School Children's Salt Intake Is Correlated with Salty Taste Preference Assessed by Their Mothers

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Salt intake in childhood is a risk factor for developing hypertension later in life. As health education for children to decrease salt intake, it is important for them to know the relationship between salty taste preference and salt intake. The objective of this study was to investigate the relationship between children's salty taste preference and their salt intake. We employed a cross-sectional study design, and the subjects were 199 elementary school children (5th or 6th grade) and their mothers. The amount of salt intake was estimated by the amount of urinary sodium excretion. Children's salty taste preference was assessed 1) by asking children about their own salty taste preference as well as measuring their threshold level of salty taste, and 2) by their mothers' observation of their salt intake behavior using a questionnaire. The salt intake and salt taste threshold of children who liked a salty taste were similar to those in children who disliked it. No association was found between the threshold level of salty taste and sodium intake. Regarding the relationship between children's salt intake and their salt intake behavior score, assessed by their mothers using a questionnaire, the high score group had a higher estimated salt intake than the low score group. In conclusion, children's salt intake may be accurately assessed by their mother's observation rather than children's own salty taste preference. This study suggests the importance of a mother's role in salt restriction education for children. ——— salty taste preference; salt intake; sodium excretion; health education; mothers' roles.

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Excess salt intake can be detrimental to overall health and mortality, as salt intake is directly related to blood pressure and increases the risk of cardiovascular disease and stroke (Frost et al. 1981; Tuomilehto et al. 1981; Ikeda et al. 1986; Intersalt Cooperative Research Group 1988; Tuomilehto et al. 1989; Michael et al. 1998; Chobanian and Hill 2000; Kaplan 2000; Nagata et al. 2004). There is now increasing evidence that salt intake in childhood is a risk factor for developing hypertension later in life (Danise and

Simons 1997; Antonios 2000). Salt is often ingested in excess of physiological need, particularly in industrialized countries. In Japan, the National Health and Nutrition Survey in 2004 reported that an average adult's salt intake was 11.2 g/day (Ministry of Health, Labor and Welfare 2006), although the Ministry of Health, Labor and Welfare recommends reducing the average adult salt intake to below 10 g/day. It also recommends that children should become accustomed to eating low-salt food.

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From the standpoint of health education for children to decrease their salt intake, it is important for them to know the relationship between salty taste preference and salt intake. Children will restrict their salty food intake if they know that the more they like salty food, the more salt they will ingest; however, few studies have examined the relationship between salty taste preference and salt intake by children. We hypothesized that children's salty taste preference is associated with their salt intake. Children who like a salty taste may have a higher salt intake than those who dislike it. The objective of this study was to investigate the relationship between children's salty taste preference and their salt intake.

METHODS

Study design and subjects

This survey was a cross-sectional study. Subjects were all 5th and 6th grade elementary school children aged 10-12 years ($n = 251$) at two elementary schools chosen from urban and rural areas of the Kanto region in Japan. The aim and procedure of this survey were explained to their mothers by class teachers and school nurses in May 2004. Among them, 199 children (108 girls and 91 boys) and their mothers (79.3% of all subjects) gave written informed consent to participate in this study. This study was approved by the Tokyo Kasei Gakuin University Ethics Committee.

Procedure

Height and weight were measured according to standardized procedures at regular health checks stipulated by the School Health Law. The amount of salt intake was estimated by the amount of urinary sodium excretion. Urinary sodium excretion was estimated from second morning voiding urine specimen using Kawasaki's method (Kawasaki et al. 1993). Urinary sodium was measured by the ion selective electrode method, and urinary creatinine was measured by Creatinase (Sarcosine Oxidase/POD) at Mitsubishi-kagaku Bio-Clinical Laboratories Inc. (Tokyo).

The children's salty taste preference was assessed by two methods. Children were asked about their salty taste preference using a multiple choice question with three possible answers: dislike, no preference or like. Because we are not sure whether children of this age can accurately assess their own salty taste preference, we

measured their threshold level of salty taste in order to support the validity of their taste preference. In adults, salty taste preference is associated with the salt taste threshold level (Zumkley 1987; Beauchamp and Engelman 1991; Okoro et al. 1998; Serafin 2004), and we hypothesized that this association would also be found in children. Children who liked a salty taste might have a higher salt taste threshold level. To measure the children's threshold level of salty taste, we used a slip of paper called Salsave (Advantech Toyo Co., Fukuoka), impregnated with several salt concentrations (0.6% to 1.6%) (Nishimoto et al. 1996, 2005). After rinsing their mouth with mineral water, the Salsave paper impregnated with 0% salt was placed on the front-center of the subject's tongue for three seconds, followed by the same procedure using paper with 0.6% salt. Subjects were asked whether they were able to distinguish 0.6% from 0%. If they could not distinguish between them, a higher salt concentration was used until they could. The lowest concentration determined by these procedures was defined as their salt taste threshold. The test was carried out by trained college students using a manual.

The other assessment was carried out by their mothers who rated their children's salt intake behavior using a questionnaire that included 7 questions related to their children's salt intake: daily food tastes, preference for salty food, preference for salty snacks, frequency of drinking soup per day, amount of table salt used, frequency of eating cup noodles per week and frequency of eating meals and snacks after school. If mothers thought that their children's behavior regarding salt intake showed a tendency toward more salt, the salt intake behavior score was one point, with the other responses receiving zero. The children's salt intake behavior score was obtained by summing these scores (minimum 0, maximum 7 points), and the score was dichotomized to a low score group (0-3 points) and high score group (4-7 points).

Statistical analysis

Differences in mean age, height, weight, Rohrer index and estimated sodium excretion between boys and girls were compared using Student's *t*-test. Differences in taste preference and taste threshold between groups were compared using the chi-square test. Differences in estimated sodium excretion among three different taste preference groups were compared using ANOVA. If the differences among groups were statistically significant, differences between groups were compared using

Bonferroni multiple comparison. Pearson's correlation coefficients were used to evaluate the association between the children's salt intake behavior score and estimated sodium excretion. Differences in estimated sodium excretion were compared between the low score group and high score group using ANCOVA, adjusting for age and Rohrer index. SPSS for WINDOWS, version 12.0 (SPSS Inc., Tokyo) was used for the analyses. Differences were considered significant at $p < 0.05$.

RESULTS

Table 1 shows no difference between boys and girls regarding age, height, weight and Rohrer index. The average estimated sodium excretion of boys was significantly higher at 227 mmol (S.D.: 65) than that of girls at 173 mmol (44).

Table 2 shows the relationship between school children's own salty taste preference and their salt intake estimated by the amount of uri-

nary sodium excretion. Children who thought that they liked a salty taste were not found to have a higher salt intake than those who disliked it. On the contrary, girls who disliked a salty taste had a significantly higher salt intake than those who liked it, with boys showing the same tendency.

Table 3 shows no relationship between school children's own salty taste preference and their salt taste threshold. The salt taste threshold of those who liked a salty taste was not higher than those who disliked it.

No association was found between the threshold level of salt taste and salt intake (Table 4). The salt intake of those who had a higher salt taste threshold was not higher than those with a lower salt taste threshold.

Table 5 shows the relationship between school children's salt intake and their eating

TABLE 1. Subjects' characteristics.

	Boys	Girls	p-value
<i>n</i>	91	108	
Age	11.2 ± 0.5	11.2 ± 0.6	0.956
Height (cm)	142.0 ± 6.7	143.2 ± 7.0	0.260
Weight (kg)	35.9 ± 8.0	36.1 ± 7.8	0.876
Rohrer index	124.4 ± 18.3	122.0 ± 16.7	0.323
Estimated sodium excretion (mmol/day)	227 ± 65	174 ± 44	0.000

Height and weight were measured according to standardized procedures at regular health checks stipulated by School Health Law. Estimated sodium excretion was estimated using Kawasaki's method (Kawasaki et al. 1993).

Data are the mean ± S.D. *n*, number of subjects. Differences in variables between boys and girls were compared using Student's *t*-test.

TABLE 2. Relationship between children's own salty taste preference and salt intake.

Salty taste preference	Boys sodium (mmol/day)				Girls sodium (mmol/day)			
	<i>n</i>	mean	S.D.	p-value	<i>n</i>	mean	S.D.	p-value
Dislike	23	250 ± 74			50	186 ± 51		
Not preference	41	213 ± 57*		0.085	33	166 ± 32*		0.037
Like	27	229 ± 66			25	161 ± 40*		

Children's own salty taste preference was measured using a multiple-choice question: dislike, ordinary or like. Salt intake was estimated by urinary sodium excretion using Kawasaki's method (Kawasaki et al. 1993).

Differences in salt intake among three different taste preference groups were compared using ANOVA and Bonferroni multiple comparison. * $p < 0.05$ difference from dislike group.

TABLE 3. Relationship between children's own salty taste preference and salt taste threshold.

Salt taste threshold										
		Total		0.6%		0.8%		1.0~1.6%		p-value
		<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	
Salty taste preference										
Dislike		73	100.0	43	58.9	16	21.9	14	19.1	0.630
Not preference		74	100.0	46	62.2	20	27.0	8	10.9	
Like		52	100.0	29	55.8	15	28.8	8	15.3	

Children's own salty taste preference was measured using a multiple-choice question: dislike, ordinary or like. Salt taste threshold was the lowest salt concentration recognized as salty. It was measured by Salsave of 0.6% to 1.6% salt concentration.

n, number of subjects. Differences in taste preference and taste threshold between groups were compared using χ^2 test.

TABLE 4. Relationship between children's threshold of salty taste and salt intake.

Salt taste	Boys sodium (mmol/day)				Girls sodium (mmol/day)			
	<i>n</i>	mean	S.D.	p-value	<i>n</i>	mean	S.D.	p-value
0.6%	52	231 ± 76		0.481	66	174 ± 43		0.825
0.8%	26	214 ± 51			25	171 ± 48		
1.0~1.6%	13	237 ± 43			17	180 ± 46		

Salt taste threshold was the lowest salt concentration recognized as salty. It was measured by Salsave of 0.6% to 1.6% salt concentration. Salt intake was estimated by urinary sodium excretion using Kawasaki's method (Kawasaki et al. 1993).

Differences in salt intake among three different threshold groups were compared using ANOVA.

behavior observed by their mothers. Boys who liked salty food or who ate a cup noodle more than once a week ingested significantly more salt than those who did not like salty food or ate a cup noodle less than once per two weeks.

Regarding the relationship between the salt intake behavior score and salt intake, a significant relationship was shown in boys ($r = 0.282$, $p = 0.007$) with a similar tendency shown in girls ($r = 0.144$, $p = 0.066$). After adjusting for age and Rohrer index, the high score group had a higher estimated salt intake than the low score group (Table 6).

DISCUSSION

To our knowledge, this is the first study that has suggested that children's salt intake may be accurately assessed by their mother's observation

of their salt intake behavior; however, our hypothesis that children's own salty taste preference is associated with their salt intake was not proven, nor that children's own salty taste preference is associated with their salt taste threshold level. These negative results are consistent with previous studies that there is no relationship between the salt taste threshold and salt intake (Pangborn and Pecore 1982) or between salty taste preference and the salt taste threshold (Lauer et al. 1976). Pangborn and Pecore (1982) considered that few sensory measures, especially discrimination, sensitivity, perceived intensity, preference, and hedonic responses, are related to estimated salt intake, and Lauer et al. (1976) considered that salt taste preference is a phenomenon unrelated to the taste threshold of sodium chloride.

In addition to these possible reasons, two

TABLE 5. Relationship between children's salt intake and their eating behaviors observed by their.

Children's eating behavior observed by mothers	Boys sodium (mmol/day)				Girls sodium (mmol/day)			
	<i>n</i>	mean	S.D.	p-value	<i>n</i>	mean	S.D.	p-value
Daily food taste								
Bland taste	48	221 ± 69		0.417	50	175 ± 47		0.840
Rich taste	43	233 ± 61			58	173 ± 43		
Preference for high salt content food								
Dislike	43	209 ± 57		0.011	38	165 ± 32		0.105
Like	48	244 ± 69			70	179 ± 49		
Preference for high salt content snack								
Dislike	9	201 ± 43		0.199	9	152 ± 33		0.133
Like	82	230 ± 67			99	176 ± 45		
Frequency of eating soup								
Less than once/day	67	225 ± 65		0.570	75	173 ± 43		0.857
More than twice/day	24	234 ± 68			33	175 ± 47		
Table salt seasoning use								
Little	41	223 ± 65		0.554	38	172 ± 42		0.718
Much	50	231 ± 66			70	175 ± 46		
Frequency of eating cup noodle								
Less than once/2 weeks	64	217 ± 59		0.017	97	174 ± 45		0.749
More than once/week	27	252 ± 74			11	170 ± 35		
Frequency of eating meals and snacks after school								
Less than twice/day	87	226 ± 66		0.570	103	171 ± 43		0.008
More than three times/day	4	245 ± 44			5	225 ± 37		

Children's eating behaviors were assessed by their mothers using 7 questions related to children's salt intake. Salt intake was estimated using Kawasaki's method (Kawasaki et al. 1993).

Differences between these two groups were compared using Student's *t*-test.

TABLE 6. Relationship between salt intake behavior score and salt intake.

Salt intake behavior score	Boys sodium (mmol/day)				Girls sodium (mmol/day)			
	<i>n</i>	mean	S.D.	p-value	<i>n</i>	mean	S.D.	p-value
Low score group	49	213 ± 62		0.067	61	167 ± 38		0.066
High score group	42	244 ± 62			47	183 ± 50		

ANCOVA: adjusted for age and Rohrer index.

If mothers thought that their children's behavior regarding salt intake showed a tendency to eat more salt, salt intake behavior score was one point; others had zero on 7- item questions. Salt intake behavior score was obtained by summing these scores. Low score group: 0-3 points. High score group: 4-7 points. Salt intake was estimated by urinary sodium excretion using Kawasaki's method (Kawasaki et al. 1993).

Differences in salt intake were compared between low score group and high score group using ANCOVA adjusting for age and Rohrer index.

others may explain these negative results. First, there is a possibility that we were not able to measure the true salt taste threshold. We used Salsave, which had a taste recognition threshold for NaCl of 0.6% in our study. In other studies, the taste recognition threshold for NaCl was 0.35% (Okoro et al. 1998) or 0.04–0.12% (Okamoto and Taguchi 1996). Because about 60% subjects recognized the salty taste in the 0.6% sample, the concentration of the test paper which measured the threshold might have been too high (Nishimoto et al. 1996, 2005). Second, we measured children's own salty taste preference using only one multiple choice question: dislike, no preference and like, but the reliability of the question was not examined. There is a possibility that we could not accurately assess the subjects' salty taste preference.

This study showed that school children's salt intake behavior observed by their mothers was related to children's salt intake. Children who were observed by their mother to have a liking for salty food ingested more salt than those who did not like salty food. This result may be explained if we consider that school children's salt intake behavior observed by their mothers was more reliable than children's own perception of liking salty food. This indicates the importance of a mother's role in reducing children's salt intake. Showing this result to mothers is expected to motivate them to educate their children to eat less salty food and snacks. Recently, salt intake has become dependent on the amount of salt added by food manufacturers rather than on salt added during cooking or at the table (Samara et al. 2002; Antonio 2000). In Finland, most salt intake derives from manufactured foods, such as bread, meat and fish products (Reinivuo 2007). In this study, more than 90% of subjects preferred high salt content snacks and the frequency of eating cup noodles was associated with salt intake. In addition to individual health education for children, the development of low-salt and reduced salt products, and clear food labeling are also important in consideration of the increased numbers of manufactured foods in Japan.

There are several limitations of this study.

First, we cannot reject the possibility that we could not accurately assess children's salty taste preference. Both the reliability of the question to school children asking about their own salty taste preference, and the reliability and validity of the questionnaire for their mothers asking them about their children's eating behavior in terms of salt intake were not verified. Second, salt intake should ideally be estimated by salt ingested in food, but our study estimated salt intake from the amount of urinary sodium excretion from the second morning voiding urine specimen.

As a future task, measurement of the salt taste threshold using a more sensitive method is needed. Development of a questionnaire with reliability and validity in order to assess children's salty taste preference is also required.

CONCLUSION

Children's salt intake may be accurately assessed by their mother's observation of their salt intake behavior. This study suggests the importance of a mother's role in salt restriction education for children.

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