Self-monitoring urinary salt excretion in adults: A novel education program for restricting dietary salt intake

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Received March 29, 2011; Accepted May 10, 2011

DOI: 10.3892/etm.2011.265

Abstract. This study aimed to examine the usefulness of the self-monitoring of urinary salt excretion for educating individuals about the risk of excessive dietary salt intake. The subjects were 30 volunteers (15 men and 15 women) not consuming anti-hypertensive medication. The subjects measured urinary salt excretion at home for 4 weeks using a self-monitoring device. Blood pressure (BP), anthropometric variables and nutritional variables (by a dietary-habits questionnaire) were measured before and after the measurement of urinary salt excretion. Statistical analyses were performed, including paired t-tests, Chi-square test, Pearson's product moment correlation coefficient and multiple linear regression analysis. In all subjects, the average urinary salt excretion over 4 weeks was 8.05±1.61 g/day and the range (maximum-minimum value) was 5.58±2.15 g/day. Salt excretion decreased significantly in weeks 3 and 4 ($P<0.05$ and $P<0.01$, respectively). Diastolic BP decreased from 77.7±14.3 (at baseline) to 74.3±13.3 after 4 weeks ($P<0.05$), while systolic BP and anthropometric variables remained unchanged. Nutrition surveys indicated that energy intake was correlated with salt intake both before and after the measurements; changes in both variables during the observation period were correlated ($r=0.40$, $P<0.05$). The percentage of subjects who were aware of the restriction in dietary salt intake increased from 47 to 90%. In conclusion, daily monitoring of the amount of urinary salt excretion using a self-monitoring device appears to be an effective educational tool for improving the quality of life of healthy adults.

Introduction

The number of hypertensive subjects in Japan is estimated to be 40 million. Since the proportion of elderly people in the population is increasing and the incidence of hypertension increases with age, management of hypertension is an important problem in our country. Lifestyle factors, particularly excess dietary salt intake, play major roles in the onset as well as the development of hypertension (1-5). Salt intake of the Japanese population was among the highest for countries that participated in the INTERSALT study (6), and thus salt restriction is the most important lifestyle modification for the Japanese.

Hypertension prevention is one of the important outcomes of 'Healthy Japan 21', which is a project designed to create a healthy nation in the 21st century.

In 'Healthy Japan 21', the goal is a daily salt intake of less than 10 g in males and less than 8 g in females. However, according to this interim report, the goal seems to be very difficult to achieve (7,8). Thus, it is important to develop strategies for educating people about the need to reduce their salt intake.

One strategy is the self-monitoring of urinary salt excretion; this was recommended as a useful strategy by the Working Group for Dietary Salt Reduction of the Japanese Society of Hypertension (9). A device that may be useful with this strategy is a self-monitoring device that was recently developed and estimates 24-h urinary salt excretion from overnight urine samples (10). However, the usefulness of this medical device as an educational tool has not yet been established. The purpose of this study, therefore, was to determine the usefulness of this urinary salt self-monitoring device for educating healthy adults regarding their levels of salt intake and the dangers of excessive salt use.

Materials and methods

Study protocol. The study protocol was approved by the Ethics Committee of Nishikyushu University. Informed written consent was obtained from each subject, and the study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki. We prospectively enrolled healthy adult volunteers between March and April of 2009 in Saga, Japan. Exclusion criteria included physical, psychic and social difficulties, subjects under medical treatment and those ≥65 years of age. A total of 30 subjects (15 males and 15 females) were enrolled in the study.

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Key words: urinary salt excretion, hypertension prevention, salt restriction education, self-monitoring, blood pressure

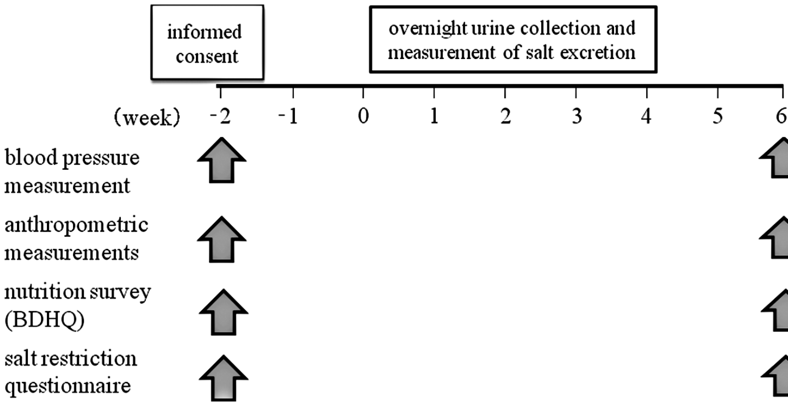

Figure 1. Study protocol. Variables were measured at baseline and 8 weeks later. Variables included blood pressure, dietary habits and nutritional parameters. Subjects collected overnight urine samples for 4 weeks. A medical device was used to measure salt excretion in the urine samples.

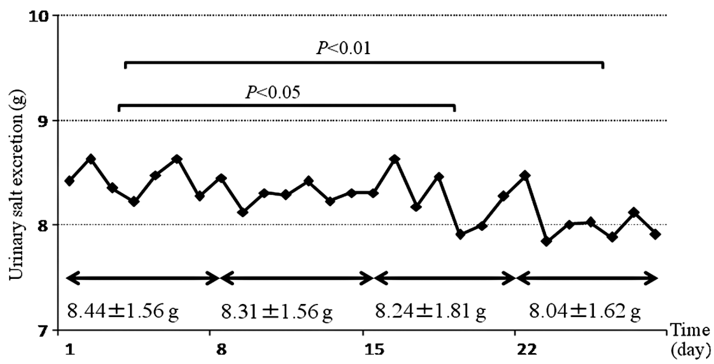

Figure 2. Trend of urinary salt excretion in all subjects. P<0.01; P<0.05 vs. mean salt excretion during the 1st week.

Participant occupations included administrative officials (n=22) and public health nurses (n=8).

The intervention schedule is shown in Fig. 1. At baseline and 8 weeks later we measured blood pressure (BP), anthropometric variables and nutritional variables (by a dietary habits questionnaire). BP was measured with a sphygmomanometer by a public health nurse while subjects were sitting quietly at a room temperature of 25˚C. Anthropometric measurements, including waist circumference, were prformed by a dietitian. Survey of nutritional variables was carried out using a brief self-administered dietary history questionnaire (BDHQ) that was able to evaluate the nutrient intake of the previous month (11). The BDHQ was developed based on a self-administered dietary history questionnaire (DHQ) (12,13). The practice of salt restriction was investigated using a salt restriction questionnaire. This included awareness of salt restriction and of the salt content of food, frequency of the use of seasoning, frequencies of eating pickles, noodles and soup, and opportunities to eat out. In this survey, the salt awareness was obtained based on the participant's self-evaluation. Scores for these items were added and the total score was used to investigate the relationship between awareness of salt restriction and actual urinary salt excretion. Subjects were asked to measure daily salt excretion at home for 4 weeks using the self-monitoring device.

Outcome markers. The main outcome measures were salt excretion levels and changes in systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Statistical analysis. Values are presented as the means ± standard deviation (SD). Differences in variables were compared by paired t-tests. A Chi-square test was also utilized when appropriate. Correlations between variables were analyzed using Pearson's product moment correlation coefficient and multiple linear regression analysis. All data were statistically analyzed with the assistance of the JMP software program (ver. 8; SAS Institute, Cary, NC, USA). The α-level was set at P=0.05.

Results

Baseline characteristics and urinary salt excretion. The mean age of the subjects was 43.2±8.8 years. The mean salt excretion for all subjects (averaged over 4 weeks) was 8.05±1.61 g/day and the range (maximum-minimum value) was 5.58±2.15 g/day in all subjects (Table I). Fig. 2 demonstrates the trend of daily salt excretion for all subjects throughout the 4 weeks. The average urinary salt excretion significantly decreased from week 1 to weeks 3 and 4 (P<0.05 and P<0.01, respectively).

Clinical parameters. Table II shows the changes in BP and anthropometric measures from baseline to the end of week 8. The decrease in DBP was significant, but the decreases in SBP and in the anthropometric variables were not. Urinary salt excretion was significantly correlated with SBP (r=0.54, P=0.005), DBP (r=0.55, P=0.005), body

Table I. Background of participants and urinary salt excretion.

Participants (no.)	30
(male/female)	15/15
Age (years)	43.20±8.8
Urinary salt excretion for 4 weeks (g/day)	8.05±1.61
Maximal value (g/day)	11.05±2.10
Minimum value (g/day)	5.47±1.86
Range (g/day)	5.58±2.15
Urinary salt excretion of 1st week (g/day)	8.44±1.56
Urinary salt excretion of 2nd week (g/day)	8.31±1.56
Urinary salt excretion of 3rd week (g/day)	8.24±1.81[a]
Urinary salt excretion of 4th week (g/day)	8.04±1.62[b]

Values are the means ± SD. [a]P<0.05, [b]P<0.01 vs. baseline by paired t-tests.

Table II. Changes in blood pressure, anthropometrics and nutritional intake.

	Baseline	End of week 8
SBP (mmHg)	123.0±20.7	122.1±18.8
DBP (mmHg)	77.7±14.3	74.3±13.3
BW (kg)	60.8±11.0	60.6±11.3
BMI (kg/m^2)	22.8±3.3	22.7±3.5
Waist circumference (cm)	81.1±9.1	80.7±8.7
Total energy (kJ)	7,800±3,073	7,155±2,801[a]
Protein (g)	62.3±21.2	58.3±20.2
Fat (g)	53.8±21.0	50.8±18.7
Carbohydrate (g)	245.2±90.7	229.5±96.4
Potassium (mg)	2,269±905	2,234±868
Calcium (mg)	416±180	420±180
Magnesium (mg)	231±87	221±82
Salt (g)	9.1±2.8	8.5±3.1[b]

Values are the means ± SD. [a]P<0.01; [b]P<0.05 vs. baseline by paired t-test. SBP, systolic blood pressure; DBP, diastolic blood pressure; BW, body weight; BMI, body mass index.

weight (BW) (r=0.63, P=0.005), body mass index (r=0.41, P=0.05) and waist circumference (WC) (r=0.37, P=0.05). Multiple linear regression analysis showed that DBP, body weight and WC were significantly and independently associated with urinary salt excretion (R^2=0.5399 for total of DBP, BW and WC).

Dietary intake. Table II shows the changes in nutritional intake from baseline to the end of the 8th week. Energy and salt intakes decreased significantly, while intake of other nutritional variables did not significantly change during this period. Energy intake was significantly correlated with salt intake both at baseline (r=0.85, P<0.0001) and at the end of the study (r=0.90, P<0.0001). Furthermore, changes in both variables during the observation period were correlated with each other (r=0.40, P=0.0286).

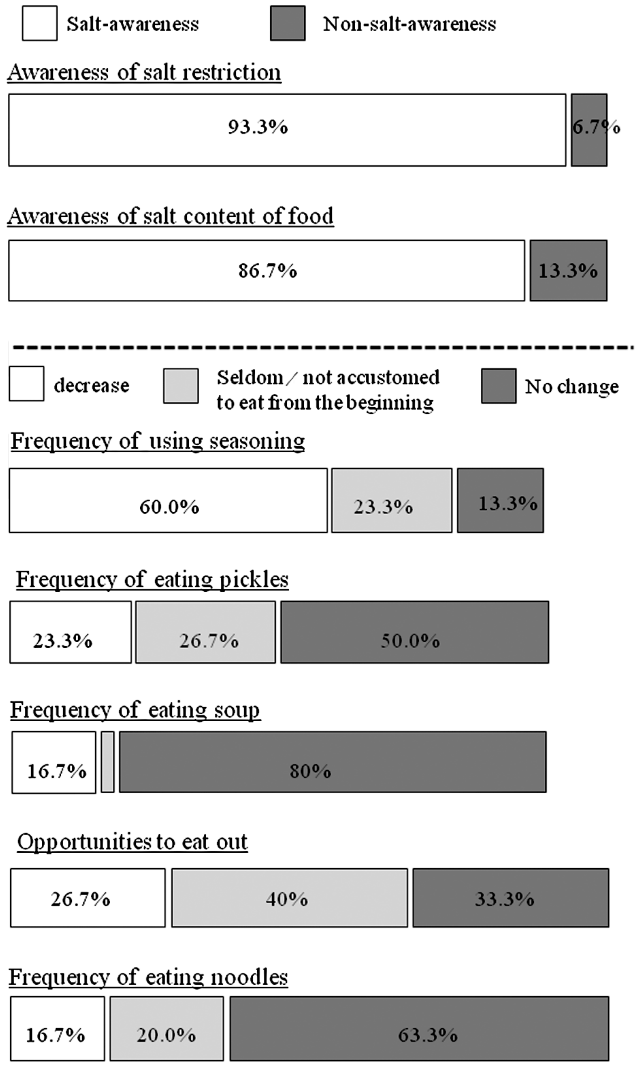

Figure 3. Changes in awareness of salt restriction during the study period.

Salt restriction questionnaire. The proportion of those who were aware of salt restriction increased from 47% at baseline to 90% after 8 weeks. Among the items investigated, awareness of the salt content of food increased and the use of seasoning decreased, while other items failed to show significant changes (Fig. 3). When urinary salt excretion was compared between the high- (>6 points) and low-score (≤6 points) groups, subjects in the high-score group showed significantly lower salt excretion (7.07±0.80 g/day) compared to those in the low-score group (8.46±1.70 g/day, P<0.01).

Discussion

There were two main findings of the present study. i) Self-monitoring of urinary salt excretion at home for 4 weeks significantly reduced urinary salt excretion in healthy adults. ii) DBP, BW and WC were correlated with urinary salt excretion.

Ohta *et al* reported that urinary salt excretion is reduced by the use of a self-monitoring device by hypertensive patients, and that BW is significantly correlated with salt excretion (14). Meland *et al* also reported that during a randomized controlled trial for 12 weeks, BP decreased significantly in hypertensive patients who were using self-monitoring of urine for Cl^- in addition to receiving nutritional instruction (15). These reports are consistent with our results showing the short-term usefulness of the self-monitoring of urinary salt excretion, and the relationship between salt excretion and BW. The present observation that self-monitoring of urinary salt excretion effectively decreases salt excretion even in healthy adults clearly indicates the potential usefulness of this method as an educational tool that will increase salt restriction and lead to the prevention of hypertension. However, salt restriction and weight control may not last long, as suggested by our TOHP II study (16). Thus, future studies are necessary to investigate long-term effectiveness of our salt-excretion self-monitoring method for decreasing salt intake.

The decrease in salt intake was observed not only in those engaged in self-monitoring of urinary salt excretion, but also by results from our nutrition survey. In the nutrition survey, there was a significant and strong correlation between energy and salt intakes. Since salt intake of obese subjects was reported to be high compared to normal weight subjects (17), the restriction of energy intake may lead to salt reduction.

It is intriguing that self-monitoring of urinary salt excretion improved the awareness of salt restriction in normotensive subjects. However, there was no significant association between urinary salt excretion and awareness of salt restriction at baseline (data not shown). This observation is compatible with previous findings by Ohta *et al* that there is no relationship between awareness of salt restriction and the actual salt intake evaluated by 24-h urine collection (18). Since subjective awareness of salt restriction may not necessarily be reflected in actual salt reduction, monitoring of salt excretion seems extremely important to educate the population about the health benefits of salt restriction.

Concerning the validity of the self-monitoring device, Yamasue *et al* reported a significant correlation between i) salt excretion values estimated using overnight urine and a self-monitoring device, and ii) salt excretion measured by 24-h urine collection ($r=0.72$, $P<0.001$) (10). Ohta *et al* also reported that salt excretion measured with a self-monitoring device correlated well with that determined by 24-h home urine evaluation in hypertensive subjects ($r=0.63$, $P<0.01$) (14). Since the self-monitoring device can be used at home to evaluate daily urinary salt excretion, it can be used as a strong motivational tool to help individuals reduce salt intake. As a matter of fact, in this study urinary salt excretion by itself, without any specific educational program, reduced salt intake. Therefore, it seems more practical to use this device rather than 24-h urine collections for educating people about their need for salt restriction.

Several potential limitations of the present study include its non-randomized observational design, use of a small number of subjects and a short duration. Another limitation is that subjects were relatively young and of above average intelligence. Therefore, it is not yet clear whether the present findings can be extrapolated to the general population.

In conclusion, the use of a self-monitoring device leads to a decrease in salt excretion, which indicates that subjects reduced their salt intake. Use of the device thus seems to be an effective tool for educating healthy adults about the health benefits of salt restriction.

Acknowledgements

The present study was supported by funds from the Nishikyushu University. The authors greatly appreciate the technical assistance received from the staff of the Department of Health promotion, Tosu Health Center.

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