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SHORT COMMUNICATION

Subjective evaluation of the frequency of salty food intake and its relationship to urinary sodium excretion and blood pressure in a middle-aged population

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Abstract
Objectives The aim of this study was to examine the relationship between subjective evaluations of the frequency of salty food intake and both urinary sodium excretion and blood pressure (BP) in a middle-aged population.
Methods Urinary sodium and creatinine concentrations in a spot sample and brachial BP were measured in 419 subjects (mean age 37 ± 9 years, 385 men) during a health examination at a company in Kanagawa, Japan, 2011. Twenty-four-hour urinary sodium excretion was estimated from sodium and creatinine concentrations in the spot sample. The subjects were asked about the frequency of salty food intake on a self-reported questionnaire, choosing their answer from 'seldom', 'sometimes', or 'always' based on their own subjective evaluation. The amount of daily salt intake was converted from 24-h urinary sodium excretion.
Results The prevalence of high salt intake, defined as greater than the daily average salt intake of Japanese according to the National Health and Nutrition Survey in 2010, gradually increased from the 'seldom' to the 'sometimes', and then 'always' categories (10.3, 13.4, and 24.0 %, respectively; $P = 0.013$ for trend). The 24-h urinary sodium excretion among these groups also tended to be different; however, the differences did not reach a significantly significant level (145 ± 41, 152 ± 34, and 160 ± 40 mEq/day, respectively; $P = 0.076$). Both systolic and diastolic BP were similar among the groups.
Conclusions Although some of our findings raise the possibility of a relationship between a subjective evaluation of the frequency of salty food intake and urinary sodium excretion, further studies are needed to confirm the relationship. In contrast, no relationship with BP was found.

Keywords Blood pressure · Hypertension · Questionnaire · Salt intake · Urinary sodium excretion

Introduction

The association between excess salt intake and an elevation in blood pressure (BP) has been shown in a number of epidemiologic and clinical studies [1–3]. It is therefore crucial to identify subjects with excess salt intake for the prevention of future BP elevation. There are several objective and reliable methods for evaluating salt intake, such as the measurement of urinary sodium excretion, a record of consumed foods, and weighing method [4]. However, actually carrying out these procedures in the field of general health examination is difficult because such methods are complicated and time-consuming. A previous study showed an association between self-reported salt preference and daily salt intake as evaluated by urinary sodium excretion [5]. These findings suggest the potential usefulness of subjectively evaluated information on salty foods intake for estimating the amount of actual salt intake.

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However, that study could not show a difference in the BP between salt preference and non-salt preference subjects, even though excess salt intake may increase BP.

To further elucidate the usefulness of self-reported information on salt intake, we have examined the relationship between the subjectively evaluated frequency of salty food intake and both urinary sodium excretion and BP in a middle-aged Japanese population.

Methods

Study population

This study was conducted during an annual health examination at a semiconductor manufacturing plant in Kanagawa, Japan, in 2011. A total of 499 individuals underwent the health examination, and 438 of these gave informed consent to participate in the present study. Of these 438 individuals, 19 were excluded from the study because they were taking antihypertensive medications. We initially intended to exclude those individuals with a history or presence of cardiovascular disease, but no such individuals were present among the 438 individuals screened. The final study cohort comprised 419 individuals (mean age 37 ± 9 years, 385 males). This study was approved by the Ethics Committee of Nippon Medical School, and all participants gave written informed consent.

Measurement of variables

All participants underwent anthropometric and BP measurements and blood and urine sampling. Body weight and height were measured, and the body mass index (BMI) was calculated as the weight (kg) divided by the square of the height (m^2). Obesity was defined as a BMI of $\geq$25.0 kg/m^2. The right brachial BP was measured with the subject in a seated position using a mercury sphygmomanometer. Hypertension was defined as a systolic BP of $\geq$140 mmHg or a diastolic BP of $\geq$90 mmHg. Blood samples were obtained from the antecubital vein after overnight fasting. The serum low-density and high-density lipoprotein cholesterol, triglycerides, plasma glucose levels, and HbA1c were then measured. Dyslipidemia was defined as a low-density lipoprotein-cholesterol level of $\geq$140 mg/dl, a high-density lipoprotein-cholesterol level of <40 mg/dl, a triglyceride level of $\geq$150 mg/dl, or the use of lipid-lowering medications. Impaired fasting glucose/diabetes mellitus was defined as a fasting plasma glucose level of $\geq$110 mg/dl, HbA1c of $\geq$6.5 %, or the use of glucose-lowering medications.

Urinary sodium and creatinine concentrations were measured using a spot sample. The 24-h urinary sodium excretion was estimated using the following equation, as presented by Tanaka et al. [6] and recommended by the Japanese Society of Hypertension [7]: 24-h urinary sodium excretion (mEq/day) $= 21.98 \times [(\mathrm{NaS}/\mathrm{CrS}) \times \mathrm{Pr.UCr}_{24}]^{0.392}$, where NaS indicates the sodium concentration in the spot urine sample (mEq/l), CrS indicates the creatinine concentration in the spot urine sample (mg/l), and $\mathrm{Pr.UCr}_{24}$ indicates the estimated 24-h urinary creatinine excretion (mg/day) calculated as $-2.04 \times$ age (years) $+ 14.89 \times$ weight (kg) $+ 16.14 \times$ height (cm) $-$ 2,244.45. Because most of the salt (sodium) ingested is thought to be excreted in urine, we regarded the 24-h urinary sodium excretion as a reflection of daily salt intake, in accordance with the recommendations of the Japanese Society of Hypertension [4]. The daily salt intake (g/day) was converted from the 24-h urinary sodium excretion (mEq/day) multiplied by 0.0585 [4]. We adopted two definitions of high salt intake. Definition 1 defined high salt intake as greater than the average daily salt intake of Japanese ($\geq$11.5 g/day for men and $\geq$9.9 g/day for women) according to the National Health and Nutrition Survey in 2010 [8]. Definition 2 defined high salt intake as greater than the recommended amount of daily salt intake ($\geq$9.0 g/day for men and $\geq$7.5 g/day for women) according to the Dietary Reference Intakes for Japanese in 2010 presented by the Ministry of Health, Labour and Welfare [9].

A self-reported questionnaire was used to collect the information on the subjects' smoking status, alcohol intake, and frequency of salty food intake. Excess alcohol intake was defined as an ethanol intake of $\geq$300 g/week [10]. The subjects were also asked "How often do you eat salty foods?". The possible answers from which they could chose were 'seldom', 'sometimes', or 'always', and the answers were taken to be a subjective assessment. To answer the question, the subjects were required to decide upon two issues based on their feelings: (1) whether the consumed foods were actually salty or not; (2) the frequency at which they consumed salty foods.

Statistical analysis

All statistical analyses were performed using SPSS software (ver. 19.0.0; IBM Corp, Somers, NY) or MedCalc software (ver 10.1.4; MedCalc Software, Mariakerke, Belgium). Continuous and categorical variables were expressed as the mean ± standard deviation (SD) and the percentage of the total, respectively. The differences in the variables among the 'seldom,' 'sometimes,' and 'always' groups were compared by an analysis of variance or the chi-square test (and chi-square test for trend, if needed), as appropriate. The 24-h urinary sodium excretion and BP among the groups were also compared using an analysis of covariance; variables that showed a P value of <0.1 by an analysis of variance or the chi-square test were used as covariates. Systolic and diastolic BP were further compared among the groups with the inclusion of other potential confounding factors in the models as covariates. All statistical tests were two-sided, and a P value of <0.05 was considered to be significant.

Results

There were significant differences in age and the prevalence of obesity among the 'seldom' ($n = 39$), 'sometimes' ($n = 284$), and 'always' ($n = 96$) groups (Table 1). The prevalence of male sex tended to be different among the groups, but the other characteristics were similar.

Overall, the 24-h urinary sodium excretion (daily salt intake) was 153 ± 36 mEq/day (9.0 ± 2.1 g/day), and the systolic and diastolic BP were 122 ± 10 and 71 ± 9 mmHg, respectively.

The 24-h urinary sodium excretion (daily salt intake) among the 'seldom,' 'sometimes,' and 'always' groups are shown in Table 2. The prevalence of high salt intake according to Definition 1 gradually increased across the groups ($P = 0.013$ for trend). When Definition 2 was used, the prevalence of high salt intake across the groups also gradually increased; however, it did not reach a statistically significant level ($P = 0.096$ for trend). Similarly, the 24-h urinary sodium excretion gradually increased across the groups, but the difference did not reach a statistically significant level ($P = 0.075$). However, after adjusting for age, sex, and obesity, which were the variables showing a P value of <0.1 by an analysis of variance or the chi-square test, the 24-h urinary sodium excretion showed a significant difference among groups ($P = 0.049$).

The systolic and diastolic BP were similar among the groups, even after adjusting for age, sex, and obesity (Table 2). These findings remained insignificant after further adjusting for multiple potential confounders, including dyslipidemia, impaired fasting glucose/diabetes mellitus, current smoking, and the categorized amount of weekly ethanol intake (0, ≤99, 100–199, 200–299, and ≥300 g/week) (data not shown). When the BMI was used as a continuous variable instead of obesity in the analysis, the insignificance of the results remained (data not shown).

Table 1 Characteristics of the study participants according to the subjectively evaluated frequency of salty food intake

Patient characteristics	Frequency of salty foods intake			P value
	Seldom ($n = 39$)	Sometimes ($n = 284$)	Always ($n = 96$)	
Age (years)	39 ± 8	38 ± 9	35 ± 8	0.001[a]
Male sex	84.6	91.5	95.8	0.090[b]
Obesity	7.7	25.4	20.8	0.042[b]
Hypertension	0.0	5.6	3.1	0.21[b]
Dyslipidemia	30.8	36.6	35.4	0.77[b]
IFG/DM	5.1	4.6	5.2	0.96[b]
Current smoking	25.6	32.7	34.4	0.61[b]
Excess alcohol intake	0.0	4.2	5.2	0.37[b]

IFG/DM Impaired fasting glucose/diabetes mellitus

Data are presented as the percentage of participants, except for age, which is presented as the mean ± standard deviation (SD)

[a] Analysis of variance

[b] Chi-square test

Discussion

In the present study, the prevalence of high salt intake, defined as more than average daily salt intake of Japanese according to the National Health and Nutrition Survey in 2010 [8], gradually increased across the 'seldom,' 'sometimes,' and 'always' groups. In contrast, the 24-h urinary sodium excretion did not reach a statistically significant difference among the groups, which appears to be in conflict with previous observations [5, 11]. However, after adjusting for age and the prevalence of obesity and male sex, the 24-h urinary sodium excretion showed significant differences among the groups. Taken together, although some of our findings raise the possibility of a relationship between a subjective evaluation of the frequency of salty food intake and urinary sodium excretion, further studies are needed to confirm the relationship.

Similar to previously reported results [5], the present study failed to show a relationship between the subjective evaluation of salty food intake and BP. One possible reason for this lack of relationship being identified may be the small differences in daily salt intake among the three groups (the maximum differences in the mean value of 0.8–0.9 g/day). This small difference may have resulted in a difference in systolic BP of 1 mmHg among the groups, which is clearly not a statistically significant difference. These results are supported by the findings of a previously reported meta-analysis that indicated a decrease in systolic BP of approximately 1 mmHg with a decrease in daily salt intake of 1 g/day [3]. Another possible reason is that the present study is a cross-sectional investigation. Therefore, subjects with a high BP may already be attempting to reduce their salt intake.

There are limitations to the present study. First, the 24-h pooled urine was not used to obtain the daily urinary sodium excretion; alternatively, it was estimated from a spot urine sample. Indeed, only a moderate correlation has

Table 2 Comparison of 24-h urinary sodium excretion and blood pressure among the groups according to the subjectively evaluated frequency of salty food intake

Parameters	Frequency of salty food intake			*P* value
	Seldom	Sometimes	Always	
High salt intake (%)				
Definition 1[a]	10.3	13.4	24.0	0.030[e] 0.013[f]
Definition 2[b]	41.0	47.2	55.2	0.25[e] 0.096[f]
24-h urinary sodium excretion				
mEq/day	145 ± 41	152 ± 34	160 ± 40	0.075[g]
g/day[c]	8.5 ± 2.4	8.9 ± 2.0	9.4 ± 2.4	
Adjusted[d] 24-h urinary sodium excretion				
mEq/day	147 ± 36	152 ± 36	161 ± 36	0.049[h]
g/day[c]	8.6 ± 2.1	8.9 ± 2.1	9.4 ± 2.1	
Systolic BP (mmHg)	121 ± 9	122 ± 11	122 ± 11	0.70[g]
Diastolic BP (mmHg)	69 ± 6	71 ± 9	70 ± 9	0.21[g]
Adjusted[d] systolic BP (mmHg)	122 ± 10	122 ± 10	123 ± 10	0.83[h]
Adjusted[d] diastolic BP (mmHg)	69 ± 8	71 ± 8	71 ± 8	0.34[h]

BP Blood pressure

Data are presented at the mean ± SD unless indicated otherwise

[a] Defined as a daily salt intake of more than average daily salt intake of Japanese (≥11.5 g/day for men and ≥9.9 g/day for women) according to the National Health and Nutrition Survey in 2010

[b] Defined as a daily salt intake of more than the recommended amount of daily salt intake (≥9.0 g/day for men and ≥7.5 g/day for women) according to the Dietary Reference Intakes for Japanese in 2010 presented by the Ministry of Health, Labour and Welfare

[c] Converted values to daily salt intake (g/day) from 24-h urinary sodium excretion (mEq/day), multiplied by 0.0585

[d] Adjusted for age, sex, and obesity

[e] Chi-square test

[f] Chi-square test for trend

[g] Analysis of variance

[h] Analysis of covariance

been reported between the actual measured 24-h urinary sodium excretion and that estimated from a spot sample ($r = 0.54$), and in that study the estimated values from spot urine samples were lower than the actual measured values from 24-h pooled urine [6]. In addition, all ingested salt is not necessarily excreted through urine only. Therefore, caution is needed when interpreting our present results; for example, the prevalence of high salt intake presented here may be lower than the true prevalence. However, it is difficult to fully carry out 24-h urine collection in real occupational settings as well as during general health examinations. Second, the study participants included only middle-aged Japanese workers at a single manufacturer. Therefore, it is unclear whether the present results can be extrapolated to other populations, including the elderly and other ethnic groups.

In conclusion, some of the present findings suggest that subjective evaluations of the frequency of salty food intake were related to urinary sodium excretion. These findings raise the possibility that such information is useful for identifying subjects with high salt intake in a middle-aged Japanese population. However, all of our results do not necessarily support this relationship; therefore, further studies are needed to confirm such a relationship. In contrast, the relationship between the subjective evaluation of salty foods intake and BP was not found in our study. Further studies are also needed to clarify this relationship.

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Conflict of interest The authors declare that there are no conflicts of interest.

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