Evaluation of the Individual Effects of a Health Education Program for Sodium Restriction by a Simple Method for Measuring 24-Hour Urinary Sodium Excretion

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TAKEMORI, K., NIHRA, S., MIKAMI, S. and SASAKI, N. Evaluation of the Individual Effects of a Health Education Program for Sodium Restriction by a Simple Method for Measuring 24-Hour Urinary Sodium Excretion. Tohoku J. Exp. Med., 1990, 162 (1), 65-72 — A simple method for measuring 24-hr urinary sodium excretion was applied to the evaluation of the individual effects of a health education program for sodium restriction in a rural community in Japan. Eighteen subjects (6 males and 12 females) between 35 and 72 years of age were advised to reduce their sodium intake. Twenty-four-hour urinary sodium, potassium excretion, and sodium/potassium ratio were measured using the simple method for seven consecutive days in three periods which were before the sodium restriction, 6 months after the sodium restriction, and 6 months after the end of the program. Mean sodium excretion of 18 subjects significantly decreased (p <0.05) after the end of the program. The reduced level was maintained until six months after the end of the program. Within individual cases, sodium excretion decreased significantly in subjects who had levels higher than 170 mmol at the initial stage. The reduced levels of sodium excretion were maintained until six months after the end of the program except for one subject. The subjects who had an initial level lower than 170 mmol of sodium, which is the upper limit of present recommendation for Japanese adults, did not change their levels. —— sodium; potassium; urinary excretion; intervention; epidemiologic methods

Epidemiological (Kesteloot et al. 1987; Intersalt Cooperative Research Group 1988; Takemori et al. 1989) and experimental studies (Dahl et al. 1972) have suggested that excessive sodium intake is associated with elevated blood pressure. Recent studies suggest that dietary intervention trials in individuals are effective in lowering blood pressure in hypertensive patients (Beard et al. 1982; MacGregor et al. 1982, 1989; Australian National Health and Medical...
Controlled trials of sodium restriction in general population samples have recently been published (Staessen et al. 1988; Forte et al. 1989). The Portuguese salt trial (Forte et al. 1989) showed that intervention at the community level can be successful in lowering both sodium intake and blood pressure.

It is necessary to observe changes in individual sodium intakes for the evaluation of a health education program for sodium restriction. A single 24-hr measurement of urinary sodium excretion was of no value in assessing mean sodium intake accurately (Liu et al. 1979; Joossens et al. 1980; Luft et al. 1982); instead, six (Langford and Watson 1975), seven (Cooper et al. 1980), seven to fourteen (Liu et al. 1979), nine (Luft et al. 1982) or twenty (Takemori and Mikami 1989) 24-hr collections are necessary. Previously, we reported a simple method for measuring 24-hr urinary excretions of salt and potassium in field surveys (Takemori et al. 1988). In this report, by using the simple method, we evaluated changes in individual salt excretion as a result of the health education program.

**Subjects and Methods**

One hundred and forty-eight subjects who had a systolic blood pressure equal to or greater than 160 mmHg and/or diastolic blood pressure (fifth phase) equal to or greater than 95 mmHg at the previous year's health examination, were given notice of a health education program for sodium restriction by the Health Department of Noheji Town in northeast Japan. Twenty-one subjects (9 males and 12 females) between 35 and 81 years of age participated in the health education program. Three males (55, 64 and 81 years of age) were excluded because they could not complete the entire course of the program. Subject profiles (6 males and 12 females between 35 and 72 years of age) are shown in Table 1.

The program for sodium restriction consists of five courses: (1) Guidance of the program using a text book including statistical data on the town, general information about blood pressure and the curriculum of this program, and an explanation of the method for sampling urine and distribution of the materials. (2) (Twenty days after the first course) A lecture by a doctor on the relation between salt intake and hypertension, and practical exercises on the change in blood pressure caused by the cold pressor test and psychological factor (mental arithmetic and telling number conversely). (3) (Sixteen days after the second course) Dietary diagnosis by the recall method (recalling the composition and weight of foodstuffs used the previous day) and advice on a balanced diet aimed at salt restriction by a nutritionist. (4) (Twelve days after the third course) Cooking practice on meals with a salt content of less than 10 g (170 mmol of sodium) in which females actually participated, and males participated in three ways: actually himself, with his wife, or by observation. In addition there was a lecture by a nutritionist on the salt content in foodstuffs, and information on the results of salt determination before sodium restriction. (5) (Four months after the fourth course) Expression of the subject's impression of the program, distribution of the materials for the second urine sampling (for 6 months after the sodium restriction), and a ceremony at the completion of the course.

Twenty-four-hour urinary sodium and potassium excretions of the subjects were measured by our simple method for seven consecutive days in three periods which were before the sodium restriction, 6 months after the sodium restriction, and 6 months after the end of the program. The simple method has been fully described elsewhere (Takemori et al. 1988). In brief, the subjects carried eight pieces of filter paper strip per man-day for collecting urine samples in field survey. Each filter paper was made of a filter paper strip
(4 × 25 mm, No. 6 ; Toyo Roshi, Co., Ltd., Tokyo) stuck on a vinyl chloride board with double-sided, adhesive acrylic tape. For every excretion, a suitable, non-fixed volume of urine was absorbed directly in a filter paper strip by intersecting the strip across the stream of urine during urination. The strips were dried at room temperature. For excretions outside the home, the strips absorbed urine samples were wrapped on the spot with aluminum foil and brought back home. The strips were then taken out of the aluminum foil and dried at room temperature. After the end of seven days, the strips were mailed to our laboratory 80 km away. A day’s filter paper strips cut away from a part of the vinyl chloride holder were immersed in 15 ml of blank solution (consisting of Lithium standard solution and hydrochloric acid solution) (Takemori 1981) for flame spectrophotometry (by internal standardization technique) at 25°C for one hour. Sodium and potassium in the extract were measured using flame photometry, and creatinine was measured by the Jaffe method. By multiplying the ratios of sodium/creatinine and potassium/creatinine by 24-hr creatinine excretion predicted from the equations of Kawasaki et al. (1986) (predicted creatinine mg/day for males = 15.12 × weight + 7.39 × height - 12.63 × age - 79.9, for females = 8.58 × weight + 5.09 × height - 4.72 × age - 74.9) 24-hr urinary excretion of sodium and potassium was obtained.

Height, weight and blood pressure were measured. Blood pressure was measured by three public health nurses using standard mercury sphygmomanometers. Diastolic blood pressure was taken at the point where the Korotkoff sound disappeared (fifth phase). Information regarding subjects’ history of antihypertensive medication and the frequency of meals eaten outside the home was gathered.

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<th>Weight (kg)</th>
<th>Blood pressure (mmHg)</th>
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Results

Changes of mean 24-hr urinary sodium, potassium, and sodium/potassium ratio (mean±s.e.) for eighteen subjects are shown in Fig. 1. Mean sodium excretion after restriction (137.4±9.9 mmol) decreased significantly (p<0.05) from the initial level (159.0±14.9 mmol), and its level was maintained 6 months following the end of the program (follow-up) (134.6±11.2 mmol). There was no difference in mean potassium excretion or in the sodium/potassium ratio among these three periods.

Fig. 2 shows the changes in sodium excretion for 18 subjects. Means for seven days before restriction, after restriction, and follow-up, together with standard error, are arranged in order of increasing sodium excretion in the initial level. Sodium excretion significantly decreased in subjects who had levels higher than 170 mmol at the initial stage, except for subject number 13. The reduced levels of sodium excretion were maintained until 6 months after the end of the program (follow-up), except for subject number 16.

Fig. 1. Changes in mean 24-hr urinary sodium, potassium, and sodium/potassium ratio for eighteen subjects before restriction, after restriction, and 6 months after the end of the program (follow-up). Values are means±s.e. *p<0.05 against the initial level (paired samples t-test).
Coefficients of variation of individual sodium excretion for seven days ranged from 54.2 to 15.0% (24.2±2.3%) before restriction, from 42.7 to 6.2% (21.1±2.1%) after restriction, and from 44.2 to 9.0% (21.7±1.9%) at follow-up, respectively.

Height, weight, blood pressure and history of antihypertensive medication are shown in Table 1. Subjects dined at home with few exceptions (subject number 1 before restriction, subject number 4 after restriction, and subject numbers 10 and 16 at follow-up dined out once in the three periods of sodium determination).

**DISCUSSION**

In order to assess the effects of the sodium restriction program, it is necessary to observe individual changes in sodium intake. There are few epidemiological studies on individual changes in sodium intake or excretion. This is because there is no simple method for measuring 24-hr urinary excretion for long periods of time for free-living individuals. Therefore, we devised a simple method (Takemori et al. 1988) using a filter paper method (Takemori 1980a).

For basic research on the filter paper method, a recovery test and a long-term preservation test were investigated. Recovery of sodium, potassium, and creatinine was almost 100%. The vinyl chloride board and double-sided adhesive tape had no influence on the extraction of sodium, potassium, and creatinine absorbed in the filter paper (Takemori and Mikami 1987). There were no changes in sodium, potassium, and creatinine concentration for eight weeks when strips were dried and preserved at room temperature (Takemori 1980a, b, 1983).

The simple method is based on the data as follows: the ratios of sodium/creatinine and potassium/creatinine in any five fractions in a discharge
significantly correlated with the ratio of combined urine of the fractions \( r = 0.983 - 0.999, p < 0.01 \) (Takemori et al. 1983); the ratios of sodium/creatinine and potassium/creatinine in the solution extracted from a day's filter paper strips absorbed in each strip a suitable, non-fixed volume of urine significantly correlated with the ratios of the 24-hr control \( r = 0.955 \) for sodium/creatinine and \( r = 0.938 \) for potassium/creatinine (Takemori et al. 1988); Kawasaki et al. (1986) reported the equations to predict 24-hr urinary creatinine excretion from sex, age, height and weight as quoted in the methods, and the correlation coefficient between the predicted creatinine and 24-hr control creatinine obtained from 17 subjects (7 males and 10 females, between 28 and 65 years of age) for 15 through 24 days was \( 0.955 \ (p < 0.0001, Y = 0.99X + 1.43) \); the correlation coefficients between the simple method described in the methods (obtained by multiplying the ratios of sodium/creatinine and potassium/creatinine in the solution extracted from a day's filter paper strips by 24-hr creatinine excretion predicted from the equations of Kawasaki et al.) and the 24-hr control ranged from 0.872 \((p < 0.05)\) to 0.951 \((p < 0.01)\) for sodium, from 0.557 \((p > 0.05)\) to 0.898 \((p < 0.01)\) for potassium (further improvement was necessary for the determination of potassium) (Takemori et al. 1988).

Previous reports showed that seven or more 24-hr urine collections would be necessary to assess mean sodium intake (Liu et al. 1979; Luft et al. 1982; Cooper et al. 1980; Takemori and Mikami 1989). However, considering the accurate estimation of the mean and the practicability of urine collection for the subjects, a collection over seven consecutive days including weekdays and the weekend was employed in this study. The degree to which the free-living individuals of this study varied their day-to-day sodium excretion is shown in Fig. 2 by means of the range of standard error. The effect of the program was assessed by the change of the seven-day mean. The subjects who had an initial level lower than 170 mmol of sodium (10 g of salt) did not change their levels, whereas the subjects who had an initial level higher than 170 mmol of sodium decreased their sodium intake significantly (except for subject number 13) and maintained that lowered level until six months after the end of the program (except for subject number 16).

It should be said that 170 mmol of sodium (10 g of salt) is the goal for the program, and is also the upper limit of the Ministry of Health and Welfare of Japan's present recommendation for Japanese adults (Ministry of Health and Welfare 1984). Subjects who initially attained the proposed goal could not achieve a further decrease in sodium. This suggests that a second goal must be showed for such subjects.

Subject number 1 did not add salt to food either at the table or in cooking and avoided foods that are known to have a large amount of added salt. She had a low mean sodium excretion \(31, 34, 37 \text{ mmol}/24 \text{ hr}\), a high mean potassium excretion \(74, 106, 112 \text{ mmol}/24 \text{ hr}\) and a low sodium/potassium ratio \(0.42, 0.33, 0.31\) during each of the three periods.
Since blood pressure was not measured by a strictly comparable method, the relation between sodium excretion and blood pressure was not investigated.

Finally, we believe that our simple method for measuring 24-hr urinary excretion of sodium may be useful for epidemiological studies such as evaluation of the individual effect of a health education program, or for studies on the relation between sodium intake and blood pressure.

References


