Japanese Dietary Intake of Salt and Protein — Relating to the Strategy of Salt Restriction —

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SAKATA, S. and MORIYAMA, M. *Japanese Dietary Intake of Salt and Protein — Relating to the Strategy of Salt Restriction —*. Tohoku J. Exp. Med., 1990, 162 (4), 293-302 — The high level of Japanese salt intake, which has been the major risk factor for cerebrovascular disease and hypertension, has decreased since World War II, and reached a steady level. In the present study, the dietary salt intake in Tohoku (once the district of highest sodium intake) and that in Kyushu (once the district of median or low sodium intake) were studied in relation to nutritional status by the analysis of sodium and urea-nitrogen excretion in 24-hr urine samples collected from 305 healthy Japanese. When the amount of urinary creatinine and urea-nitrogen were adjusted, the mean value of urinary sodium in females was significantly larger in Tohoku than in Kyushu, but not significantly in males. The regional difference of salt intake still remains, although it seems to be disappearing. Traditionally, Japanese high intake of salt was accompanied by poor nutritional status. In the present study, however, a significant positive correlation was observed between sodium and urea-nitrogen. The excess of protein intake would cause the excess of salt intake. Therefore, the strategy of further salt restriction should be directed to not only traditional salty foods but also nutritional status such as protein intake. ——— sodium; urea-N; twenty four-hour urine; nutritional status; secular trend of salt intake

High salt intake has long been considered as the major dietary risk factor for cerebrovascular disease and hypertension (Kondo 1952; Dahl 1958, 1961; Sasaki 1962). Some prefectural governments, as well as the Japanese Ministry of Health and Welfare undertook health education activities to reduce salt intake. As a result, the average salt intake of Japanese has decreased from 14.5 g/day in 1972 to 12.2 g/day in 1988 (Ministry of Health and Welfare, the Government of Japan 1990). In accordance with the preventive activities of hypertension, the mortality of cerebrovascular disease has declined from 160.7 per 100,000 population in the year 1960 to 105.5 in 1988 (Health and Welfare Statistics Association 1990).

The trend toward reduced salt intake, however, has ceased and salt intake has

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reached a steady level, which is still higher than the goal (10 g/day/person or less) set by the Ministry of Health and Welfare. To attain the further reduction of salt intake, we should, at first, understand the mechanism of sustaining this level, and then, adopt the proper strategy of public health corresponding to this situation. In this paper, the authors focused on the relationship between sodium (Na) and nutrition. It is well known that the Japanese general nutritional status improved greatly after World War II. The changing level of general nutritional status should be linked to the changing level of Na intake. Therefore, we observed the statistical relationship between the level of Na intake and nutritional intake in two regional populations. In order to estimate the intake of Na and nutrition at the same time for a given individual, we collected 24-hr urine and determined Na and urea-nitrogen (UN) as indicators of intake of salt and protein, respectively. Urinary UN is used as an indicator of the dietary intake of total protein from both animal and vegetable sources (Folin 1905; Simmons 1972; Steffee et al. 1981; Yukawa 1981; Middendorf et al. 1986; Sakai 1989).

SUBJECTS AND METHODS

Three hundred and five healthy participants (118 males, age = 57.9 ± 12.7 (means $\pm$ s.d.); 187 females, age = 57.1 ± 12.9) volunteered to provide single 24-hr urine specimens. Subjects were classified into two district groups according to their living areas (Fig. 1). Sixty one subjects (23 males, age = 49.4 ± 6.4 ; 38 females, age = 49.5 ± 8.2) were living in towns of either Ikawa or Ohazama located in northern part of Honshu Island (Tohoku district), Japan. Two hundred and forty four subjects (95 males, age = 60.0 ± 13.0 ; 149 females, age = 59.0 ± 13.2) were living in towns of Kawatana, Saikai or Seihi in Kyushu Island (Kyushu district), Japan. Most of subjects consisted of own-account farm managers and their co-operatives, the rest of them were professional/technical workers and retired persons. No restrictions were placed on the activity and diet during the day of urine collection. To avoid the excess of sweating, urinary samples were collected only during

Fig. 1. Location of the two districts (dist) in Japan.

winter seasons (from October to February) of the year from 1982 to 1986. The 24-hr urine collection started at 6:30 A.M. and continued up until the next morning. Before collecting, all subjects were given instruction for the method of collecting, and were recommended to record the time of voiding. Subjects were called several times during the collection and the time record was reviewed over the phone by medical staff. The accuracy of 24-hr collecting was checked by referring to the value of creatinine height index (CHI), defined as milligrams of urinary creatinine (Cr) excreted in 24-hr period divided by an individual's height in cm (Bistran et al. 1975; Heymsfield et al. 1983; Suzuki et al. 1984). If the time record was incomplete, or if CHI value was out of the range (7.09 ± 3.41 (means ± 2 s.d.)), the completeness of urine collection was questioned, and the questioned sample was not used in the later analysis. On the day collection was completed, samples from each subject were placed into 10 ml sample tubes and stored at -30°C until analysis. Urinary Cr was determined by the Jaffe reaction (Bonsnes and Taussky 1945). Urinary Na was measured by flame atomic absorption spectrophotometry (model Z-8000, Hitachi; Hitachi) (Takeuchi and Suzuki 1969). Urinary UN was determined by diacetylmonoxime reaction (Coulombe and Favreau 1963). Height and weight were measured on the day of urine collection. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2).

RESULTS

The means and standard deviations of selected variables are shown in Table 1. Because of disparity in age distribution between Tohoku and Kyushu, Table 1 shows the values adjusted for age. In both males and females, the mean values of 24-hr urinary Na were significantly ($p < 0.01$ for males, $p < 0.01$ for females) larger in Tohoku than in Kyushu. The mean values of UN were also larger in Tohoku than in Kyushu. When the amount of urinary Cr and UN were adjusted by the analysis of covariance, mean urinary Na in females was significantly ($p < 0.01$) larger in Tohoku ($210.7 \text{ mmol}/24\text{-hr}$) than in Kyushu ($169.8 \text{ mmol}/24\text{-hr}$), but not significantly in males.

Fig. 2 shows relationships between 24-hr urinary excretion of UN and Na. In both Tohoku and Kyushu, urinary Na increased significantly ($p < 0.01$) in accordance with the increase of urinary UN.

TABLE 1. Age standardized means of selected variables

	Males				Females			
	Tohoku ($n=23$)		Kyushu ($n=95$)		Tohoku ($n=38$)		Kyushu ($n=149$)	
Height (cm)	163.1 $\pm$	6.1	161.4 $\pm$	5.9	149.8 $\pm$	5.0	149.6 $\pm$	4.8
Weight (kg)	58.4 $\pm$	7.9	59.8 $\pm$	7.6	54.8 $\pm$	8.4	52.0 $\pm$	8.2
BMI ^a (kg/m^2)	21.9 $\pm$	2.8	22.9 $\pm$	2.7	24.4 $\pm$	3.4	23.2 $\pm$	3.3
Sodium (mmol/24-hr)	243.8 $\pm$	88.5**	178.2 $\pm$	85.4	228.9 $\pm$	70.9**	165.2 $\pm$	69.0
Urea-nitrogen (mmol/24-hr)	681.8 $\pm$	186.2	606.0 $\pm$	179.7	584.3 $\pm$	161.4**	496.2 $\pm$	157.0

Values are means $\pm$ s.d. (number of subjects).

^aBody mass index.

** $p < 0.01$.

Fig. 2. Scatter plots of 24-hr urinary sodium (mmol/24-hr) vs. 24-hr urinary urea-nitrogen (mmol/24-hr) of Tohoku district (left, □) and Kyushu district (right, +). The regression lines (— Tohoku; --- Kyushu) show that urinary sodium increased in accordance with the increase of urinary urea-nitrogen [$y=0.16x+131.91$ ($r=0.30$, $p<0.01$) for Tohoku and $y=0.16x+87.87$ ($r=0.39$, $p<0.01$) for Kyushu].

TABLE 2. Correlation coefficients of 24-hr urinary sodium excretion with each variable

	Males	Females	Tohoku	Kyushu
	r^a	r^a	r^a	r^a
Age	-0.049	-0.096	0.172	0.007
Height	0.090	0.075	0.123	0.069
Weight	0.051	0.147*	0.093	0.095
BMI ^b	0.006	0.121	-0.012	0.067
Urea-nitrogen	0.334**	0.490**	0.301*	0.390**

^acorrelation coefficient of 24-hr urinary sodium excretion with each variable.

^bBody mass index.

* $p<0.05$; ** $p<0.01$.

In Table 2, Pearson's correlation coefficients were obtained for Na and other variables by sex and district. In both Tohoku and Kyushu district, as well as in both males and females, the most significant correlation was observed between Na and UN ($p<0.01$).

To remove the linear effects of covariates (sex, district, age and BMI) from relationship between Na and UN, partial correlations were calculated (Table 3). In both males and females, Na correlated significantly ($p<0.01$) with UN adjusted for district and age. When adjusted for district, age and BMI, both males and females still showed significant correlation ($p<0.01$). Similarly, both Tohoku and Kyushu also showed significant correlation ($p<0.01$) adjusted for covariates.

TABLE 3. *Partial correlation coefficients relating 24-hr urinary sodium excretion and 24-hr urinary urea-nitrogen excretion*

	Urea-nitrogen		
	Unadjusted	Adjusted for district ^a and age	Adjusted for district ^a , age and BMI ^b
Sodium			
Males	0.334**	0.323**	0.322**
Females	0.490**	0.455**	0.451**
	Urea-nitrogen		
	Unadjusted	Adjusted for sex and age	Adjusted for sex, age and BMI ^b
Sodium			
Tohoku district	0.301*	0.361**	0.367**
Kyushu district	0.390**	0.431**	0.428**

^aTohoku and Kyushu.^bBody mass index.* $p < 0.05$; ** $p < 0.01$.

DISCUSSION

After World War II, the Japanese general nutritional status as well as the Na intake changed greatly. In Table 4 are shown population based studies on salt intake or excretion in Tohoku and other districts. Fig. 3 shows the trend toward the decreased level of salt intake and the increased level of total protein intake for these 40 years. By our polynomial regression model (Fig. 3), average Japanese consumption of salt at the year of 1950 (21.7 g/day) nearly halved to 11.7 g/day at the year 1990. In contrast, average Japanese consumption of total protein increased 1.2 times (from 66.2 g/day to 80.2 g/day) during these 40 years. Traditionally, the following two factors have contributed to the high salt intake of Japanese, 1) regional factor and 2) dietary factor. The results of the present study add two important findings to each of 1) and 2).

Regional factor

Salt consumption has been higher in Tohoku district than in other districts (Fig. 3). In Kinki and Chugoku district (middle and western part of Honshu Island), the intake of salt was small. The medium intake was observed in Kyushu (Sasaki et al. 1958). In the year 1965, consumption of salt was 1.6 times higher in Akita (Tohoku district) (23.2 g/day) than in Osaka (Kinki district) (14.2 g/day) (Ozawa 1968). Fig. 3 shows the gradual disappearance of regional differences between Tohoku and other districts for these 40 years. In the present

TABLE 4. *Studies on salt intake or excretion for these 40 years in Japan*

Investigator	Year	Area ^a	Number (sex)	Object	Method	Value
Kimura	1952	<u>Akita</u>	293(M•F)	Farmer	24-hr urine	26.3 g/day
Takamatsu	1955	<u>Akita</u>	65(M)	Farmer	24-hr urine	27.3 g/day
		<u>Okayama</u>	59(M)	Farmer	24-hr urine	15.4 g/day
Sasaki et al.	1958	Tohoku district		Farmer	Nutritional-survey	27.0 g/day ^b
		Kinki district		Farmer		17.0 g/day ^b
Suzuki et al.	1959	<u>Yamagata</u>	36(M)	Farmer	24-hr urine	27.3 g/day
		<u>Yamagata</u>	40(F)	Farmer	24-hr urine	21.5 g/day
Dahl et al.	1959	Hiroshima	26(M)	Farmer	24-hr urine	14.0 g/day
Mitsuhashi	1960	<u>Akita</u>	38(M•F)	Farmer	24-hr urine	18.1 g/day
Okisu	1964	Nagasaki	276 house-holds	Farmer	Nutritional-survey	18.0 g/day ^b
Takahashi	1967	<u>Aomori</u>	20(M•F)	Farmer	24-hr urine	18.6 g/day
		<u>Okayama</u>	30(M•F)	Farmer	24-hr urine	14.6 g/day
Ozawa	1968	<u>Akita</u>	29 house-	Farmer	Nutritional-survey	23.2 g/day ^b
		Osaka	31 holds	Farmer		14.2 g/day ^b
Yamori et al.	1982	Shimane	48(M•F)	Farmer	24-hr urine	11.8 g/day
Yoshii et al.	1982	Toyama	11(M)	Official	24-hr urine	16.9 g/day
		Toyama	19(F)	Health-nurse	24-hr urine	14.8 g/day
Takemori et al.	1983	<u>Akita</u>	93(M•F)	Infant ^c	Casual urine	13.7 g/day
		Nagasaki	138(M•F)	Infant ^c	Casual urine	11.7 g/day
Hashimoto et al. (INTERSALT)	1989	Toyama	200(M•F)	Worker ^d	24-hr urine	12.4 g/day
		Tochigi	194(M•F)	Farmer	24-hr urine	10.5 g/day
		Osaka	197(M•F)	Worker ^e	24-hr urine	9.8 g/day
Authors	1990	<u>Akita, Iwate</u>	<u>61(M•F)</u>	<u>Farmer</u>	<u>24-hr urine</u>	<u>13.6 g/day</u>
		Nagasaki	244(M•F)	Farmer	24-hr urine	10.0 g/day

Values are means.

^aUnderlined areas are located in Tohoku district.

^bEstimated amounts of salt intake.

^c3-year-old infants.

^dWorkers employed in a factory.

^eWorkers and their wives in a life insurance company.

study, the difference of urinary Na between Tohoku and Kyushu is still statistically significant by *t*-statistics (Table 1). When other covariates are standardized by the analysis of covariance, however, significant difference is observed only for females. Converting Na (mmol) into salt (g), urinary salt excretion of Tohoku (12.3 g/day) is 1.2 times larger than that of Kyushu (9.9 g/day) in females. From these findings, it is concluded that regional difference of salt intake is still present, although it seems to be disappearing. The difference of urinary UN excretion between Tohoku and Kyushu also is statistically significant (Table 1). Accord-

Fig. 3. Relation between total protein intake ($\square$) and urinary salt excretion ($\bullet$, Tohoku district; $\circ$, other districts) for these forty years. The quadratic curves show the trend toward the decreased level of urinary salt excretion [— , $y = 28.40 - 0.56x + 0.004x^2$ ($r = 0.881$); — , $y = 14.97 + 0.14x - 0.006x^2$ ($r = 0.827$)] and the increased level of total protein intake [$-\text{--}$, $y = 66.18 + 0.75x - 0.01x^2$ ($r = 0.958$)]. The authors referred to Japanese Nutritional Survey from 1951 to 1988 for the amount of total protein intake and to the values of Table 4 for urinary salt excretion.

ing to the Japanese Nutritional Survey in 1988 (Ministry of Health and Welfare, the Government of Japan 1990), total and vegetable protein intake of Tohoku district is the highest of all districts. Therefore, the higher urinary UN excretion in Tohoku may be explained by the higher protein intake, especially from vegetable sources such as rice.

Dietary factor

In the traditional Japanese diet, high intake of salt was accompanied by high intake of carbohydrates and poor proteins (Kondo 1952; Ozawa 1968). In this context, salt intake is expected to correlate negatively with protein intake. In fact, Suzuki et al. (1959) summarized that the nutritional status of the farmers who lived in Yamagata Prefecture in Tohoku district resulted in deficiencies in protein, but on the other hand excesses of salt and carbohydrate. The present results, however, contradict with these traditional traits. In Tables 2 and 3, significant positive correlation is observed between Na and UN ($p < 0.01$) in both Pearson's correlation and partial correlations.

Traditionally, the following two public health strategies have been adopted

to decrease the high salt intake of Japanese, 1) avoid some salty traditional food items and 2) westernize the Japanese diet to increase the protein intake. In fact, the first strategy was realized as the campaign for reduction of intake of salty foods (gen-en-undo). It is no doubt that the general westernization of Japanese lifestyle contributed to accomplishment of the second strategy. In the present study, however, the positive correlation is observed between salt and protein intake. Therefore, we have to re-evaluate the former two strategies.

If the Japanese major source of Na is still some traditional salty foods, strategy 1) is effective. Yet if the source of Na is more evenly distributed among variety of foods, we have to re-evaluate this strategy. According to Japanese Nutritional Survey in 1988 (Ministry of Health and Welfare, the Government of Japan 1990), miso (soybean paste) and tsukemono (vegetables which are preserved in salt) account for only 22% of salt intake. Miso and tsukemono seem to be no longer the major source of Na intake for the average Japanese, and the Japanese seem to have a fair opportunity to take Na from variety of foods. For example, at least 2 g of salt are already included among Japanese dietary foodstuffs (Nakamuta et al. 1984), and cooking of these foodstuffs inevitably increase the Na content. Our study also revealed the positive correlation between intake of salt and protein. The further increase of protein intake is predicted to cause the increase of salt intake. Therefore, we have to re-evaluate this second strategy.

Our study revealed the ineffectiveness of both of the former two strategies. In order to take an appropriate public health action to reduce further salt intake of Japanese, we have to reconfirm the changing relationship between Na and nutrition observed in the present study, and form the new strategy.

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