Comparison of Young Women's Salt Intake between Japan and England: Consideration of Different Measurement Methods in National Nutrition Surveys

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Summary Japanese salt intake is calculated through the Food Composition Table in the National Nutrition Survey, whereas English salt intake is through urinary sodium excretion in 24h. This study is a comparison of salt intake between Japan and England. As different measuring methods were used in both National Nutrition Surveys, we recalculated using the same measuring method. Seven Japanese young women's sodium intakes were calculated through the Food Composition Table, and the amounts of their urinary-excreted sodium were measured. These quantities were compared, and a coefficient (87.7%) was obtained. The Japanese young women's salt intake was 9.74 g/day from the Japanese National Nutrition Survey, and the coefficient was multiplied by 8.51 g/day. While comparing these experimental results with English data in 1992, the English salt intake converted from sodium intake of 3,040 mg/day was 7.72 g, 0.79 g/day lower than the Japanese salt intake.

Key Words method of measurement for salt, sodium intake, excreted sodium, Japanese young women, English young women

Because excessive salt intake induces diseases such as high blood pressure and kidney damage (1,2), a reduction of salt intake has been recommended in many countries after investigating sodium levels of their citizens.

The minimal sodium requirement for Japanese adults is said to be 500 mg/day, based on the experimental results of Dahl, L. K. (3) (1958). This value converts into 1.3 g/day of salt intake. Adults should maintain salt intake between this minimal value and 10 g/day. However, according to the National Nutrition Survey (1994), Japanese per capita salt intake is 12.6 g/day, while the salt intake of women in their twenties is 9.7 g/day.

Differences in investigation methods of salt intake among countries affect the results. In England, which surveyed people's nutritional intake recently (English
National Nutrition Survey, 1994), salt intake was measured by the quantity of sodium in a 24-h urine excretion. In Japan, it is calculated using the quantity of food intake using the Japan Standard Food Composition Table (1982).

This study was conducted to compare English and Japanese women’s salt intake differences using the same investigation method.

METHODS

1. Experimental subjects. The subjects were seven healthy woman students, aged 21.4±0.5, having no special exercise regimen. Their height was measured by the Martin method height measuring scale before the experiment. Their weight was measured for three days, two times a day, when they were hungry after getting up, evacuating, and urinating and when hungry before going to bed. BMI (Body Mass Index) was calculated using their height and weight on the first day.

2. Experimental term. Data was taken in November so as to be in accord with that of the National Nutrition Survey. The term was three consecutive days except for the occurrence of menstrual periods.

3. Food intake based on weighted average table of National Nutrition Survey. Foods combination was decided according to the values of the age-matched women in the National Nutrition Survey. As the food material, only natural material was used, with processed foods with a high salt content excluded completely.

All food material and seasonings were weighed and were only used for cooking. For seasonings, a Tanita electronic scale which can measure to the first decimal place was used.

Water and hot water were measured before drinking time with a graduated cylinder. Sodium intake was calculated using the weighted average table of the National Nutrition Survey (the 11th Table) in the Japanese Nutrition Survey of 1994. Moreover, sodium and water were calculated for every food material using the nutritional calculation software 'Health-make'.

4. Measurement of urine and sodium excretion. During the experiment, all of the experimental subjects urine was gathered. The urine was measured using a graduated cylinder, then part of it was preserved as a sample by freezing to $-20^\circ$C for later analysis. Sodium was measured by Beckmann’s flame-light intensity method.

5. Sodium intake mentioned in National Nutrition Survey in 1994. Using the Japanese Nutrition Survey in 1994, Japanese young women’s sodium intake based on the weighted average table and the experimental subjects’ that were calculated.

6. Salt intake of English women aged 18–24. The salt intake of English women aged 18–24 was based on the data from the National Nutrition Survey executed by the Department of Health (4) in England.

The Dietary and Nutritional Survey of British Adults was carried out between October 1986 and August 1987, and its results were published in 1991. A total of 2,197 people completed a full seven-day dietary record, and a 24-h urine collection.
was made by people who cooperated with the survey.

The best estimate of total sodium intake is that derived from urinary sodium excretion, since the body is normally maintained in sodium balance. Urine samples were analyzed for their sodium concentration and these were measured using flame photometry. The coefficient of variation for sodium was 1.7%. It was concluded that the results of these analyses were acceptable throughout the survey.

Approval for the study was obtained from the Ethical Committee for Showa Women’s University. Written informed consent was obtained from all subjects before being entered into the study.

RESULTS

1. Experimental subjects

In this experiment, as shown in Table 1, the experimental subjects height was $157.0 \pm 3.5$ cm and weight was $50.8 \pm 4.2$ kg. Both values were little different from the age-matched average values which is shown in the Japanese Physical Strength Standard Table. The BMI was $20.6 \pm 1.6$, which is only 0.2 higher than the age-matched average value of $20.4 \pm 2.5$, so the experimental subjects were of average physical status for Japanese women.

2. Sodium intake

Table 2 shows sodium intake (salt intake) of Japanese women aged 20–29 based on food composition $3,835.1$ mg (salt intake $9.7$ g), and that of the experimental subjects $3,016.3$ mg (salt intake $7.7$ g), showing a difference of $2.0$ g. This difference depends on the quantity of drinks and dairy products preferred.

| Subjects | Age (years) | Height (cm) | Weight (kg) | BMI |
|----------|-------------|-------------|-------------|-----|
| 1        | 22          | 160.1       | 56.1        | 21.9|
| 2        | 22          | 157.0       | 51.1        | 20.7|
| 3        | 22          | 153.1       | 49.2        | 21.0|
| 4        | 21          | 154.3       | 53.8        | 22.6|
| 5        | 21          | 163.0       | 52.0        | 19.5|
| 6        | 21          | 156.0       | 42.8        | 17.6|
| 7        | 21          | 155.3       | 50.5        | 21.0|
| M±SD     | 21.4        | 157.0       | 50.8        | 20.6|
|          | 0.5         | 3.5         | 4.2         | 1.6 |

Average of 21 years women: $157.8^{\pm}3.0$ $50.5^{\pm}5.0$ $20.4^{\pm}2.5$

*Standards of Japanese physical status (Fourth Edition).
Table 2. Amount of foods and sodium intakes.

| Groups                        | National nutrition survey (20–29 years) | Subjects of the experiments |
|-------------------------------|----------------------------------------|----------------------------|
|                               | Weight of food group (g) | Sodium intakes (mg) | Weight of food group (g) | Sodium intakes (mg) |
| Rice                          | 131.8 | 2.6 | 130±10 | 2.6 |
| Wheat                         | 114.8 | 433.1 | 115±10 | 415.8 |
| Nuts and Seeds                | 0.6 | 0.2 | 1±0 | 0.4 |
| Potatoes and Starches         | 29.6 | 2.6 | 45±5 | 3.4 |
| Sugars and Sweeteners         | 10.3 | 0.3 | 20±2 | 0.6 |
| Confectioneries               | 25.0 | 41.9 | 5±0 | 8.4 |
| Fats and Oils                 | 19.3 | 71.0 | 20±2 | 70.9 |
| Pulses                        | 27.7 | 272.1 | 30±5 | 293.3 |
| Fruits                        | 54.6 | 1.5 | 70±20 | 1.9 |
| Green and Yellow Vegetables   | 47.1 | 8.9 | 60±15 | 10.2 |
| Other Vegetables              | 88.6 | 13.5 | 110±10 | 16.8 |
| Fungi                         | 11.8 | 2.6 | 7±1 | 2.2 |
| Algae                         | 2.6 | 40.0 | 4±0 | 60.1 |
| Seasonings and Beverages      | 133.9 | 2,102.4 | 79±5 | 1,240.4 |
| Fish and Shellfish            | 48.6 | 322.2 | 50±5 | 331.4 |
| Meats                         | 67.3 | 133.2 | 50±3 | 99.0 |
| Eggs                          | 39.9 | 79.1 | 40±2 | 52.7 |
| Milks                         | 72.4 | 48.2 | 315±15 | 210.2 |
| Others                        | 5.2 | 259.7 | 4±0 | 196.0 |
| Total                         | 3,835.1 | 3,016.3 |
| Salt: 9.74 g                  | Salt: 7.66 g |

Sodium was calculated for the National Nutrition Survey in Japan (1994) and subjects of the experiments.

3. Sodium and water intakes

Table 3 shows the average quantity of sodium and water intakes during the experiment. The sodium intake was 3,019±400 mg/day, corresponding to 7.67±1.02 g of salt intake. The water intake was 1,251±122 ml/day, including water in food composition drinks. There was a correlation of $r=0.50$ ($p<0.01$) between water and salt intake.

4. Quantity of urine and sodium excretion

As shown in Table 3, the average quantity of sodium excretion in urine was 2,656±458 mg/day, and the volume of urine was 1,053±173 ml/day. All these values were within the normal range, so there was little difference among the subjects. Converting the sodium intake into salt intake, the result was 6.75 g. There was no correlation between the quantity of urinary excreted sodium and the urine volume.
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Table 3. Sodium and water intakes and urinary sodium excretion, volume.

| Subjects                  | 1    | 2    | 3    | 4    | 5    | 6    | 7    | M±SD          |
|---------------------------|------|------|------|------|------|------|------|---------------|
| Na intakes (mg/day)       | 2,660| 3,150| 2,750| 2,990| 3,850| 2,930| 2,800| 3,019±400     |
| (I) ±SD                  | 100  | 290  | 80   | 100  | 260  | 90   | 190  | *             |
| Water intakes (ml/day)    | 1,442| 1,339| 1,225| 1,184| 1,139| 1,104| 1,323| 1,251±122     |
| ±SD                      | 142  | 132  | 141  | 150  | 151  | 150  | 146  |               |
| Na in urine (mg/day)      | 2,283| 2,690| 2,384| 2,569| 3,641| 2,617| 2,405| 2,656±458     |
| (E) ±SD                  | 245  | 244  | 321  | 427  | 216  | 382  | 284  | **            |
| Urinary volume (ml/day)   | 815  | 908  | 1,279| 1,070| 1,005| 1,027| 1,269| 1,053±173     |
| ±SD                      | 160  | 160  | 150  | 130  | 140  | 140  | 170  |               |
| (E)/(I) (%)              | 85.8 | 85.4 | 86.7 | 85.9 | 94.6 | 89.3 | 85.9 | 87.7±3.1      |

(E): Excretion, (I): Intakes, *: r=0.50 (p≤0.01), **: r=0.40 (N.S.).

5. Sodium excretion ratio
Sodium was excreted at the rate of 87.7±8.1% into urine.

6. English age-matched women’s sodium excretion in urine
In 1990, urinary excreted sodium was 3,036mg/day, corresponding to a salt intake of 7.71 g/day. In 1992, that was 3,040mg/day, corresponding to a salt intake of 7.72 g/day.

7. Comparison between England and Japan
Comparing salt intake between the English data in 1992 and the Japanese data in 1994, the results are as follows: English data value in 1992 was 7.72 g/day. While, in this experiment, Japanese subjects salt intake was 9.74 g, multiplied by the above mentioned rate 87.7% was 8.51 g theoretically, only 0.79 g/day higher than the English value.

DISCUSSION

The reason why data from the English National Nutrition Survey were used is as follows:
Some countries perform a National Nutrition Survey. In Asia, South Korea performs it every year using the same scale as Japan. China performs it only once a decade. In such countries, salt intake is calculated using a food ingredient table, as in Japan, so that it is meaningless to compare the salt intake with that of Japan.

The results of such surveys are too old in Thailand, Indonesia, and the Philippines, and salt intake is not surveyed regularly in such countries.

In Western countries, National Nutrition Surveys of the U.S., England, and Canada are famous. As to the U.S., depending on HANES I, HANES II and HANES III which is now under way, a great deal of effort is put into surveying intake of cholesterol, fat, vitamins, or macro nutrition and body states, while salt intake is not surveyed enough.

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Therefore, the data from the U.S. survey is of little worth in this study. As to Canada, the data is too old. For these reasons, the result of the English National Nutrition Survey, which is very similar to Japan in experimental objectives, was used.

In England, salt intake is calculated from the quantity of urinary-excreted sodium, based on the following viewpoints.

Sodium and chloride are not naturally found in high concentrations in foods, but are added to many foods during processing as well as by the addition of salt in the home. Although the average sodium and chloride content of the foods consumed by respondents was assessed, it was not possible to measure the amount of salt added at the time of cooking or on the plate; the intakes of sodium and chloride measured are therefore based on average values attributed to foods eaten and do not allow for additions in cooking and at table. These results should therefore be interpreted with caution.

Questions on habitual practice with regard to the use of salt in cooking and at the table were included in the questionnaire and addressed to all respondents. For this report, these responses have not been quantified and there has been no attempt to combine them with the results for the measured intake of sodium and chloride. The best estimate of total sodium intake is that derived from urinary sodium excretion since the body is normally maintained in sodium balance.

Comparing the causes of death between England and Japan, the incidence of cardiac and cerebrovascular disease in England is much higher than in Japan. Although fat intake is thought to be the primary cause, salt intake must also be considered.

Comparing the results of the National Nutrition Survey between the two countries, the age-matched young women's salt intake is 9.7 g/day in Japan, while it was 7.70 g/day (1990) and 7.72 g/day (1992) in England, much smaller than in Japan. In England, salt intake is calculated through sodium excreted in the urine because the quantity of the salt used for seasoning was not measured. Therefore, the difference of the measuring method may be the cause of this difference.

It is said that salt is excreted through the urine, skin, and feces, but mostly through urine. However, when sodium intake is restrained and only natural foods are taken in, as shown in the fourth study on Japanese Recommended Dietary Allowances (1994), the quantity of sodium excretion through the urine is 150 mg or less, through the skin 60 mg or less, and through feces 60 mg or less. Therefore sodium excretion through skin and the feces is not negligible.

In order to study the differences in the measurement methods, Japanese young women as experimental subjects were monitored to show how much the value based on food composition differs from the value based on the 24-h urine method.

This experiment aimed to research intake and excretion of sodium and water under the following conditions:

Gathering healthy age-matched almost standard physical status women as experimental subjects, as shown in the Table 1, giving them diets for three days, with no
fluctuation of their weight and no difference in income and expenditure of their energy. There was a correlation of \( r = 0.50 \) (\( p \leq 0.01 \)) between sodium intake and water intake.

A person's needs for water fluctuates (5) basically with the contents of the diet (high protein diet), the quantity of the activity, and the seasons, increasing as their salt intake increases. However, this experiment used normal protein diets, the quantity of the activity was level and physical activity and perspiration hardly occurred in the season. Therefore, the experimental subjects appeared to have been little influenced by these factors.

When considering the quantity of urinary-excreted sodium and that of the urine with normal kidneys, electrolytes such as sodium increase as the quantity of urine excretion increases late in the afternoon, decreasing from midnight to early morning. It is said that this phenomenon corresponds to fluctuation in the renin-aldosterone system (6). Although, there was no measured data about renin activity and aldosterone in this experiment, it seems safe to assume that the experimental subjects' kidney functions were normal as based on the following two reasons:

First, the experimental subjects did not urinate at all after sleeping, urinating only on waking. Second, as shown in the Table 3, excreted sodium was 2,656±458 mg/day (116.0±20.0 mEq/day), being within the normal range (111–446 mEq/day) (7) and below the average of the normal value.

Using the data from this experiment, salt intake of 7.66 g is shown in the Table 2, which is the weighted average table of National Nutrition Survey, which, when multiplied by 87.7\%, was 6.72 g. This value was close to the value 6.73 g converted from salt intake 7.67 g and sodium intake 3,019±400 mg/day shown in Table 3.

On the other hand, Japanese young woman's average salt intake 9.7 g (sodium intake 3,835.1 mg/day) multiplied by the coefficient 87.7\% gave 8.51 g. This value was 1.79 g higher than the salt intake 6.72 g from this experiment. As shown in Table 2, this resulted from the difference of the quantity of preferred drinks and dairy foods in the food combinations. While comparing these experimental results with English data in 1992, the salt intake converted from sodium intake 3,040 mg/day was 7.72 g, 0.97 g higher than the salt intake 6.75 g converted from urinary excreted sodium 2,656±458 mg/day.

Using the experimental intake excretion value of 12.3\% (100−87.7), the salt intake 7.72 g was converted into the theoretical English women's salt intake of 8.67 g/day. This value was close to the Japanese young women's converted value of 8.51 g, 1.01 g/day higher than the value of 7.66 g/day based on food composition, and 1.0 g/day higher than the value of 7.67 g/day shown in the weighted average table of the National Nutrition Survey.

According to these results, using the 24-h urine method is accurate, but it is not possible for countries such as Japan which use the food composition table. For further accuracy, the most appropriate and simple method would be to consider perspiration, investigate using small number of experimental subjects in a season,
find a coefficient, and multiply the result by it, as shown in this experiment. Although Japanese average salt intake is 12.6 g/day, it is 13–14 g/day among those 40–59 years of age. This induces many manifestations of vascular heart diseases. Therefore, it is urged for Japanese to have a stronger awareness about salt intake than ever.

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