24- hour urine (Figure 1) (11). Randomization for the sample was performed using Altman and Bland procedure (RAND) (13), according to gender and four age groups. According to age groups and gender, 210 out of 244 (86.1%) healthy participants were selected to participate in this study. Participants were divided into four age groups: 20 to 29, 30 to 39, 40 to 49, and 50 and above. All participants provided written informed consent to participate in the study.

The sample size was determined based on the WHO Eastern Mediterranean Region Office (WHO-EMRO) protocol, published in 2010 for 24-hour urine collection and analysis (12). To be able to detect a minimum difference in sodium excretion with 20 to 35 mmol, which is equivalent to approximately 500 mg with a standard deviation of 20 to 30 mmol, the required sample size for each age group per gender was around 21 to 25 participants. Therefore, the recommended sample size for each age group with both genders with a ratio of 1:1 was 46 with 4- age groups with a total number of 188 (alpha = 0.05, power = 0.83).

The exclusion criteria for this study were implemented at two stages: At the screening (self-report) and after urine collection; those that were unable to collect adequate urine within the 24 hours (i.e. volume < 500 ml), urine samples with creatinine level reference range of 500 to 2000 mg/day, which is equivalent to 9 -26 mg/kg of body mass for female participants and 13-29 mg/kg of body mass for male participants were excluded (10, 14).

This study was approved by the University of Sharjah Research Ethics Committee (Blinded for peer review) and was conducted according to the stated principles in the Declaration of Helsinki. All participants were asked to read and sign a written informed consent form.

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1.2 Anthropometric measurements

Body weight and height were measured for each participant and their body mass index (BMI) was calculated as weight (kg) divided by height (m) squared (kg/m^2). Height was recorded to the nearest 1 cm using a stadiometer (Seca Stadiometer, Seca Ltd., Birmingham, UK) and weight was recorded using a balance (Seca Stadiometer, Seca Ltd., Birmingham, UK) to the nearest 0.1 kg (15). Systolic and diastolic blood pressures were measured in triplicate after five minutes of resting in a seated position using a calibrated digital automated blood pressure monitor (Omron HEM-907-E7). The measurements were taken at three-minute intervals, and the average of the last two readings was used. Participants were designated as having normal blood pressure if their systolic BP was <120 mmHg and/or diastolic BP was equal to <80 mmHg (16).

1.3 Assessment of food intake and physical activity

The aim of collecting food records on the same day as the 24-hour urine collection is to estimate participants' protein intake and compare it with 24-hour urinary creatinine excretion, as well as to ensure the adequacy of a 24-hour urine sample. Participants were asked to record their food intake on the same day as the urine collection using a 24-hour record. In the food records, all consumed food and beverages (excluding leftovers) were documented with detailed information, including brand names, preparation methods (e.g., adding salt, sugar, oil, butter, or ghee), measurements (e.g., teaspoon or tablespoon), and cooking methods (e.g., deep frying, grilling, or boiling). This approach was consistent with the methods reported in sources (15) and used in studies(17, 18). In addition to recording the quantities of food intake, participants were asked to record the use and the quantities of chicken cubes, monosodium glutamate, or any other sauces and dressing oils. All participants were given verbal and provided with written instructions on how to determine food portion size. Food photographs with different portion sizes were used to aid participants in estimating the correct portion size consumed. The food record was collected by the research team at the same time as collecting urine bottles. The Food Processor® Nutrition and Fitness Software- ESHA food analysis program (version 10.4) and Kuwaiti Food Composition database, were used to analyze the energy and macronutrient contents of foods (carbohydrate, protein, and fat) (19). ESHA software was chosen for the analysis of food intake by several studies conducted in the UAE (17, 18).

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Physical activity for the participants was measured using a 7-day self-reported short International Physical Activity Questionnaire (IPAQ), associated with scoring points based on time spent per day and week according to the type of activity levels (20). Physical activity classification was performed according to Forde (2018) (21) into three categories (low, moderate, and high) levels of physical activity.

1.4 Knowledge, attitude, and practice questionnaire (KAP)

Participants were asked to complete a self-reported questionnaire. The questionnaire assessed the knowledge related to salt and health outcomes, frequency of consumption, and perceived salt consumption, and was developed according to the WHO/PAHO (12) recommendations for the assessment of population sodium intake and behaviors. In addition, this questionnaire was used by other previous studies conducted in the UAE to measure KAP (10, 22). The KAP questionnaire consists of 44 items and is divided into three components: knowledge, attitude, and practice. The knowledge component includes 28 questions, and it is divided into food and health-related knowledge (19 and 9 items respectively). Food-related knowledge questions included 19 questions, the questionnaire inquired about the percentage of sodium in salt (response options "20%", "40%", "60%", and "I don't know"), other food-related questions were to classify specific foods as high or low in salt/sodium, these food items included Arabic bread, Iranian bread, Cheddar cheese, rice, processed meat, chicken cubes, pickles, salad dressings, instant noodles, fresh vegetables and canned vegetables (10, 22). Each correct response earned 1 and the incorrect response earned 0 (10). The total score for food-related knowledge of 19 items was converted into a score out of 10 by dividing the obtained score over 19 and multiplying it by 10. While health-related knowledge questionnaire included questions about the relationship between high salt intake and specific health conditions such as hypertension, cardiovascular disease, fluid retention, fever, renal diseases, and diabetes, and if participants think that reducing salt intake improves their blood pressure and overall health (response options "yes", "no", "I don't know"). Similarly, health-related knowledge was converted from a total score of 9 into a score of 10 by dividing the obtained score over 9 and multiplying it by 10, as presented in Table 3.

The attitude and practice component includes 16 questions. Attitude components include 5 questions related to how much salt you consume, whether are you concerned about the amount of salt consumed, and whether reducing salt intake is important to you, as shown in Table 4. The

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practice component of the questionnaire includes 11 questions, and it contains questions about the use of food labels in purchase and the frequency of adding salt during food preparation, cooking, or at the table. Attitudes and practice were assessed by a three-point Likert scale, with answers of "Agree or Often or Yes", or sometimes with "Disagree not often or No". Agree or yes was associated with a positive attitude or practice, sometimes with a neutral attitude or practice, and no or not often with a negative attitude and practice (10). The development and performance of the specific questionnaire have been described elsewhere (10).

1.5 24-hour urine collection and analysis

A single 24-hour urine collection was obtained for the estimation of sodium excretion. Participants were given written and verbal instructions for the 24-hour urine collection procedure. A 3L coded plastic bottle was given to each participant for urine collection. Participants were asked to discard the first urine of the day and to collect all the urine in the plastic bottle provided over the following 24 hours. Participants were also asked to write on a separate sheet the time and date at the start and end of the urine collection, indicating occasions they missed collecting urination. The 3 Liter coded plastic bottle was collected by the research team after a 24-hour completing the test. Urine analysis for sodium, potassium, and creatinine levels was conducted in the College of Agriculture & Veterinary Medicine (CAVM) laboratories at United Arab Emirates University (UAEU). For the measurement of sodium and potassium levels in the urine, 50 mL of the urine sample was mixed with 200 µL of 1% nitric acid. Analytical solutions were introduced to a Varian ICP-OES model 710-ES spectrometer for sodium and potassium measurements (23). Salt was calculated from urinary sodium excretion (24-hour) multiplied by a conversion factor 2.5 of (14). While Potassium intake was calculated from urinary potassium excretion (24-hour) * conversion factor of 1.3 (24). 24-hour urinary creatinine was measured using ab204537 Creatinine Assay Kit based on colorimetric assay (25) with UV-visible spectrophotometer (Multiscan Go, Thermo-Fisher Scientific, MA, USA). The assay relies on the Jaffe` reaction (26).

1.6 Statistical analysis

Data were recorded and analyzed using the Statistical Package for Social Sciences (SPSS) software, version 25 (SPSS, Chicago, IL, USA). The normality of data across a combination of

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independent variables was tested using the Shapiro-Wilks test. Continuous variables were presented as mean ± standard deviation and categorical variables were expressed as numbers and percentages. Descriptive statistics were used to summarize the baseline characteristics of the study participants. A two-way ANOVA test was performed to assess the main effects of gender and age groups on 24-hour urinary sodium, potassium, and creatinine excretions.

For interaction analysis, one-way ANOVA, followed by Bonferroni post hoc test, and independent t-test were used to compare dependent variables according to gender and age groups. One-sample t-test was used to compare the mean urinary sodium, salt, and potassium excretions with the recommended dietary allowance (RDA), and an assessment was carried out based on gender. The effect size was calculated as Cohen d for the t-test and partial eta-squared ($\eta p2$) for ANOVA.

A Chi-square test was used for the categorical variables. Univariate analysis was carried out to select covariates for the final model only variables with p value less than 0.2 were included in the final two-stage hierarchical multiple regression. A two-stage hierarchical multiple regression was performed to assess the association of urinary sodium and potassium excretions (dependent variables) with KAP after controlling for the influence of age, gender, marital status, and energy intake. Statistical significance was set as a p-value<0.05.

2. Results

2.1 Sample characteristics

A total of 210 participants provided urine specimens out of which three participants were excluded due to limited urine sample collection (< 500 ml urine), and a further 17 participants were excluded due to creatinine levels below 500 mg /day in the urine. A final sample size of 190 participants (alpha = 0.05, power = 0.83) was included in the analysis as shown in Figure 1. Table 1 shows the socio-demographic and physical characteristics of the study participants. The mean age of the participants was 38.6±12.5 years, with 50.5% females. The mean BMI for participants was 25.4±4.8 kg/m^2. About 50% of the study population had normal blood pressure. The prevalence of overweight and obese individuals was 32.8% and 14.3%, respectively. Only 2.1% of the participants had a high level of physical activity.

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2.2 Mean 24-hour urinary sodium, potassium, and creatinine

Table 2 the urinary (24-hour) sodium, potassium, and creatinine excretions among the study participants. The mean sodium excretion in urine was 2816.2 ± 675.7 mg/day, which is equivalent to 7040 ± 1689.3 mg/day of salt. The mean value for sodium excretion in urine exceeded the WHO recommendations and the RDA for sodium intake of less than 2300 mg. Of the 190 participants, 131 (65.3%) had a sodium excretion above the WHO-recommended level of 2300 mg. A significant difference was observed in mean urinary sodium excretion for male participants compared with female participants (p=0.001). The mean potassium intake was lower than the WHO recommendations of 3510 mg/day. There was a significant difference in the potassium intake between male and female participants (p=0.007). The mean 24-hour urinary creatinine excretion for females and males was within the normal range of 24-hour creatinine excretion as mg/day and as mg/kg/day (14).

Figure 2 illustrates the urinary sodium and potassium excretions according to gender and age groups. The maximum urinary sodium excretion was detected among male participants in the age group of 20-29.9 years. Moreover, the maximum urinary sodium excretion was detected in female participants in the age group of 30-39.9 years. All age groups showed a significant difference in the intake of sodium and potassium compared to the RDA.

2.3 Salt-related knowledge, attitudes, and practices

Table 3 presents the mean food-related and health-related knowledge scores. Female participants had significantly higher scores for food-related knowledge compared with male participants (p=0.008). However, both were classified as poor food-related knowledge (below 6 out of 10) (22). Health-related knowledge for each gender was classified as fair (between 6 to 7 out of 10) (22), this suggests that health-related knowledge was significantly higher compared with food-related knowledge (P<0.05).

As shown in Figure 3, almost 65% of the study population exceeded the WHO recommendation for sodium intake (69.1% of male participants and 61.5% of female participants).

Table 4 illustrates that only 20% of the participants reported “too much salt intake” and only 21% had concerns about the amount of salt/sodium in their diet. Moreover, only 15.8% of the study population tended to check food labels often, with a higher percentage of female

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participants than males ($p = 0.008$). Out of these, only 8% reported checking the sodium contents of the food often. Most of the study population (60%) reported that they often add salt during cooking. Almost 19% of male participants reported adding salt before tasting the food, which was significantly higher than females ($p=0.001$). Almost 45% of the study population reported having tried to reduce salt intake before.

Table 5 shows that most of the study sample failed to identify Arabic/ Iranian bread and cornflakes as sources of high salt/sodium. On the other hand, most of the study sample (60-75%), were able to identify instant noodles, chicken stock cubes, cheddar cheese, salad dressing, tomato paste, canned-vegetable foods, and pickles as sources of high salt/sodium. Moreover, female participants had significantly higher scores in identifying foods with high salt contents, such as cheddar cheese, ketchup, tomato paste, and corn flakes, and low sodium contents, such as basmati rice, milk, and yogurt compared to males ($p<0.05$).

2.4 Dietary intake and physical activity

Table 6 presents macronutrient intake among the study sample (n=190), with a mean ± standard error for energy, carbohydrates, protein, and fat intakes of 1850.8±33.8 kcal, 232.0±6.4 g, 74.5±1.1 g, and 69.3±1.8 g, respectively. The percentage of energy from carbohydrates, protein, and fat was within the Acceptable Macronutrient Distribution Range (AMDR) for the study population within 45-65% for carbohydrates, 10-35% for protein, and 25-35% for fat.

2.5 Predictors of urinary sodium and potassium excretions

Table 7 illustrates the association between KAP total scores with urinary sodium and potassium excretion. A two-stage stepwise multiple regression analysis revealed a negative relationship between KAP and urinary sodium excretion. In the first model (step 1, Table 7-A), four variables including age, gender, marital status, and caloric intake were entered. Age and gender were good (significant) predictors of urinary sodium excretion ($p<0.05$); however, marital status ($p = 0.175$) and caloric intake ($p = 0.672$) were not significantly associated with urinary sodium excretion. The four variables in step 1 explained 22.4% ($F(4, 185) = 13.356$, $p < 0.001$; $R^2=0.224$, $p<0.001$). of the variance in urinary sodium excretion. In step 2, the KAP-total variable was entered while controlling for age, gender, marital status, and caloric intake. Adding the KAP-total variable significantly explained an additional 2.4% of the urinary sodium excretion variance

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(R^2 change= 0.024, p=0.017). Overall, the five variables explained 24.8% (F (5, 184) = 12.113, p < 0.001) of the variance in the urinary sodium excretion. In step 2, when all of the five variables were in the final model, two variables failed to predict urinary sodium excretion, marital status (p = 0.104) and caloric intake (p= 0.844), while age (B= -25.040, p < 0.001, r = -0.435), gender (males) (B=349.094, p < 0.001, r = 0.281) and KAP (B= -6.840, p < 0.017, r = -0.174) were predictors for urinary sodium excretions. These results showed a negative correlation between KAP and urinary sodium excretion. Furthermore, age was inversely associated with urinary sodium excretion. Males were more likely to show higher urinary sodium excretions than females.

A two-stage stepwise multiple regression analysis was conducted (Table 7-B) to assess the association of urinary potassium excretion with KAP after controlling it for the influence of age, gender, marital status, and caloric intake. Age and gender were significant predictors of urinary potassium excretion (p<0.05). The four variables in Step 1 explained 13.3% (F (4, 185) = 7.109, p < 0.001) of the variance in urinary potassium excretion. In step 2, the added KAP-total variable did not significantly provide an additional explanation of the variance in the urinary potassium excretion (p = 0. 147). In the final model, both caloric intake (p= 0.392) and KAP total (p= 0.147), failed to predict urinary potassium excretion, while age (B= -12.663, p < 0.001, r = -0.311), gender (males) (B=210.683, p < .001, r = 0.230) and marital status (B= 109.724, p < 0.041, r = 0.150) were predictors for urinary potassium excretions.

3. Discussion

To our knowledge, this is one of the few studies in the UAE to report the 24-hour urinary sodium excretion levels using the WHO/PAHO protocol (12) and the KAP questionnaire. However, this is the first study that measured the relationship between urinary sodium execration and food-related knowledge and urinary excretion ratio of sodium to potassium among a group of healthy residents of the UAE.

A 24-hour urinary sodium excretion is considered the gold standard method to estimate sodium intake (27) since this period is necessary to capture the marked diurnal variation in sodium, chloride, and water excretion. In healthy individuals, electrolyte excretion normally reaches the maximum at or before midday and the minimum at night towards the end of sleep (28). In the

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current study, several methods were used to confirm the adequacy of 24-hour urine collection, including the inclusion criteria recommended by WHO/PAHO protocol, such as urine log sheet and urine volume, as well as the creatinine levels as recommended by the WHO and other studies (10, 12, 28, 29, 30, 31, 32). In addition, the cut-off point for creatinine level was expressed in mg/kg body weight and with a total of 24-hour creatinine level as mg/day according to gender (10, 15, 31, 32).

The results of the current study showed a 3.6 % increase in salt consumption in a sample of the UAE population compared with a past study conducted in 2015 (10), which showed that the level of salt intake was 6783.5 mg in 2015 compared with 7040.5 mg in the current study. Similar findings on high salt intake were reported in Morocco with an intake of 7.1 g/day (31). These findings highlight the fact that there has been no change or reduction in the salt intake in the UAE population since 2015. A study conducted in Eastern Saudi Arabia presented the mean intake of sodium assessed by a 24-hour sodium excretion to be 3.2 ± 1.1 g/day (8.0 g salt/day) (32). In a Jordanian study using 24-hour urinary sodium excretion, the intake of salt was doubled (10.4 g/day) to the current WHO recommendation with an average sodium intake of 4.1 g/day. Likewise, a study conducted in Oman using the National Nutrition Survey based on a 24-hour dietary recall, noted the average intake of salt to be 11-12 g/day (34), which is also significantly higher than the WHO recommendation. Two further studies analyzing food consumption in Kuwait (35, 36) reported the average salt intake was within 8-10 g/day. Both studies in Oman and Kuwait recommended the 24-hour urinary sodium excretion method to have accurate results of sodium and salt intakes in the population.

Globally, the mean intake of sodium is high in East Asia, Central Asia, Eastern Europe, Central Europe, and Middle East/North Africa ranging between 3.9-4.2 g/day, which is equivalent to 9.75-10.5 g/day of salt (37). These results exceed the WHO recommendations, which align with our findings. Moreover, the mean urinary sodium excretion in Japan and the United Kingdom was 4.47 ± 1.6 g/day and 3.9 ± 1.3 g/day respectively, which was attributed to high intake of canned and processed foods (38). Moreover, in the current study, the salt intake for males was significantly higher ($p=0.003$) than for females. This finding is not limited to the current study as similar findings were reported in other studies conducted in KSA, and Malaysia (28, 33).

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Furthermore, several studies conducted in Europe showed the mean sodium intake for males was higher than for females (39), which was confirmed by another study conducted in the adult population in the USA (40). This finding was discussed and explained by two other studies (41, 42); which reported that females preferred unsalted foods in the menstrual phase more than in the luteal phase of the cycle. Moreover, statistical analysis revealed significant differences in the preference rating between the menstrual phase and the other two phases (luteal and follicular phases). There was no significant difference in preference between the luteal and follicular phases.

High dietary sodium and low dietary potassium intakes are linked to elevated blood pressure and an increased risk of CVD, which may contribute to the development of NCDs (43). In the current study, 24-hour urinary potassium excretion was significantly below the WHO recommended amount of 3.510 g/day (2). This finding aligns with the 2005 UAE Global School-Based Student Health Survey (GSHS), which reported a high incidence of insufficient fruit and vegetable consumption, a trend that worsened by 2016 (40). Another study involving 620 participants from the UAE found that only 28% met the recommended daily intake of fruits and vegetables, contributing to low potassium intake (45).

The UAE has undergone a rapid transition from a traditional semi-urban lifestyle to a modern urbanized society since the 1960s, following major oil discoveries (44). This shift has led to dietary changes, including frequent snacking, replacing traditional foods with energy-dense fast foods, and substituting water with soft drinks, resulting in low fruit and vegetable consumption (16, 44).

The 24-hour urinary potassium excretion is correlated with dietary potassium intake (8, 28). Moreover, the sodium to potassium ratio in the current study was 1.15 ± 0.30; thus, suggesting that not only did sodium intake for this study exceed the WHO recommendations but also potassium intake was low. A high urinary sodium-to-potassium ratio can be an indicator of the need for reducing sodium intake and increasing potassium intake (10). Therefore, WHO has suggested a sodium-to-potassium ratio of approximately 1.00, which is associated with a low risk for the development of CVDs (3).

Furthermore, the macronutrient distribution for carbohydrates, protein, and fat was within the Acceptable Macronutrient Distribution Range (AMDR) (27). The mean energy, carbohydrate,

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protein, and fat intakes observed in this study were like those reported in other studies of the UAE population (18, 46). However, fiber intake was about 50% of the Adequate Intake recommendation, posing a potential risk for non-communicable diseases (NCDs) in this population (46).

In the current study, 65.3% of the participants exceeded the WHO recommendations for salt intake, while only 20% admitted to doing so. This suggests that around 45% were unaware of their high salt consumption. The study also found that over 60% of participants had limited knowledge about the main dietary sources of salt. These findings align with a Canadian study where less than 50% of the participants knew the salt content in various foods like processed cheese and canned vegetables (47), though 70% could identify health issues related to salt consumption. A significant negative correlation between knowledge, attitudes, and practices (and urinary sodium excretion was observed, similar to studies in Northern India (48) and Malaysia (49). This was particularly evident in food-related knowledge, with participants failing to identify low-salt foods. Additionally, participants' inability to recognize bread and cornflakes as high-sodium foods was comparable to findings from a study among university students in Sharjah, UAE (18).

Cereal products, in particular bread (a popular staple food in the Arab countries), were found to be the major contributor of salt in the Gulf diet (5). Moreover, in Kuwait, a neighboring Gulf country, it was indicated that bread was the second main source of salt after Kuwaiti composite dishes prepared at home (5). Similarly, in Qatar, the government found that the main source of salt in the Qatari diet was bread and other baked products (5). Low knowledge of sodium/salt contents of foods, particularly bread (Arabic/Iranian), may be considered one of the main reasons behind high salt intake in the UAE. In addition, adding salt to the food during cooking and before tasting it, is also considered one of the factors that contribute to the high salt intake in the UAE population. This indicates that education and public awareness programs are required to be established so that the general population is aware of salt portion sizes and the salt content of staple, processed, and other foods in general.

A recent systematic review and meta-analysis determining consumer acceptance of reformulated food products showed that salt could be reduced by about 40% in bread and approximately 70% in processed meats without significantly affecting consumer acceptability (50), which can be

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used as an initiative for the UAE to reduce salt intake effectively. A combined approach for salt reduction programs was used by the United Kingdom (UK) and South Korea, these approaches focused on improving consumer awareness through campaigns, increased availability of low-sodium foods at school, and voluntary reformulation of processed foods. These component initiatives for salt reduction programs achieved major reductions in the population's sodium intake (15% in UK adults and 24% in South Korean adults) (9).

Moreover, the results of the current study indicated that there is very high sodium with low potassium intakes within the general population of the UAE, which consequently may increase the risk of hypertension, CVD, and other NCDs. This accelerates the need to initiate salt reduction programs to reduce the risks of NCD.

Despite our significant findings, a limitation of this study was that urinary sodium was assessed by a single 24-hour urine collection and this may not represent the average sodium intake in a person due to the daily individual variability. However, a single urine measurement is considered a more accurate measure of sodium intake at a population level though possibly less accurate for individuals (28, 31). Another limitation was the food record was self-administered.

4. Conclusion

The mean 24-hour urinary sodium excretion in the current study exceeded the WHO's recommended sodium intake and was consistent with findings from reports published in 2015. Additionally, none of the participants met the WHO recommendation for potassium intake, indicating issues with both high sodium and low potassium intake.

Participants' food and health-related knowledge were classified as poor and fair, respectively. These findings highlight the need for educational and public awareness programs that focus on food-related knowledge, including salt portion sizes and the salt content of staple foods, processed foods, drinks, and other foods. There is also a need for regulations aimed at reformulating food products, particularly staples like bread. National campaigns should emphasize increasing fruit and vegetable intake. Nutrition awareness and educational programs should be incorporated into school curricula to improve nutritional status and practices among young people.

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Table 1. Socio-demographic and physical characteristics of study participants (n = 190).

Characteristics	N	(%)
Age (years)	190	100
20-29.9	48	25.3
30-39.9	49	25.8
40-49.9	47	24.7
≥ 50	46	24.2
Gender		
Female	96	50.5
Male	94	49.5
Nationality		
Emirati	78	41.1
Arabs	112	58.9
Geographic distribution by region		
Northern Region	60	31.6
Eastern Region	68	35.8
Western Region	62	32.6
Educational Level		
Undergraduate university level	166	87.4
School level (Intermediate or lower)	13	6.8
Postgraduate level	11	5.9
Employment status		
Student	81	42.6
Unemployed	30	16.0
Employed	79	41.4
Marital Status		
Single	67	35.3
Married	116	61. 1
Divorced	7	3.7
Body Mass Index (kg/m^2)		
Underweight (18.5)	14	7.4

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Normal weight (18.5-24.9)	87	45.8
Overweight (25-29.9)	62	32.6
Obese	27	14.2
Physical activity levels[b]		
Low level of physical activity [c]	89	46.8
Moderate level of physical activity [c]	97	5 1. 1
High level of physical activity [c]	4	2. 1
Blood Pressure (mm Hg)		
Normal (< 120/80)	100	52.6
Elevated (systolic 120–129 and diastolic <80)	46	24.2
High Blood Pressure Stage 1 (systolic 130–139 or diastolic 80–89)	44	23.2

[α] Data are presented as mean ± standard deviation for continuous variables or number (%) for categorical variables. [b] According to International Physical Activity Questionnaire (IPAQ) (23) [c] Forde C. (24).

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Table 2. Urinary (24-hour) sodium, potassium, and creatinine excretions (n=190).

Variables	Mean ± SD[α]			P-value[c]
	Total	Female (n=96)	Male (n=94)	
Urinary Sodium (mg)	2816.2 ±675.7[b]	2671.7± 545.3[b]	2963.7± 761.9[b]	0.003
Salt (mg)	7040 ±1 689.3	6679.3± 1363.3	7409.3±1904.9	0.003
Urinary Potassium (mg)	1948.7± 473.1	1857.5± 440.8	2041.8±488.9	0.007
Potassium Intake (mg)	2533.3± 615[d]	2414.7±573[d]	2654.4±635[d]	0.007
Sodium to potassium intake ratios	1. 15 ± 0.30	1. 15±0.29	1. 16±0.32	0.872
Creatinine 24- hour (mg)	1440.5± 325.0	1223.9± 225.8	1621.7± 254.6	0.001
Creatinine (mg/kg/24hr.)	18.1± 3.2	16.1±2.6	20.6±3.5	0.001

[α]Data presented as Mean ± standard deviation. [b] Significantly higher than, the WHO recommendations for sodium, (One- Sample t-test used to compare mean with RDA=2300 mg/day, Significance at ($p<0.05$). [c] Independent-Samples T-test used to assess significance according to gender ($p<0.05$).

[d]Significantly lower than, the WHO recommendations for potassium, (One- Sample t-test used to compare mean with RDA=3510 mg/day, Significance at $p<0.05$).

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Table 3. Food and Health related knowledge scores for the study population.

Variables	Mean ± SD[α]						P-value [d]
	Total (n=190)	C [e]	Female (n=96)	C [e]	Male (n=94)	C [e]	
Foods-related knowledge [b]	5.1 ±2.3	Poor	5.5 ±2.0	Poor	4.6 ±2.5	Poor	0.008
Health-related knowledge [b]	6.2± 2.9	Fair	6.4 ±2.9	Fair	6.1 ± 2.9	Fair	0.562
P-value [c]	0.001		0.009		0.001		

[α] Mean ± standard deviation. [b] Knowledge scores are reported out of 10. [c] Paired sample t-test used to compare means for health and food-related knowledge, ($p< 0.05$). [d] Independent-samples T-test used to assess significance at $p<0.05$ for variables according to gender. [e] Classification according to the score for Knowledge < 6 classified as "Poor", 6–7 classified as "Fair", >7 classified as "Good" (25)

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Table 4. Salt-related attitudes and practice among the study population by gender (n=190).

Variable[a]	Total n (%) [b]	Female n (%)	Male n (%)	Chi-Square (p-value) [c]
Attitudes among the study population				
How much salt do you think you consume (Just the right amount)	134 (70.5)	69 (71.9)	65 (69.1)	0.742 (p=0.690)
Are you concerned about the amount of salt/sodium in the diet (Yes)	21 (11.1)	9 (9.4)	12 (12.8)	1.534 (p=0.464)
Reducing added salt to foods is important to you (Agree)	49 (25.8)	26 (27.1)	23 (24.5)	4.114 (p=0.128)
Reducing consumption of processed foods is important to you (Agree)	80 (42.1)	35 (36.5)	45 (47.9)	3.483 (P=0.175)
Reducing your sodium intake is important to you (Agree)	39 (20.5)	14 (14.6)	25 (26.6)	6.115 (p=0.047)
Practice among the study population				
Check food labels (Often)	30 (15.8)	23 (24.0)	7 (7.5)	9.742 (0.008)
Information on food labels affects purchasing decisions (Often)	17 (9.0)	10 (10.4)	94 (7.4)	0.660 (0.719)
Check labels specifically for salt/sodium content (Often)	15 (8.0)	7 (7.3)	8 (8.5)	1.723 (0.423)
Salt/sodium content on label affects purchasing decisions (Often)	13 (6.8)	7 (7.3)	6 (6.4)	2.552 (0.279)
Try to buy “low salt” foods (Often)	25 (13.2)	11 (11.5)	14 (14.9)	0.495 (0.781)
Add salt to food during cooking (Often)	120 (63.2)	62 (64.6)	58 (61.7)	0.661 (0.719)
Use Stock Cubes during cooking (Often)	33 (17.4)	19 (19.8)	14 (14.9)	0.795 (0.672)
Add salt to food at the table (Often)	24 (12.6)	11 (11.5)	13 (13.8)	1440.0 (0.487)

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Add salt before tasting the food (Often)	23 (12.1)	5 (5.2)	18 (19.2)	13.681 (0.001)
Did you try to reduce salt intake before (Yes)	89 (46.8)	46 (47.9)	43 (45.7)	0.657 (0.720)
Did you try to use spices (lemons and herbs) to reduce salt (Yes)	65 (34.2)	37 (38.5)	28 (29.8)	4.266 (0.118)

[a] Practice was assessed based on a three-point Likert scale but only answers of “Agree or Often or Yes” are presented. [b] Data presented as number and frequencies of agree or yes answers. [c] Chi-square test used to compare variable association with gender, ($p<0.05$).

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Table 5. The number and percentage of participants who answered correctly on food-related knowledge.

Sodium contents of selected foods[α]	Total n (%)	Female n (%)	Male n (%)	P-value[c]
Arabic bread (High)	66 (34.7) [b]	35 (36.5)	31 (33.0)	0.219
Iranian bread (High)	68 (35.8)	38 (39.6)	30 (31.9)	0.302
Rice- Egyptian (Low)	100 (52.6)	54 (56.3)	46 (49.0)	0.107
Rice-Basmati (Low)	106 (55.8)	60 (62.5)	46 (49.0)	0.018
Milk/yoghurt (Low)	100 (52.6)	56 (58.3)	44 (46.8)	0.07
Fresh red meat (Low)	66 (34.7)	29 (30.2)	37 (39.4)	0.721
Fresh poultry (Low)	95 (50.0)	43 (44.8)	52 (55.3)	0.533
Fruits (Low)	132 (69.5)	70 (72.9)	62 (66.0)	0.182
Fresh vegetables (Low)	135 (71.1)	69 (71.9)	66 (70.2)	0.622
Canned vegetables (High)	119 (62.6)	67 (69.8)	52 (55.3)	0.058
Cheddar cheese (High)	137 (72.1)	77 (80.2)	60 (63.8)	0.016
Pickles (High)	141 (74.2)	74 (77.1)	67 (71.3)	0.484
Olive oil (Low)	101 (53.2)	48 (50.0)	53 (56.4)	0.271
Salad dressing oil (High)	126 (66.3)	69 (71.9)	57 (60.6)	0.198
Ketchup (High)	113 (59.5)	64 (67.3)	49 (0.52)	0.032
Tomato paste (High)	123 (64.7)	69 (71.9)	54 (57.4)	0.009
Corn flakes (High)	50 (26.3)	32 (33.3)	18 (19.1)	0.015
Chicken cubes (High)	115 (60.5)	63 (65.6)	52 (55.3)	0.083
Instant noodle (High)	110 (58)	60 (62.5)	50 (53.2)	0.087

[α] The correct answers are provided in brackets next to each variable, [b] Data presented as number and frequencies of the correct answer. [c] Independent-samples T-test used to assess significance at $p<0.05$ for variables according to gender.

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Table 6. Daily energy and macronutrient distribution for the study population.

Variables	Mean ± SE[1]			
	Total	**Females (n=96)**	**Male (n=94)**	**P-value [3]**
Energy (Kcal)	1850.8±33.8	1816.0±38.5	1918.2±55	0.833
Carbohydrate [2]	232.0±6.4 (50.2%)	228.2±8.5 (50.3%)	238.2±9.6 (49.6%)	0.851
Protein (g) (%)	74.5±1.1 (16.1%)	70.9±1.1 (15.6%)	79.7±1.9 (16.6%)	0.667
Fat (g) (%)	69.3±1.8 (33.7%)	67.0±2.6 (33.2%)	71.9±2.5 (33.8%)	0.633
Cholesterol (mg)	181.8±9.2	200.2±8.0	215±16.0	0.126
Fiber (g)	15.1±0.9	13.9±1.1	16.4±1.4	0.181

[1] Data presented as Mean ± Standard error. [2] Data displayed in grams and % from total Calorie.

[3] Independent-Samples T-test used to assess significance at $p<0.05$ for variables according to gender.

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Table 7. Stepwise multiple regression to assess predictors of Urinary sodium and potassium excretions

MODEL	Variables [2] (Unit)	B (CI 95%) [3]	S.E. [4]	R	P-value
A- Urinary sodium excretion [1]					
1	Age (>30 years)	-24.245 (-31.848, -16.642)	3.854	-0.420	<0.001
	Gender (Males)	317.957 (143.946, 491.968)	88.202	0.256	<0.001
	Marital status (Married)	97.838(-43.848, 239.523)	71.817	0.100	0.175
	Caloric intake (Kcal)	0.035 (-0.129, 0.199)	0.083	0.031	0.672
2	Age (>30 years)	-25.040 (-32.576, 17.504)	3.820	-0.435	<0.001
	Gender (Males)	349.094 (175.381, 522.807	88.048	0.281	<0.001
	Marital status (Married)	116.679 (-24.075, 257.433)	71.342	0.120	0.104
	Caloric intake (Kcal)	0.016 (-0.146, 0.179)	0.082	0.015	0.844
	KAP-Total [5]	-6.840 (-12.461, -1.220)	2.849	-0.174	0.017
B- Urinary potassium excretion [6]					
1	Age (>30 years)	-12.303 (-17.930, -6.677)	2.852	-0.302	<0.001
	Gender (Males)	196.585 (67.820, 325.349)	65.268	0.216	0.003
	Marital status (Married)	101.193 (-3.651, 206.037)	53.143	0.139	0.058
	Caloric intake (Kcal)	0.061 (-0.060, 0.183)	0.061	0.073	0.319
2	Age (>30 years)	-12.663 (-18.294, -7.033)	2.854	-0.311	<0.001
	Gender (Males)	210.683 (80.885, 340.480)	65.789	0.230	0.002
	Marital status (Married)	109.724 (4.553, 214.894)	53.307	0.150	0.041
	Caloric intakes (Year)	0.053 (-0.069, 0.174)	0.062	0.063	0.392
	KAP-Total [5]	3.097 (-1.103, 7.297)	2.129	0.107	0.147

[1]Urinary sodium excretion as a total for both genders (mg/ 24- hour). [2] Reference group for age (20-29.9 years); reference group for gender (female); reference group for marital status (single), [3]Confidence interval, [4]Standard error, [5]Total score of food-related knowledge, health-related knowledge, a score of attitudes and a score of practice, [6] Urinary potassium excretion as a total for both genders (mg/24-hour)

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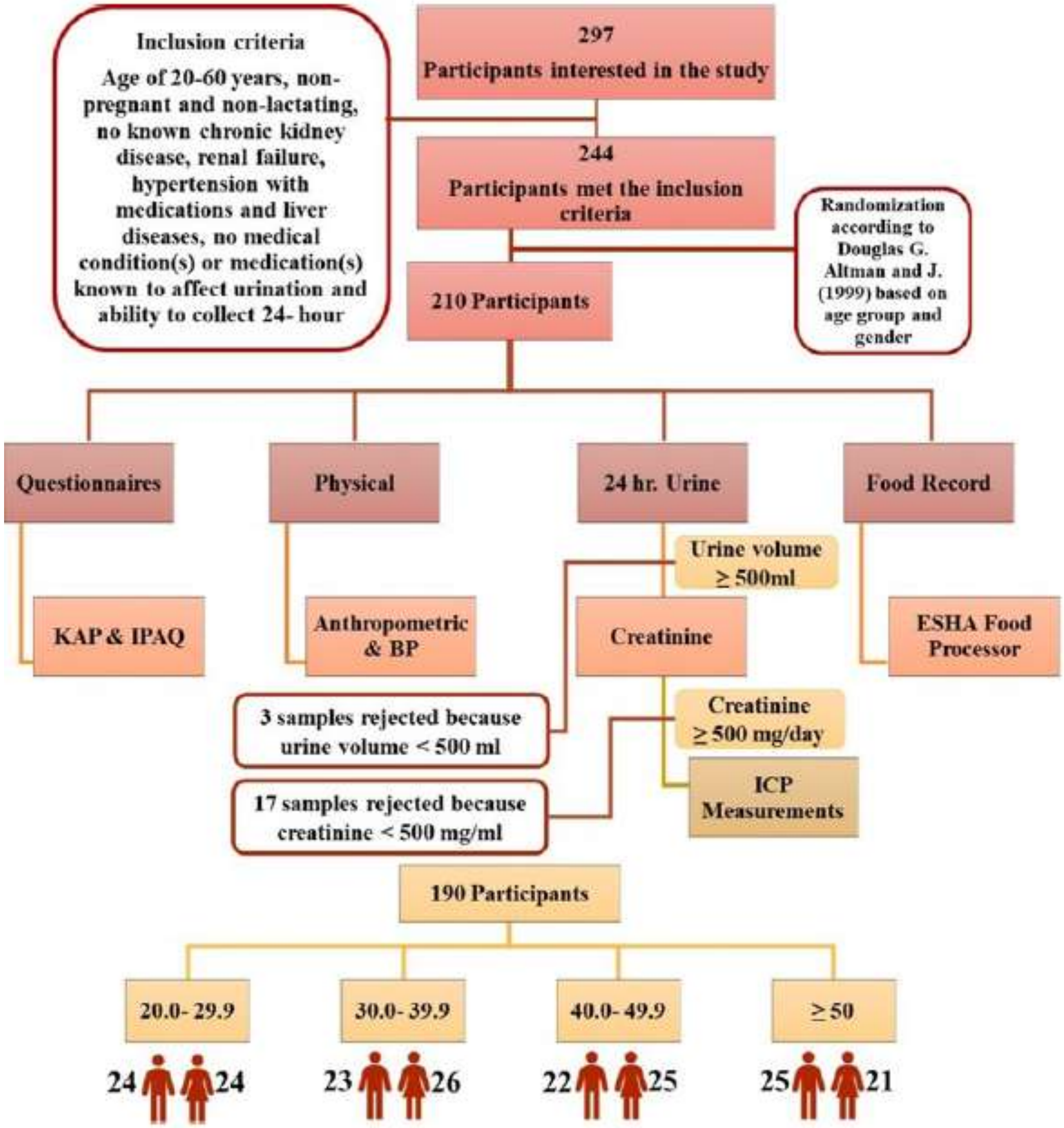

Figure 1. Flow chart of the study. KAP: Knowledge, attitude and practice; IPAQ: International physical activity questionnaire; ICP: Inductively coupled plasma

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Figure 2. Urinary sodium and potassium excretions according to gender and age groups

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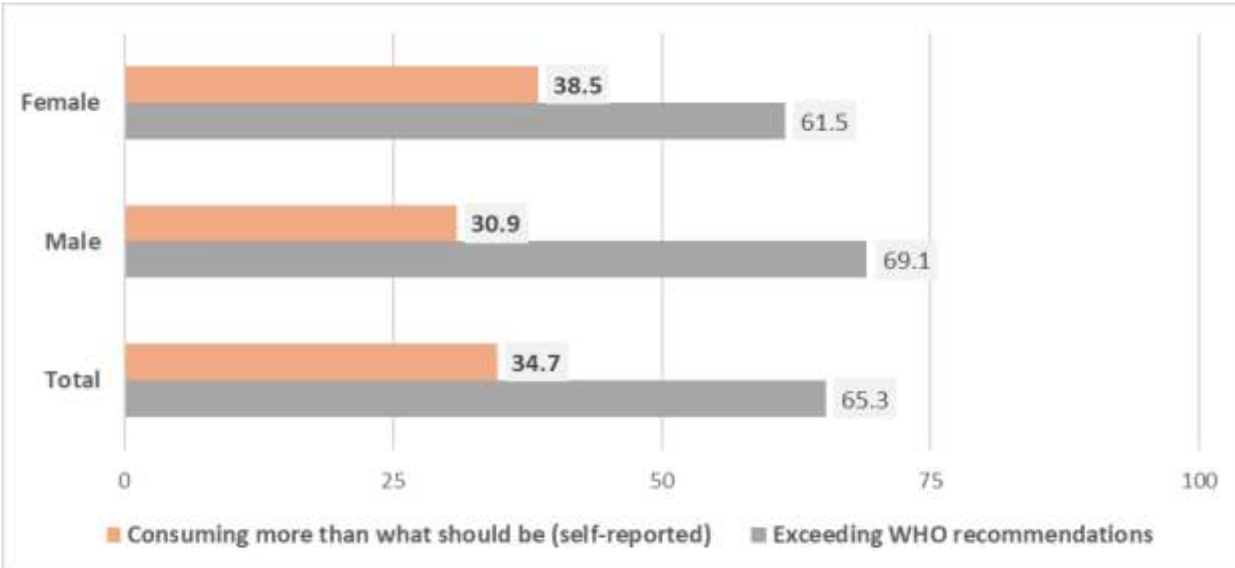

Figure 3. Percentage of the study population with actual urinary sodium excretion exceeding WHO recommendations compared with the percentage of participants reporting excess sodium intake.

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