Original Article

Salt usage behaviors are related to urinary sodium excretion in normotensive Korean adults

Hyun Ju Kim MSc[1], Hee Young Paik ScD[1], Sim Yeol Lee PhD[2], Jae Eun Shim PhD[3] and Young Sik Kim MD, PhD[4]

[1]*Department of Food and Nutrition, College of Human Ecology, Seoul National University, Seoul, Republic of Korea*
[2]*Department of Home Economics Education, College of Education, Dongguk University, Seoul, Republic of Korea*
[3]*Research Institute of Human Ecology, Seoul National University, Seoul, Republic of Korea*
[4]*Department of Family Medicine, College of Medicine, Ulsan University, Seoul, Republic of Korea*

High sodium intake is considered to be the major risk factor for hypertension but studies about sodium intake on prevention and management of hypertension is limited due to the difficulties in assessment of sodium intake. Dietary sodium comes not only from naturally occurring sodium in foods but also from the added sodium during processing, cooking and at the table. Present study was conducted to identify salt usage behavior questions related to urinary sodium excretion among normotensive adult Koreans. The test version of the salt usage questionnaire included six items of salt usage behaviors and nine items of high salt containing foods. A survey was conducted in 189 adults over 18 years of age in three age groups in both genders. Each participant answered the questionnaire and collected one 24-hour urine and urine samples were analyzed for sodium contents. Correlation analyses between scores of the questions and sodium excretion in 24-hour urine were performed to identify question items related to sodium excretion. Among fifteen questions, scores of three questions on salt usage behaviors were significantly correlated to urinary sodium excretion ($r=0.17\sim0.19$; $p<0.05$) and the sum of scores of the three questions showed higher correlation coefficients. ($r=0.26$, $p<0.001$) The salt usage behavior questions developed in this study would be useful in predicting sodium intake and in studying the relationship between sodium intake and health among Korean adults.

Key Words: Sodium intake, urinary sodium excretion, Salt usage behavior

Introduction

Hypertension is the major cause of deaths among Korean adults.[1] Salt consumption has been reported to be the strongest dietary risk factor for hypertension.[2-8] However, researches on sodium intake and prevention and management of hypertension have been hindered by the difficulties in assessment of sodium intake. Dietary sodium comes not only from the naturally occurring sodium in food, but also from the sodium during storage, processing, and cooking. People may also add salt and/or various forms of salt-containing condiments at the table for taste. Discretionary sodium intake, which means sodium added by the consumer, makes the sodium intake assessment almost impossible due to high variation of sodium in diet depending on the preference of salty taste of the consumer.

Fregly[9] estimated American's daily salt intake was 10□14.5g, with one third occurring naturally in food, another one third added during food processing and the other one third added by the consumer. The amount of discretionary sodium intake varies among people with different food habits and different taste preference. Discretionary sodium intake of Koreans were estimated to be 45~85 %, [10-12] which tend to be higher than reports from Western countries.[13-15]

Sodium excretion in twenty-four hour urine has been known to be the best method to estimate sodium intake,[16-20] but it is impractical to use it in field surveys or clinical settings. Although lithium tagged salt was used in several studies to monitor discretionary salt intake, it is not readily available for sodium intake assessment in population.

Therefore, development of a more convenient tool to estimate sodium intake is necessary to advance the knowledge applicable to prevention and management of hypertension. Since discretionary sodium intake is related to the preference for salty taste and the use of salt and salty spices,

Corresponding Author: Dr Hee Young Paik, Department of Food and Nutrition, College of Human Ecology, Seoul National University, San 58-1, Shillim-dong, Kwanak-ku, Seoul 151-742, Korea.
Tel: 82 2 880 6834; Fax: 82 2 879 1423
Email: hypaik@snu.ac.kr
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questions addressing to such behaviors may be useful for estimation of discretionary and total sodium intake. Simple food frequency questionnaires including high-salt food items were used in other studies[18, 21-24] but the questionnaires are valid only in the target community since they were developed based on the diet data of target population. Considering the high contribution of discretionary intake to total sodium intake and diversity of the sources of sodium among Koreans, application of behaviors related to sodium intake on developing such a method may be particularly important in this population.

The purpose of this study was to develop and validate salt usage questionnaire useful to estimate of sodium intake in normotensive Korean adults.

Materials and Methods

Selection of questions for test version of the salt usage questionnaire

Questions included in the test version of the salt usage questionnaire were derived by two approaches - (1) common behaviors related to salt and/or soy sauce usage of the Korean population, and (2) identification of food items commonly consumed by adults with high salt intake. Regarding common behaviors, six questions including the preference of salty taste and the habits of salt and soy sauce usage for typical Korean diet were included. For identification of food items related to high salt intake, the 24-hour recall data from 965 adults in Seoul and its surrounding areas were used. Subjects were divided into quartile groups according to their sodium intake and the food items eaten more frequently among subjects of the lowest and the highest quartiles were compared. Nine high sodium food items were identified to be eaten more frequently among the subjects of the highest sodium intakes and were selected as candidate questions. Therefore, the test version of salt usage questionnaire included total of fifteen questions - six questions related to salt usage behaviors and nine questions of high sodium content food items as shown in Table 2. Answers to the questions were divided into three to five categories depending on the nature of the questions. However, each question was scored between 0 and 12 scores. Questions with three answer categories were scored as 0, 6 or 12, those with four examples were scored as 0, 4, 8 or 12, and those with five examples were scored as 0, 3, 6, 9 or 12. For all questions, higher score indicated the higher salt usage or higher consumption of high salt food items. Score for each question was assigned according to the answer category selected by the subject. Scores of salt usage behavior questions were added together to obtain salt usage behavior score, and scores of the high salt food items questions were added to obtain high salt food score. Total score was the sum of the scores of all of the questions on the test version of the questionnaire.

Selection of items for questionnaire

To select questions for the final form of the questionnaire, a survey was conducted in 189 healthy adults with no history of hypertension. The test version of the questionnaire was administered and sodium excretion in 24-hour urine was measured in study subjects. Characteristics of study subjects are shown in Table 1.

Table 1. Subjects' age, BMI and 24-hour urinary sodium excretion (mmol/day)

		Age groups (years)			Total
		18~34	35~49	Over 50	
Males	Number of subjects	31	30	34	95
	Age (mean±SD)	27.9±4.6	41.7±4.9	59.2±5.2	43.3±14
	BMI [1] (mean±SD)	22.6±2.7	23.8±2.9	23.8±2.4	23.4±2.7
	24-hour urinary sodium excretion (mmol/day)				
	Mean±SD *	179±70.2^{b}	195±72.9^{ab}	230±80.7^{a}	202±77.3
	Median	174	190	216	191
	Q1 ~ Q3	118~227	148~252	170~320	153~252
Females	Number of subjects	33	30	31	94
	Age (mean±SD)	27.9±4.6	43.3±4.3	57.5±6.2	42.6±13
	BMI (mean±SD) **	20.6±2.5^{b}	22.5±3.1^{a}	22.9±3.0^{a}	22.0±3.0
	24-hour urinary sodium excretion (mmol/day)				
	Mean±SD *	140±61.3^{b}	152±48.2^{ab}	179±71.5^{a}	157±62.8
	Median	129	147	158	153
	Q1 ~ Q3	104~171	124~168	142~225	115~196
Total	Number of subjects	64	60	65	189
	Age (mean±SD)	27.7±4.5	42.5±4.7	58.4±5.7	42.9±14
	BMI (mean±SD) ***	21.6±2.7^{b§§}	23.2±3.0^{a}	23.4±2.7^{a}	22.7±2.9§§§
	24-hour urinary sodium excretion (mmol/day)				
	Mean±SD **	159±68.2^{b§}	174±65.0^{b§§}	206±80.1^{a§§}	180±73.9§§§
	Median	152	164	183	167
	Q1 ~ Q3	112~201	130~223	155~255	126~225

[1] Body Mass Index: BMI or sodium excretion was significantly different among age groups different (ANOVA, Duncan's multiple range test, * $p<0.05$, ** $p<0.05$, Means with same letter in each age group were not significantly different); BMI or sodium excretion was significantly different between males and females (t-test, $^{§}p<0.05$, $^{§§}p<0.01$, $^{§§§}p<0.001$)

Table 2. Mean of responses and Spearman's correlation coefficients of the salt usage questionnaire items with 24-hour urinary sodium excretion (n=189)

Salt usage questionnaire items	Mean response (±SD)	Correlation coefficients
Behavior items		
1. I usually eat salty.	6.59±2.31 [b]	0.191 [** a]
2. I add salt or soy sauce on cooked dishes.	4.93±3.85 [c]	0.174 [* a]
3. I add salt on food before tasting.	2.94±3.68 [c]	0.019
4. How much salt do you use on thick broth or soup made of beef?	9.62±2.42 [d]	0.109
5. I eat pan-fried or deep-fried food with soy sauce.	6.29±4.21 [e]	0.186 [* a]
6. I eat broiled meat or fish with salt, soy sauce or red pepper sauce.	5.40±4.53 [e]	0.068
High salt food items		
7. How frequently do you eat kimchi (including kimchi pot stew and fried rice with kimchi)?	9.22±2.33 [f]	0.072
8. How frequently do you eat soup or pot stew?	8.49±2.24 [f]	0.020
9. How frequently do you eat vegetables cooked or salad?	6.78±2.66 [f]	-0.003
10. How frequently do you eat food that stir-fried, hard-broiled or pickled with soy sauce, soybean paste or red pepper paste?	7.19±3.63 [g]	0.096
11. How frequently do you eat processed meat food such as ham, sausage or bacon?	3.27±3.29 [g]	-0.037
12. How frequently do you eat semi-cooked, instant or canned food?	2.87±3.51 [g]	-0.106
13. How frequently do you eat salted nuts, dried seafood, potato chips or popcorn?	2.90±3.35 [g]	-0.021
14. How frequently do you eat rice or noodles with black bean sauce?	1.78±2.09 [g]	-0.030
15. Which one do you prefer between animal food or vegetable food?	5.27±3.34 [h]	0.067

[a] Question 1, 2 and 5 were selected by significant correlation coefficients with urinary sodium excretion.
[b] Very salty=12, A little salty=9, Modestly=6, Little salty=3, Not salty=0.
[c] Always=12, Frequently=8, Seldom=4, Never=0.
[d] More than a tsp=12, As much as a tsp=9, Half a tsp=6, Little salt=3, No salt=0.
[e] Always=12, Sometimes=6, Never=0.
[f] More than 3 a day=12, 1~2 a day=9, 3~6 a week=6, 2~8 a month=3, Less than 1 a month=0.
[g] More than 1 a day=12, 3~6 a week=9, 1~2 a week=6, 2~3 a month=3, Less than 1 a month=0.
[h] Animal food=12, Vegetable food=0, No preference=6.
Spearman's partial correlation coefficients were significant adjusted for age, gender and BMI. ($^{*}p<0.05$, $^{**}p<0.01$)

Participants were selected in three age groups, 18~35 years, 36~49 years, and over 50 years in each gender. At least 30 subjects were included in each group. Standardized 2-liter wide-mouthed plastic jars were supplied with 2ml of toluene as preservative. Subjects were instructed to void the first urine in the morning (not included as the part of collection) and to begin urine collection with the following urination and to end with the first urine of the next day. Subjects were given written guidelines about the method of urine collection. The times of the first voided urine and the final urine collection were recorded to make any adjustments for 24-hour urinary excretion. The collection jars were kept on ice in the icebox during the collection period and brought to the survey team on the same day. When the subjects came with the urine samples, a short interview was conducted to confirm the completeness of urine collection. The volume of urine sample was measured with 2-liter mass cylinder in 10ml scales, and aliquots were stored at -20℃ until analysis. Subjects were recruited as a convenience sample of volunteers. All the volunteers were interviewed and only those with no previous diagnosis of hypertension and without current medication were included in the study. Study purpose and procedures were explained to the eligible participants before they enrolled in the study. Informed consent was obtained from each participant. The study protocol was reviewed and approved by the Institutional Review Board of the Asan Medical Center in Seoul, Korea.

Table 3. Mean of responses and Spearman's correlation coefficients of the salt usage questionnaire scores with 24-hour urinary sodium excretion (n=189)

Salt usage scores	Mean response (±SD)	Correlation coefficients
Total Score (sum of fifteen questions)	87.1±18.3	0.233 [***]
Salt Usage Behavior Score		
Sum of all six questions	33.1±12.7	0.201 [**]
Selected Salt Usage Score (sum of three selected questions [a])	17.8±7.44	0.261 [***]
High Salt Food Score (sum of nine items)	47.8±14.5	0.048

[a] Question 1, 2 and 5 were selected by significant correlation coefficients with urinary sodium excretion; Spearman's correlation coefficients were significant adjusted for age, gender and BMI ($^{**}p<0.01$, $^{***}p<0.001$)

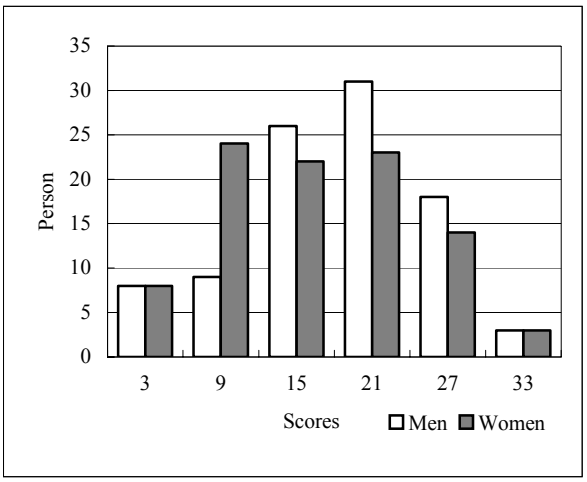

Figure 1. The distribution of the sum of the scores of the three salt usage behavior questions

Urine samples were thawed and brought to room temperature before analysis. Urinary sodium concentration was analyzed by the Ion Selective Electrode (ISE) method and urinary creatinine was assayed by Jaffe's method without deproteinization[25] using Beckman Coulter LX-20 autoanalyzer.

The sodium excretion in 24-hour urine was used as an estimate of sodium intake. Items with significant correlation with sodium excretion were selected. Scores of each of the fifteen questions on the test version of the questionnaire, salt usage behavior score, high salt food score, and total score were evaluated with their association with urinary sodium excretion of the subjects. Spearman's correlation analysis was used to identify significant questions relevant to sodium excretion because the score was a discontinuous and ordinal variable.

Statistical analysis

Analysis was performed using SAS software for Windows, Release 8.2 (SAS Institute, Cary, NC, 1999-2001). Cronbach's α coefficient was calculated to determine the consistency of responses to the questions. The Cronbach's α of the questionnaire was 0.73 and the questionnaire was considered valid. The correlation between scores and sodium excretions was analyzed adjusting for confounding variables correlated with sodium excretion of subjects.

Results

Urinary sodium excretion of the subjects

Median sodium excretion levels in 24-hour urine of the study subjects ranged from 129mmol to 216mmol depending on age and gender of the group. Females and younger age groups had lower excretion. (See Table 1)

Selection of items for salt usage behavior

In correlation analyses of scores of the 15 questions on the test version of the questionnaire with 24-hour urinary sodium excretion of the subjects, three questions showed significant correlation coefficients after adjusting for age, gender and BMI. All of the three questions were related to salt usage behavior. None of the high salt food items was correlated with sodium excretion. (See Table 2)

When the summed scores were investigated, total score and salt usage behavior score, as the sum of all six behavior questions, were significantly correlated with sodium excretion, but high salt food score was not significantly correlated. When the scores of the three behavior items with significant correlation with urinary sodium excretion were summed, the correlation coefficient was even higher than the total score. (See Table 3) Therefore, items 1, 2, and 5 in Table 2, and the summed score of the three questions, are considered to be useful in estimating the sodium intake of the Korean adult population.

The distribution of subjects by the summed score of the three selected behavior scores (Fig. 1) shows that females tend to be distributed more towards the lower score range than the males, but the distribution was not significantly different by gender (p=0.0903).

Discussion

The range of sodium excretion reported in this study confirms the high sodium intake among Korean adults. Urinary sodium excretion can be converted to sodium intake. Kim et al[10] examined a correlation between sodium excretion measured by 24-hour urine and sodium intake by duplicate urine analysis; Na intake = 49.7 + 0.87 × 24-hour Na excretion (r=0.6627, p<0.01). Even though this equation was formulated with adult females, the equation was applied to both males and females, based on the report that there is no difference in the relationship between sodium intake and 24-hour urinary sodium excretion in males and females.[22] The sodium intake estimated by the equation developed by Kim et al[10] was 226±56 mmol/day in males and 186±43mmol/day in females. Fregly[13] reported that 90% of the sodium consumed was excreted in a 24-hour urine collection. When Fregly's finding was applied, usual sodium intake was 225±74 mmol/day and 174±55 mmol/day for males and females, respectively. These results were similar to the result of 2001 Korean Health and Nutrition Survey[26], which reported 231 mmol/day sodium intake in males and 197 mmol/day in females.

Urinary sodium excretion was significantly correlated with age (Pearson's correlation coefficient was 0.2977, p<.0001) and with BMI (Pearson's correlation coefficient was 0.3227, p<.0001). And urinary sodium excretion was significantly different between males and females (p=.0078). Therefore the partial correlation coefficients were analyzed adjusted for age, gender or BMI. The recently established Dietary Reference Intakes of Koreans suggest Target Intake of sodium for Korean adults to follow WHO guideline of 2,000 mg/day (equivalent to about 87mmol/day).[27] If we assume that the excretion rate of dietary sodium was 90% of intake,[13] a person with intake level of 87mmol/day would excrete 78mmol in 24 hour urine. In the present study, 90.5% of the study subjects had urinary excretion above this level (data not shown). The subjects with urinary sodium excretion below 78mol/day tend to be younger, and females.

The salt usage behaviors identified in this study to be related to urinary sodium excretion in adults include one question on general preference of salty taste, and two

questions on using salt or soy sauce with cooked food. Scores for these questions were significantly correlated with urinary sodium excretion individually, but the sum of the three scores increased the correlation coefficients explaining 26% of total variation in urinary sodium excretion. Neither the scores of the high salt foods nor the sum of their scores were correlated significantly with sodium excretion. This seems to indicate that the variation of the sodium intake, and thus urinary sodium excretion, is mainly from the salt added by the consumer at the table rather than from the prepared foods in Korean population but we need more study to confirm the sources of variation in sodium intake in population.

Previous studies seem to indicate discretionary sodium intake in Koreans may be higher than in other populations. Fregly[9] estimated American's daily salt intake was 10□14.5g, and that one third of it was discretionary intake, which was added salt. A study from China reported the discretionary sodium to be 53% in urban and 63% in rural areas..[28] Studies conducted in Korea reported the discretionary sodium intake to be the range of 73~87% of total intake. Kim[10,12] measured total sodium intake from duplicate diet analysis, nondiscretionary sodium intake from naturally occurring sodium in the ingredients of foods eaten by dietary record and discretionary sodium intake from the difference between total intake and nondiscretionary intake. Total sodium intake was 170mmol and discretionary sodium was 72.8% of total sodium intake in female college students.[10] In another study[11], total sodium intake was estimated from 24-hour urinary excretion and nondiscretionary sodium intake was calculated from dietary records in 30 young and 62 middle-aged Korean females. Estimated total sodium intake and the percentage of discretionary intake were 120mmol and 79.4% in the young women and 245mmol and 85.7% in the middle-aged females. Therefore, although the actual proportion of discretionary intake to total sodium intake varies by age, the reported values for Korean female adults tend to be higher than those of other populations. More precise method to measure discretionary sodium intake is to use lithium tagged salt but no study is reported in Korea using this method yet. Koreans use salt for some foods but also use other salty condiments, for example, soy sauce, salted fish and bean paste, for salty taste and it may require quite extensive design to conduct a study with lithium tagged salt.

In our study, males had a higher sodium excretion and higher salt usage behavior scores compared to females. Median scores of salt usage behavior for males and females were 18 and 16, respectively out of 36 possible score (data not shown). Although it is possible that higher sodium excretion in males was due to more food intake among males and thus sodium density of diet in males may or may not be higher than females. However, higher median score for salt usage behavior in males indicates salt use per se may be more prevalent in males than females in Korea.

Previous reports indicate that the preference for salty taste can be reduced by a low salt diet.[29-33] The behavioral questions developed in this study can be used to identify subjects at risk of high sodium intake..The questionnaire developed in this study may be culturally sensitive and is targeted for Korean adults. However, the protocol with which we developed and validated the questionnaire may be applied to other populations in order to generate a simple questionnaire to estimate nutrient intake.

The present study has several limitations. First of all, the completeness of 24-hour urine collection was only confirmed by interview, not by creatinine clearance. If some of the urines were not collected completely, the data for 24-hour sodium excretion would have resulted in lower values than the actual values. However, we cannot predict the direction of the error for selection of items of the questionnaire. The survey participants were not a representative sample of the population, so the extrapolation of the results should be cautious. Moreover, the questions selected explain only a small portion of the variance in sodium excretion and more studies should be conducted to analyze the predictors of sodium intake in other adult populations, particularly those at high risk of hypertension.

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Original Article

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[1]*Department of Food and Nutrition, College of Human Ecology, Seoul National University, Seoul, Republic of Korea*
[2]*Department of Home Economics Education, College of Education, Dongguk University, Seoul, Republic of Korea*
[3]*Research Institute of Human Ecology, Seoul National University, Seoul, Republic of Korea*
[4]*Department of Family Medicine, College of Medicine, Ulsan University, Seoul, Republic of Korea*

正常血壓韓國成年人鹽使用行為與尿鈉排泄相關

攝取高鈉被認為是高血壓的主要危險因子，但研究關於鈉攝取對於預防及高血壓管理卻相當有限，肇因於評估鈉攝取的困難。飲食中鈉的來源不只是食物中天然鈉的來源，還來自食物加工、烹煮及用餐時添加的鈉。本研究探討正常血壓韓國成年人其鹽使用行為問題與尿鈉排泄的相關性。鹽使用問卷的測試版本包含 6 題鹽使用行為及 9 題含高鹽食物。本調查對象共 189 名，18 歲以上，分三個年齡組，男女都有。每位研究對象回答問卷，並收集一次 24 小時尿液，分析尿液樣本鈉量。以相關分析問卷計分及 24 小時尿鈉排泄量，確認問卷與鈉排泄的相關。在 15 個題目中，有 3 個鹽使用行為與尿鈉排泄量達顯著相關(r=0.17~0.19; p<0.05)，這 3 個問題的總分呈現較高的相關係數(r=0.26，p<0.001)。本研究所發展的鹽使用行為問題可以用於預測鈉攝取量及鈉攝取與健康的韓國成年人的研究中。

關鍵字：鈉攝取、尿鈉排泄量、鹽使用行為。