



Estimation of Daily Salt Intake through a 24-Hour Urine Collection in Pohang, Korea

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There is an established relationship between a high salt diet and public health problems, especially hypertension and cardiovascular disease. We estimated daily salt intake in a group of adults and assessed its association with related variables in Pohang, Korea. We conducted a cross-sectional survey in 2013 with 242 adults. Urine was collected for 24 hr to estimate daily salt intake, and questionnaires about salt preference were administered. The mean daily salt intake was 9.9 ± 4.6 g. There was no difference in salt intake between high systolic blood pressure (SBP) participants and normal SBP participants (10.5 ± 4.7 g/d vs. 9.6 ± 4.3 g/d, $P = 0.339$), but high diastolic blood pressure (DBP) participants reported more salt intake than normal DBP participants (10.4 ± 4.9 g/d vs. 9.7 ± 4.1 g/d, $P = 0.049$). Salt intake and body mass index demonstrated a positive correlation ($P = 0.001$). A preference for Korean soup or stew was associated with high salt intake ($P = 0.038$). Dietary salt intake in Korean adults is still higher than the recommendation from the World Health Organization. More efforts should be made to reduce the salt consumption of Korean adults.

Keywords: Salt Intake; 24-hr Urine Collection; Hypertension; Public Health

INTRODUCTION

While sodium is an essential nutrient for humans, a high salt diet is associated with hypertension and cardiovascular disease (CVD) (1-4). Furthermore, it may be a risk factor of kidney disease, osteoporosis, and even stomach cancer (5, 6). Since these diseases are a major cause of morbidity and mortality in Korea and worldwide, reductions in dietary salt intake could substantially reduce medical costs, and should be a public health priority (7). Recent data on salt intake show that populations around the world are consuming much more salt than is physiologically necessary. In many cases, they are consuming much more salt than the recommendation from the World Health Organization (WHO), which is 5 g salt/day (the equivalent of 2 g sodium/day) (8).

Salt intake can be estimated indirectly from food consumption data or a questionnaire as well as directly by measuring urine sodium. Due to problems with dietary surveys such as the underestimation of sodium intake, assessing 24-hr urinary sodium excretion has become the "gold standard" method of obtaining salt intake data for population surveys (9, 10).

The aim of this study was to estimate the salt intake in adults from Pohang, Korea and to compare the findings with previous

data in Korea and other countries. In addition, we analyzed whether there is a correlation between daily salt intake and a preference for salty foods (11-15).

MATERIALS AND METHODS

Study subjects

The baseline survey was conducted from August to December 2013. The study included 104 men and 138 women (total 242; age range, 20-88 yr). The selected subjects comprised a representative sample of Pohang, a city in Korea that has a population of 508,736.

Assessment of salt intake

After obtaining written consent, participants were asked to collect all urine during a 24-hr period starting from the second urine sample on the morning of the collection day and ending with the first urine sample from the following morning. The purpose of salt intake estimation from the collected samples was not mentioned to the participants. Participants were asked to report whether the 24-hr collection was complete or not and to provide information regarding whether the urine collection day was unusual for them. At the survey site, a well-trained health

worker measured the total volume. Urine aliquots were stored at -20°C before being transported to the certified laboratory. The completeness of 24-hr urine collection was assessed by self-reported urine loss and the 24-hr urine creatinine-based method. The 24-hr urine sample was unacceptable if a participant reported urine loss more than one time or if the creatinine index ($[(24\text{-hr urine creatinine (mg/dL)})/(21 \times \text{body weight (kg)})]$) was lower than 0.7 (16).

Urinary sodium and potassium were measured by using an ion-selective electrode method (Modular DPE chemistry; Roche Diagnostics, Germany). Creatinine was measured by using the Jaffe reaction (Kinetic colorimetric assay; Roche Diagnostics, Germany).

All participants were asked to fill out a questionnaire in order to evaluate their dietary salt habits. The questions referred to whether they prefer salty foods, whether they add extra salt before eating, how many times they have Korean soup or stew in one week, how many times they have processed foods, etc. We compared whether the eating habits were correlated with the actual sodium intake.

All analyses were performed by using SPSS statistics, version 20 (SPSS Inc., New York, USA).

Ethics statement

Study approval was obtained from the institutional review board (IRB) of Seoul National University Hospital (IRB No. H-1205-121-411) and all of the participants provided written informed consent.

RESULTS

Demographic characteristics are given in Table 1. Among the 242 participants, 104 (43%) were male and the mean age was

54.8 ± 13.2 yr. Mean body mass index (BMI) was 23.5 ± 3.1 kg/m² and among the men, 64 (26.4%) were overweight (BMI: 25.0-29.99) and 6 (2.5%) were obese (BMI ≥ 30). Fifty-three participants (21.9%) had hypertension, and the mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 126.7 ± 15.7 mmHg and 77.4 ± 9.4 mmHg, respectively (hypertension: SBP ≥ 130 mmHg or DBP ≥ 80 mmHg).

The average urine volume was $1,726.7 \pm 621.1$ mL. Urinary sodium and potassium excretion in the whole group was 170.2 ± 75.9 mM/day and 68.0 ± 28.3 mM/day, respectively. The 24-hr urine sodium to potassium ratio was 2.68 ± 1.16 .

The distribution of the participants and the Pohang city population by age is given in Table 2. There seemed to be more participants over the age of 50 compared with general population distribution even though we selected a representative sample of the Pohang city population, and this sample was statistically significant ($P < 0.001$).

Estimated salt intake in the Pohang city population was 9.9 ± 4.6 g/day. Salt intake in men (10.3 ± 4.7 g/day) was higher than that in women (9.6 ± 4.2 g/day). Overall, 87.6% of the participants (87.5% of the men and 87.7% of the women) had more salt intake than the WHO recommendation (5 g/day).

There was no difference in salt intake between high SBP participants and normal SBP participants (10.5 ± 4.7 g/d vs. 9.6 ± 4.3 g/d, $P = 0.339$), but high DBP participants had more salt intake than normal DBP participants (10.4 ± 4.9 g/d vs. 9.7 ± 4.1 g/d, $P = 0.049$) (Table 3).

Salt intake increased as BMI increased (underweight: 6.7 ± 4.7 g/d, normal BMI: 9.6 ± 4.2 g/d, overweight: 11.7 ± 4.5 g/d, obese: 12.8 ± 2.0 g/d, $P = 0.001$) (Fig. 1). Participants who reported that they prefer a high salt diet seemed to have a higher salt intake (11.0 ± 5.1 g/day) than those who do not prefer a high salt diet (9.7 ± 4.2 g/day). This finding demonstrated mar-

Table 1. Baseline characteristics of the study participants

Parameters	Mean \pm SD
Age (yr)	54.8 ± 13.2
Sex, male (n, %)	104 (43%)
Height (cm)	162.9 ± 7.6
Weight (kg)	62.3 ± 9.9
Body mass index (kg/m ²)	23.5 ± 3.1
Overweight (BMI: 25.0-29.99) (n, %)	64 (26.4%)
Obese (BMI ≥ 30) (n, %)	6 (2.5%)
Hypertension (n, %)*	53 (21.9%)
Systolic blood pressure (mmHg)	126.7 ± 15.7
Diastolic blood pressure (mmHg)	77.4 ± 9.4
24 hr urine	
Volume (mL)	$1,726.7 \pm 621.1$
Sodium (mM/day)	170.2 ± 75.9
Potassium (mM/day)	68.0 ± 28.3
Sodium/potassium	2.68 ± 1.16
Salt (g/day)	9.94 ± 4.56
Creatinine (mg/day)	$1,271.9 \pm 0.6$

Data are presented as percentage, mean \pm standard deviation (SD).

*Hypertension: SBP ≥ 130 mmHg or DBP ≥ 80 mmHg.

Table 2. Distribution of the participants and population of Pohang by age

Sex, age	Participants distribution (n, %)		Population distribution* (n, %)	
Gender				
Men	104 (43.8)		258,710 (50.9)	
Women	138 (57.0)		250,026 (49.1)	
Total	242 (100.0)		508,736 (100.0)	
Age (yr)				
20-29	10 (4.1)		64,304 (12.6)	
30-39	19 (7.9)		75,942 (14.9)	
40-49	47 (19.4)		91,575 (18.0)	
50-59	75 (31.0)		82,597 (16.2)	
60-69	63 (26.0)		42,168 (8.3)	
≥ 70	28 (11.6)		31,303 (6.2)	
Age (yr)	Men	Women	Men	Women
20-29	7 (2.9)	3 (1.2)	36,322 (7.1)	27,982 (5.5)
30-39	8 (3.3)	11 (4.5)	38,583 (7.6)	37,359 (7.3)
40-49	16 (7.4)	31 (12.8)	45,983 (9.0)	45,637 (9.0)
50-59	29 (12.0)	46 (19.0)	41,612 (8.2)	40,985 (8.1)
60-69	30 (12.4)	33 (13.6)	20,958 (4.1)	21,210 (4.2)
≥ 70	14 (5.8)	14 (5.8)	11,674 (2.3)	19,629 (3.9)

*Population and Housing Census 2010, Korea.

Table 3. Daily salt intake with related variables

Variables	Salt intake (g/day)	P
BP		
SBP \geq 130	10.5 \pm 4.7	0.339
SBP < 130	9.6 \pm 4.3	
DBP \geq 80	10.4 \pm 4.9	0.049
DBP < 80	9.7 \pm 4.1	
BMI		0.001
< 18.5 (underweight)	6.6 \pm 4.7	
18.5-24.99 (normal weight)	9.6 \pm 4.2	
25.0-29.99 (overweight)	11.4 \pm 4.5	
\geq 30 (obese)	12.8 \pm 2.0	
Eating habit		0.055
High salt diet	11.0 \pm 5.1	
Low salt diet	9.7 \pm 4.2	
Preference with Korean soup/stew		0.038
Always	11.8 \pm 5.4	
Often	10.0 \pm 4.4	
Sometimes	8.2 \pm 3.8	

Table 4. Estimated daily salt intake in various countries

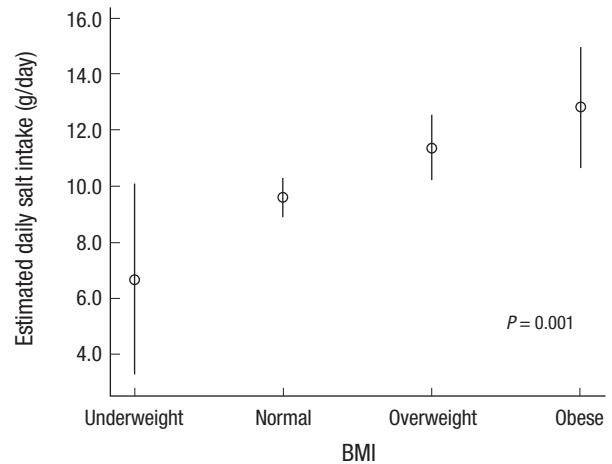
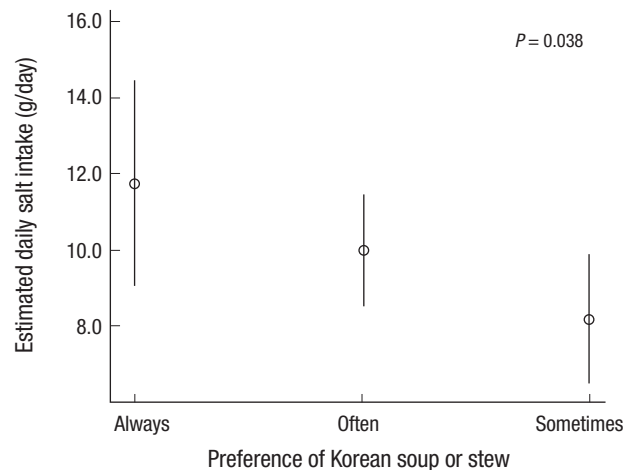
Localities	Study year	Participants (n)	Salt intake (g)		
			Total	Men	Women
Korea					
Pohang	2013	244	9.9 \pm 4.6	10.3 \pm 4.7	9.6 \pm 4.2
Goyang (11)	2011	368	9.7 \pm 0.3	10.6 \pm 0.5	8.9 \pm 0.3
Metropolitan area (12)	2005	63	12.1 \pm 3.5	-	-
Chungcheong-do (12)	2005	40	12.5 \pm 4.1	-	-
Jeolla-do (12)	2005	65	13.2 \pm 3.7	-	-
Gyeongsang-do (12)	2005	37	13.1 \pm 4.7	-	-
Busan (13)	1988	198	12.2 \pm 4.2	13.6 \pm 4.3	10.8 \pm 4.1
USA, New York (14)	2010	1,656	8.2 \pm 0.2	9.1 \pm 0.2	7.5 \pm 0.3
UK (15)	2011	547	8.1 \pm 5.8	9.3 \pm 5.8	6.8 \pm 3.6
China, Yanti (23)	2014	191	11.8 \pm 4.5	12.8 \pm 4.8	10.8 \pm 4.1

Salt intake was calculated using the equation: 17.1 mM of sodium = 1 g of salt.

ginal significance ($P = 0.055$) (Table 3). Furthermore, participants who reported that they frequently consume Korean soup or stew seemed to have a high dietary salt intake (always: 11.8 \pm 5.4 g/day, often: 10.0 \pm 4.4 g/day, sometimes: 8.2 \pm 3.8 g/day, $P = 0.038$) (Fig. 2).

DISCUSSION

In this study, the estimated daily salt intake through 24-hr urinary collection among adults in Pohang was 9.9 \pm 4.6 g/day (sodium 170.2 \pm 75.9 mM/day). It is almost 2-times higher than the WHO recommendation. There have been few studies on salt intake by collecting 24-hr urine. In the INTERSALT study (1988) (13), estimated daily salt intake was 12.2 \pm 4.2 g among the Busan population in 1988. Furthermore, Jeong et al. (12) reported that daily salt intake in a representative sample of the Korean population ($n = 215$) was 12.7 \pm 3.9 g/day. In a more recent study, Kim et al. (11) reported 9.7 \pm 0.3 g/day as the mean salt intake of 368 subjects in Goyang city, which is similar to the results of this study. It appears that there has been a reduction in the daily salt intake in the Korean population, but it is still a

**Fig. 1.** Salt intake by body mass index (BMI).**Fig. 2.** Salt intake by the taste preference of Korean soup or stew.

higher than that in other countries such as the US (8.2 \pm 0.2 g/d, 2010, New York) (14) and the UK (8.1 \pm 5.8 g/d, 2011, nationwide) (15) (Table 4).

In Korea, salt intake is higher than that in western countries because there is a tradition of adding excessive salt to foods and consuming salty sauces. In previous studies, more than 70% of the sodium intake in Koreans was from Kimchi, Korean soup or stew, and soy sauce (12, 17, 18). In this study, a correlation was demonstrated between participants who enjoy consuming Korean soup or stew and a high salt intake (Fig. 2).

The strong positive correlation between 24-hr sodium excretion and systolic and diastolic blood pressure is well established in many studies (13, 19). However, in this study, only DBP showed a positive correlation with salt intake; perhaps the number of participants was too small.

In the present study significantly higher 24-hr urinary sodium excretion was observed in obese participants in comparison to normal-weight or overweight participants (Fig. 1). The high sodium intake that was observed in conjunction with high

urinary excretion in obese subjects has also been described in many other studies (20, 21). However, several mechanisms could explain the association between sodium excretion and an increase in body fat. One explanation could be that a high intake of salt is the result of consuming large amounts of high-energy foods with a high salt content, which could consequently increase the total energy intake. Similarly, studies have shown that a high intake of salt is associated with consuming a large number of soft drinks (22).

Dietary salt intake in Korean adults is still higher than the recommendation of the WHO. Given the health concerns such as hypertension, CVD, obesity, and kidney disease that are associated with excessive salt intake, it would appear that public health initiatives are needed to reduce salt consumption. The aim is to achieve an overall reduction in the Korean population's salt intake by working directly with the food industry to reduce the amount of salt in processed foods. Indeed, campaigns are underway in many countries, such as the US National Salt Reduction Initiative, World Action on Salt and Health (WASH, UK), and the eat low sat campaign (KFDA, Korea). Moreover, a nationwide survey with a 24-hr urine collection is needed to accurately estimate the daily salt intake in Korea.

DISCLOSURE

The authors declare that they have no conflicts of interest to disclose.

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