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ARTICLE

Interventions and public health nutrition

Validation of an easy questionnaire on the assessment of salt habit: the MINISAL-SIIA Study Program

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Abstract

Background/objectives The aim of the present study was to validate a short questionnaire on habitual dietary salt intake, to quickly and easily identify individuals whose salt consumption exceeds recommended levels.

Subjects/methods A total of 1131 hypertensive subjects participating in the MINISAL-SIIA study were included in the analysis. Anthropometric indexes, blood pressure, and 24-h urinary sodium excretion (NaU) were measured. A fixed-sequence questionnaire on dietary salt intake was administered.

Results NaU was significantly associated with scores, with a linear association across categories (p for trend <0.0001). In addition, participants who achieved a total score above the median value (eight points) had significantly higher NaU than those whose score was below median ($p < 0.0001$). In the total sample, the prevalence of "high NaU" (NaU > 85 mmol/day) and "very high NaU" (NaU > 170 mmol/day) was 86 and 35%, respectively. The score of the questionnaire had a significant ability to detect both "high NaU"—with a specificity of 95% at the score of 10 points—and "very high NaU"—with a specificity of 99.6% at score of 13 points.

Conclusions The main results of the study indicates that a higher score of this short questionnaire is distinctive of habitual high salt consumption in hypertensive patients.

Introduction

Several epidemiological and experimental studies have shown an adverse role of excess dietary sodium intake on hypertension and cardiovascular disease [1–4]. The favorable effect of low sodium diet on blood pressure (BP) and cardiovascular disease is supported by several intervention studies [5–9]. Notably, a favorable effect of salt reduction on BP was detected in adult and elderly populations, and in both normotensive and hypertensive participants, but more pronounced in hypertensive people [7]. Overall, these data highlight the causal role of excess sodium intake in

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triggering the development of high BP and increasing the prevalence of non-communicable diseases.

To reduce cardiovascular diseases, the WHO recommends that adults consume less than 5 g of salt per day [10]. However, mean daily intakes of salt in most of the countries in the world exceed this recommendation, with estimates of mean salt intake for Italian general and hypertensive population largely higher than the recommended intakes [11, 12].

Therefore, valid and concrete tools are essential to identify and to correct dietary sodium excess.

Although 24-h urinary sodium excretion is considered the most reliable method to evaluate salt intake in population [13], it may be limited by the fact that a single 24-h urine specimen may not be sufficient to accurately assess an individual's usual salt consumption. According to some investigations, urinary sodium excretion may vary considerably despite a constant sodium intake [14, 15]; indeed, in one study, three 24-h collections improved accuracy up to 75% compared to a sodium ingestion and seven collections were needed to achieve a 92% accuracy [16]. Moreover, the high participation burden, lack of completeness, and high costs could be further limitations [17–19]. However, alternative methods (e.g., spot and timed urine samples) did not overcome these drawbacks [20–22]. Hence, dietary questionnaires could represent a valid and easy tool to assess—alone or with 24-h urine collection—individual salt intake.

Previous studies have analyzed dietary salt intake by dietary questionnaire, but poor agreement with 24-h urinary sodium excretion was detected [23–29]. Nevertheless, only few of them were specifically performed to develop a valid questionnaire to assess salt intake [23, 24]. In one study, including a small sample of hypertensive individuals, there was no association between salt intake scores (44 items) and single 24-h urine collection [24]. However, a weak correlation between dietary questionnaire of 42 items and three 24-h urine collections was found in other small sample of hypertensive and normotensive participants [23].

Therefore, the purpose of the present study was to validate an easy and short questionnaire to detect, in very short time, an individual's habitual high salt consumption.

Materials and methods

Study population

A total of 1284 hypertensive patients were recruited in 47 Hypertension Clinics recognized by the Italian Society of Hypertension, and distributed in 20 Italian regions (Piemonte, Liguria, Valle d'Aosta, Lombardia, Friuli Venezia Giulia, Trentino Alto Adige, Veneto, Toscana, Emilia Romagna, Umbria, Marche, Lazio, Abruzzo, Molise, Campania, Basilicata, Puglia, Sicilia, Calabria, and Sardegna) [11]. Patients were required to have been on stable antihypertensive treatment (lifestyle modifications and/or drug therapy) for at least 6 months, and to have undergone the standard screening for the diagnosis of essential hypertension and the evaluation of target organ damage [30]. All participants gave their written informed consent to participate in the study. A fixed-sequence questionnaire about every participant's medical history and dietary salt intake was administered; anthropometric indices and BP were measured; and a 24-h timed urine collection was obtained from each participant. The MINISAL study protocol was approved by the scientific committee of the Ministry of Health Center for Disease Control and by the local Ethics Committees.

Study procedures

Systolic (SBP) and diastolic BP (DBP) were measured with automatic validated devices according to ESH/ESC guidelines, after having the participant sit for at least 10 min [30]. Two measurements of BP and heart rate were made at 2-min intervals with the patient in the sitting position, and one measurement after 2 min in the standing position.

Body weight and height were measured on a standard beam balance scale with an attached ruler. Body weight was measured to the nearest 0.1 kg, and body height was measured to the nearest 1.0 cm, with subjects wearing light indoor clothing without shoes. BMI was calculated as weight (kg) divided by height squared (m^2). Waist circumference was measured at the umbilicus level with the participants standing erect, the abdomen relaxed, arms at each side, and feet together. Measurements were performed with a flexible, non-extendable plastic tape to the nearest 0.1 cm. Details on urine collection have been reported previously [11]. Briefly, the participants performed a random 24-h urine collection during the week for the assessment of sodium and creatinine values. Samples with a volume below 500 mL or with a creatinine content per kg body weight below 2 standard deviation (SD) from the population mean were excluded from the analysis.

Dietary salt intake questionnaire

A short 5-item questionnaire on behavior of salt consumption was administered to the participants. Each of the five questions had three answers with increasing scores on a scale from 1 to 3; the sum of the scores obtained for each question gave the total score. The questionnaire and its answers are shown in Supplementary File 1. Two authors (FG and PS, experts of nutrition and cardiovascular disease) developed the individual questions based on scientific and

Table 1 Relevant characteristics of the MINISAL-SIIA study population ($n = 1131$)

Variables	Mean [SD]
Age (years)	59.4 [12.6]
BMI (kg/m^2)	27.7 [4.4]
SBP (mm Hg)	134.2 [16.1]
DBP (mm Hg)	80.7 [10.1]
Heart rate (bpm)	71.1 [10.6]
Urine volume collection (ml/24 h)	1853.3 [453.4]
NaU (mmol/24 h)	151.4 [63.5]
CreaU (mg/24 h)	1156.3 [453.4]

SD standard deviation, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *NaU* urinary sodium excretion, *CreaU* urinary creatinine excretion

epidemiological evidence on this topic, and question on discretionary salt, foods and questions on salt taste were combined. For the question on discretionary salt, Italian and international epidemiological evidence was considered [31, 32]. The question on bread (major component of daily diet in Italian population, thus of salt intake) and cheese/cold cuts consumption (main sources of habitual salt intake in Italian population) was based on an Italian survey [33]. Finally, the questions on salt taste were based on several experimental data [34, 35].

Statistical analysis

The relationship between 24-h urinary sodium (NaU) and the individual question, score categories (I: ≤7, II: 8, III: 9, IV: ≥10 points), or total score median (below median-BM ≤8; above median-AM >8 points) was assessed by analysis of variance, with Bonferroni correction when required. The Chi-square test was used for differences between categorical variables. To detect individuals with "high NaU" (H-NaU), we considered the value of 24-h urinary sodium excretion above 85 mmol [10], and with "very high NaU" (VH-NaU) the NaU value above 170 mmol/24 h. Sensitivity and specificity, and receiver–operating characteristic analysis were undertaken and the area under the curve (AUC)—with its 95% confidence intervals (CIs)—was calculated to evaluate the ability of the score to identify participants with H-NaU or VH-NaU [36]. The results were expressed as mean and SD, range or 95% CIs unless otherwise indicated. Two-sided P-values < 0.05 were considered statistically significant. The study is expected to have a power of 90% (alpha error: 5%) to identify a statistically significant difference of NaU equal to or greater than 15 mmol/day (SD = 70 mmol/day) between group above the median score compared with the group below the median. All statistical analyses were performed using the SPSS software, version 20 (SPSS Inc., Chicago, IL).

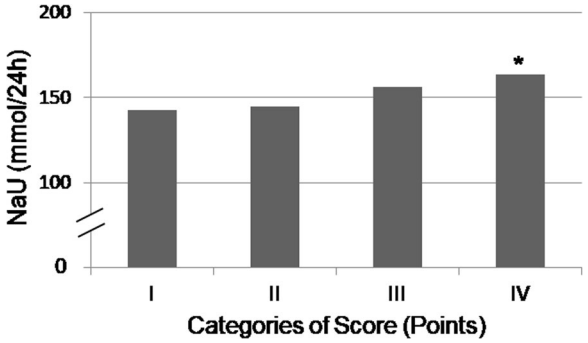

Fig. 1 Twenty-four-hour urinary sodium excretion (NaU) distribution according to categories of questionnaire score. I: Score ≤ 7, II: Score = 8, III: Score = 9, IV: Score ≥ 10 points. *p for trend < 0.0001

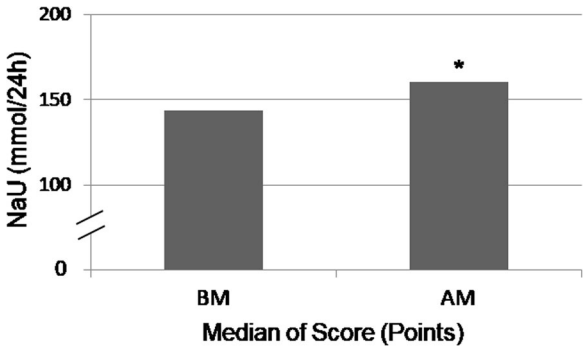

Fig. 2 Twenty-four-hour urinary sodium excretion (NaU) distribution according to median of questionnaire score. Below median (BM): Score ≤ 8, above median (AM): Score > 8 points. *p < 0.0001

Results

A total of 1131 patients (88% of all the participants involved in the study), who had a complete database, were included in the analysis. Details on the main characteristics of the sample are reported in Table 1. The scores of the questionnaires ranged from 5 to 15 points (median: 8 points) (Supplementary File 2).

The score categories were positively and linearly associated with NaU (mean [SD] I: 142.5 [63.4], II: 144.4 [60.9], III: 156.0 [62.9], IV: 163.6 [64.2] mmol/24 h; p for trend < 0.0001) (Fig. 1). Likewise, participants who achieved a total score AM had significantly higher NaU than those who scored BM (AM: 160.3 [63.7] vs. BM: 143.3 [62.2] mmol/24 h; $p < 0.0001$) (Fig. 2). This relation was also confirmed after stratification by gender (men: $p = 0.01$; women: $p = 0.002$), age (<65 years: $p < 0.0001$; >65 years: $p = 0.04$), or weight (normal weight: $p = 0.03$; overweight: $p = 0.002$; obesity: $p = 0.03$).

The score categories were also positively associated with DBP (I: 79.9 [10.4], II: 80.2 [9.8], III: 80.8 [9.8], IV: 82.1 [10.3] mm Hg, $p = 0.04$). While a significant difference both in SBP and DBP was found between participants of the

BM and AM group (SBP, BM: 133.1 [15.8] vs. AM: 135.8 [16.3], $p = 0.005$; DBP, BM: 80.0 [10.0] vs. AM: 81.9 [10.2], $p = 0.002$).

Essentially, in three questions, the association between NaU and the score indicated that those individuals whose answer indicated a high consumption of salt had significantly higher NaU: in Question 1, score = 1: NaU was 147.6 [61.8] mmol/24 h, score 2 or 3: 158.4 [65.8] ($p = 0.006$). In Question 2, when the response was 1, NaU was 134.6 [62.0] mmol/day, when 2, NaU was 148.2 [63.7], and when it was 3, NaU was 158.7 [62.5] ($p = 0.009$). Similarly, in Question 5, 1 corresponded to 140.4 [59.8] mmol/day, 2 to 156.0 [64.7], and 3 to 165.8 [61.4] ($p < 0.001$). As to the other questions, a positive trend was found (Question 3; response 1: 147.8 [65.1] mmol/24 h, response 2: 153.8 [62.6], response 3: 155.9 [60.5]. Question 4; response 1: 150.1 [62.7] mmol/24 h, response 2: 154.3 [66.3], response 3: 161.7 [61.0]).

The prevalence of H-NaU was 86% in the total population. Ninety percent of participants with a score AM had H-NaU than BM ($p = 0.002$), with a linear relationship across points of the score (≤7 points = 83%, 8 = 84%, 9 = 87%, ≥10 = 91%; $p = 0.01$). BP was similar in the participants at H-NaU and non-H-NaU. The score of the questionnaire had a significant ability to detect H-NaU group (AUC: 0.59; 95% CI: 0.56–0.61), with a specificity of 95% at the score of 10 points. On the other hand, VH-NaU prevalence was 35%, with a linear relationship across points of the score (≤7 points = 28%, 8 = 31%, 9 = 41%, ≥10 = 42%; $p < 0.0001$). Moreover, BP was significantly greater in participants at VH-NaU than at non-VH-NaU (SBP, VH-NaU: 135.7 [15.5] vs. non-VH-NaU: 133.3 [16.3] mm Hg, $p = 0.02$; DBP, VH-NaU: 81.9 [9.8] vs. non-VH-NaU: 80.1 [10.3] mm Hg, $p = 0.005$). The questionnaire had also a significant ability to detect VH-NaU group with an AUC of 0.58 (95% CI: 0.55–0.61) and a specificity of 99.6% at score of 13 points.

Discussion

The aim of this study is to develop and validate an easy and reliable questionnaire to detect individuals with habitual high salt consumption. The main results indicate that a higher score to this short questionnaire is distinctive of habitual high and very high salt consumption in hypertensive patients. Moreover, a greater score was associated with worse BP control. There was significant linear association between questionnaire score and urinary sodium excretion. In addition, there was a large prevalence of "high urinary sodium excretion" in participants who scored was higher than 8.

The analysis of the association between NaU and the score of all the questions indicated that those who reported a greater habitual consumption of salt had higher NaU, in particular higher consumption of bread, or salt use at the table, or insipid taste of the food eaten out, was associated with higher NaU. These results confirm the importance of taking into account discretionary salt and salt taste threshold, and the fact that bread alone represents the major source of habitual dietary salt intake [37, 38].

To our knowledge, this is the first short questionnaire developed to easily detect a high dietary salt habit, which combined question on discretionary salt, foods, and questions on salt taste. Although a number of studies have analyzed dietary salt intake by dietary questionnaire [23–30], those that validated the results with 24-h urinary sodium excretion were not in agreement, and few studies have specifically developed and validated questionnaires on salt intake [23, 24]. A study on small sample of Brazilian hypertensive subjects failed to find an association between a 44-item questionnaire score and single 24-h urine collection [24]. Likewise, in an Irish population, the questionnaire (150 food items) was not predictive of salt intake when compared with 24-h urinary sodium excretion samples [29]. On the other hand, a weak correlation between reported sodium intake (42 items) and three 24-h urine collections was found in a study on a small general population sample [23]. In addition, in a recent study, the score of an energy-adjusted questionnaire (114 items) was weakly associated with overnight urinary sodium excretion [39]. Could be pointed out that the questionnaires proposed were complicated by the large number of items included. Furthermore, few of them accounted for discretionary salt and acquired questionnaire and urine sample at the same time.

The strengths of our study are, first, the inclusion of a large number of male and female participants; second, since the questionnaire includes only five questions, it is simpler to use by insiders and requires little time and effort by the patients. Third, the questionnaire was specifically developed for this study, also including an estimate of discretionary salt used. Fourth, the validation was performed by the comparison with 24-h urinary excretion of sodium—the gold standard to estimate salt intake in population surveys [10]—undertaken over a similar period of assessment as the questionnaire. Finally, the score had high specificity to detect patients at H-NaU and in particular at VH-NaU. However, the study has some limitations: urinary excretion data were collected only once. Given the significant intra-individual variability in urinary sodium excretion, a sufficiently true estimate of individual sodium consumption requires at least three consecutive urinary collections. This limitation is observed in all major epidemiological studies, in which the complex logistics of sample collection seems

to limit measurements to only one. Another limitation is that the population recruited was composed of hypertensive patients only. Finally, since the study was only conducted on an Italian population, the results may not be generalizable to other countries, in particular in countries with different dietary behavior and dietary patterns, and thus different sources of sodium intake.

Noteworthy, the fact that a higher score was associated with higher BP values in the VH-NaU condition further supports the fact that the questionnaire identifies patients with a very high salt intake, given the well-known relationship between salt intake and BP.

This simple questionnaire was developed to detect individuals at high salt intake, and could be used in clinical practice. In addition, this questionnaire proved to be significantly effective in the screening of cardiovascular risk in hypertensive patients. Although this evaluation is a reliable tool to categorize patients with high salt consumption, a 24-h NaU should nevertheless be performed if accurate assessment of salt intake is required.

Although participants who achieved a score of 8 or above had significantly higher NaU and BP, the results suggest as threshold a score of 10 to detect individuals at high salt intake and of 13 for those at very high salt consumption.

The role of excess dietary sodium on hypertension development has been widely demonstrated by several observational and interventional studies [1–9]. Previous observational data by our group have shown that both general and hypertensive Italian population samples consumed high dietary salt [11], far from the WHO guidelines recommendation [10].

Therefore, the development and implementation of intervention studies targeted to reduce mortality for cardiovascular disease are needed. To achieve this, one of the essential steps is to reduce dietary salt intake. In consideration of this assumption, this questionnaire can be an effective and easy tool to detect patients with high or very high salt consumption.

It would be useful to implement health promotion and rehabilitation programs able to screen subjects at high risk of elevated salt intake and critical dietary behaviors, to plan adequate educational interventions.

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Author contributions Conception and design: GF. Analysis and interpretation of the data: D'EL, GF. Drafting of the article: D'EL, MM, SP, GF. Final approval of the article: Minisal Group. Statistical expertise: D'EL, GF. Collection and assembly of data: D'EL, MM, GF.

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Compliance with ethical standards

Conflict of interest GF is member of the advisory board of the Italian Society of Hypertension. SP is President of the Italian Society of Human Nutrition, Scientific Coordinator of the Interdisciplinary Working Group for Reduction of Salt Intake in Italy (GIRCSI), member of the committee for the preparation of the Italian Nutritional Guidelines and an unpaid member of WASH (World Action in Salt and Health). The remaining authors declare that they have no conflict of interest.

References

1. Strazzullo P, D'Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. Br Med J. 2009;339:b4567.
2. Aburto NJ, Ziolkovska A, Hooper L, Elliott P, Cappuccio FP, Meerpohl JJ. Effect of lower sodium intake on health: systematic review and meta-analyses. Br Med J. 2013;346:f1326.
3. Intersalt Cooperative Research Group. Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24 h urinary sodium and potassium excretion. Br Med J. 1988;297:319–28.
4. He FJ, Mac Gregor GA. Importance of salt in determining blood pressure in children: meta-analysis of controlled trials. Hypertension. 2006;48:861–9.
5. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med. 2001;344:3–10.
6. Svetkey LP, Sacks FM, Obarzanek E, Vollmer WM, Appel LJ, Lin PH, et al. The DASH Diet, Sodium Intake and Blood Pressure Trial (DASH-sodium): rationale and design. DASH-Sodium Collaborative Research Group. J Am Diet Assoc. 1999;99: S96–104.
7. He FJ, Li J, Macgregor GA. Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised trials. Br Med J. 2013;346:f1325.
8. D'Elia L, Rossi G, Schiano di Cola M, Savino I, Galletti F, Strazzullo P. Meta-analysis of the effect of dietary sodium restriction with or without concomitant renin-angiotensin-aldosterone system-inhibiting treatment on albuminuria. Clin J

Am Soc Nephrol. 2015;10:1542–52. https://doi.org/10.2215/CJN.09110914.
9. D'Elia L, Galletti F, La Fata E, Sabino P, Strazzullo P. Effect of dietary sodium restriction on arterial stiffness: systematic review and meta-analysis of the randomized controlled trials. J Hypertens. 2017. https://doi.org/10.1097/HJH.0000000000001604.
10. World Health Organization. WHO guideline: sodium intake for adults and children. Geneva: World Health Organization (WHO); 2012.
11. Galletti F, Agabiti-Rosei E, Bernini G, Boero R, Desideri G, Fallo F, MINISAL-GIRCSI Program Study Group, et al. Excess dietary sodium and inadequate potassium intake by hypertensive patients in Italy: results of MINISAL-SIIA study program. J Hypertens. 2014;32:48–56.
12. Donfrancesco C, Ippolito R, Lo Noce C, Palmieri L, Iacone R, Russo O, et al. Excess dietary sodium and inadequate potassium intake in Italy: results of the MINISAL study. Nutr Metab Cardiovasc Dis. 2013;23:850–6.
13. World Health Organization. World Health Organization forum on reducing salt intake in populations. Reducing salt intake in populations: report of a WHO forum and technical meeting. Paris: World Health Organization; 2006.
14. Rakova N, Juttner K, Dahlmann A, Schröder A, Linz P, Kopp C, et al. Long-term space flight simulation reveals infradian rhythmicity in human Na(+) balance. Cell Metab. 2013;17:125–31.
15. Titze J, Dahlmann A, Lerchl K, Kopp C, Rakova N, Schröder A, et al. Spooky sodium balance. Kidney Int. 2014;85:759–67.
16. Lerchl K, Rakova N, Dahlmann A, Rauh M, Goller U, Basner M, et al. Agreement between 24-hour salt ingestion and sodium excretion in a controlled environment. Hypertension. 2015;66:850–7.
17. Ji C, Miller MA, Venezia, Strazzullo P, Cappuccio FP. Comparisons of spot vs 24-h urine samples for estimating population salt intake: validation study in two independent samples of adults in Britain and Italy. Nutr Metab Cardiovasc Dis. 2014;24:140–7.
18. Sakaki M, Tsuchihashi T, Arakawa K, Fukui H, Kameda W, Tominaga M. Long-term variability of urinary salt excretion and blood pressure in hypertensive patients. Hypertens Res. 2014;37:939–43.
19. Weaver CM, Martin BR, McCabe GP, McCabe LD, Woodward M, Anderson CA, et al. Individual variation in urinary sodium excretion among adolescent girls on a fixed intake. J Hypertens. 2016;34:1290–7.
20. Peng Y, Li W, Wang Y, Chen H, Bo J, Wang X, et al. Validation and assessment of three methods to estimate 24-h urinary sodium excretion from spot urine samples in Chinese adults. PLoS ONE. 2016;11:e0149655 https://doi.org/10.1371/journal.
21. Cogswell ME, Wang CY, Chen TC, Pfeiffer CM, Elliott P, Gillespie CD, et al. Validity of predictive equations for 24-h urinary sodium excretion in adults aged 18-39 y. Am J Clin Nutr. 2013;98:1502–13.
22. Dougher CE, Rifkin DE, Anderson CA, Smits G, Persky MS, Block GA, et al. Spot urine sodium measurements do not accurately estimate dietary sodium intake in chronic kidney disease. Am J Clin Nutr. 2016;104:298–305.
23. Charlton KE, Steyn K, Levitt NS, Jonathan D, Zulu JV, Nel JH. Development and validation of a short questionnaire to assess sodium intake. Public Health Nutr. 2008;11:83–94.
24. Ferreira-Sae MC, Gallani MC, Nadruz W, Rodrigues RC, Franchini KG, Cabral PC, et al. Reliability and validity of a semi-quantitative FFQ for sodium intake in low-income and low-literacy Brazilian hypertensive subjects. Public Health Nutr. 2009;12:2168–73.
25. Murakami K, Sasaki S, Uenishi K, Japan Dietetic Students' Study for N, Biomarkers G. The degree of misreporting of the energy-adjusted intake of protein, potassium, and sodium does not differ among under-, acceptable, and over-reporters of energy intake. Nutr Res. 2012;32:741–50.
26. Day N, McKeown N, Wong M, Welch A, Bingham S. Epidemiological assessment of diet: a comparison of a 7-day diary with a food frequency questionnaire using urinary markers of nitrogen, potassium and sodium. Int J Epidemiol. 2001;30:309–17.
27. Sasaki S, Ishihara J, Tsugane S. Validity of a self-administered food frequency questionnaire in the 5-year follow-up survey of the JPHC Study Cohort I to assess sodium and potassium intake: comparison with dietary records and 24-hour urinary excretion level. J Epidemiol. 2003;13:102–5.
28. Freedman LS, Commins JM, Moler JE, Willett W, Tinker LF, Subar AF, et al. Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for potassium and sodium intake. Am J Epidemiol. 2015;181:473–87.
29. Kelly C, Geaney F, Fitzgerald AP, Browne GM, Perry IJ. Validation of diet and urinary excretion derived estimates of sodium excretion against 24-h urine excretion in a worksite sample. Nutr Metab Cardiovasc Dis. 2015;25:771–9.
30. Mancia G, Fagard R, Narkiewicz K, Redón J, Zanchetti A, Böhm M, European Society of Hypertension, European Society of Cardiology, et al. 2013 ESH/ESC guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). J Hypertens. 2013;31:1281–357.
31. Leclercq C, Ferro-Luzzi A. Total and domestic consumption of salt and their determinants in three regions of Italy. Eur J Clin Nutr. 1991;45:151–9.
32. Anderson CA, Appel LJ, Okuda N, Brown IJ, Chan Q, Zhao L, et al. Dietary sources of sodium in China, Japan, the United Kingdom, and the United States, women and men aged 40 to 59 years: the INTERMAP Study. J Am Diet Assoc. 2010;110:736–45.
33. Leclercq C, Arcella D, Piccinelli R, Sette S, Le Donne C, Turrini A, on behalf of the INRAN-SCAI 2005–06 Study Group. The Italian national food consumption survey INRAN-SCAI 2005-06: main results in terms of food consumption. Public Health Nutr. 2009;12:2504–32.
34. Stanhewicz AE, Kenney WL. Determinants of water and sodium intake and output. Nutr Rev. 2015;73:73–82.
35. Bertino M, Beauchamp GK, Riskey DR, Engelman K. Taste perception in three individuals on a low sodium diet. Appetite. 1981;2:67–73.
36. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology. 1982;143:29–36.
37. Piovesana Pde M, Sampaio Kde L, Gallani MC. Association between taste sensitivity and self-reported and objective measures of salt intake among hypertensive and normotensive individuals. ISRN Nutr. 2012;2013:301213.
38. Keogh JB, Lange K, Hogarth R, Clifton PM. Food contributing to sodium intake and urinary sodium excretion in a group of Australian women. Public Health Nutr. 2013;16:1837–42.
39. Pereira TS, Benseñor IJ, Meléndez JG, Faria CP, Cade NV, Mill JG, et al. Sodium and potassium intake estimated using two methods in the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). Sao Paulo Med J. 2015;133:510–6.

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