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Effects of Lifestyles, Dietary Habits, Food Preferences and Nutrient Intakes on Sensitivity to and Preference for Salty Tastes of Korean Women*

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ABSTRACT

This study was performed to investigate factors affecting sensitivity and preference for salty tastes of Korean adult females. Sensitivity and preference for salty tastes were determined as detection threshold concentration of NaCl solution and the optimally-preferred NaCl concentration of the bean sprout soup, respectively. A self-administered questionnaire was used to obtain the information regarding general characteristics, self diagnosis of stress, health-related lifestyle practices, dietary habits and food preferences. Dietary intake using 24-hours recall and blood pressure were measured. Salty taste detection thresholds and optimally-preferred NaCl concentrations were 0.0197% and 0.357%, respectively. There was a significant positive correlation between the optimally-preferred salt concentration and age, despite no significant correlation between either sensitivity or preference for salty taste and sodium intake, which was 3,605mg/day. Those who had bread or cereal with milk as breakfast instead of a traditional Korean meal and those who preferred jjigae to soup had significantly higher NaCl preferences for bean sprout soup. Going to bed after midnight and skipping meals ($\geq$ 3/week) decreased salty taste sensitivity without reaching statistical significance. Self awareness of one's own health, recent weight changes, family history of hypertension, sleep quality, getting-up time, rate of eating and other food preferences did not affect either perception. Stress level, TV watching, BMI and sodium intake did not have significant correlation to sensitivity or preference. Further research including a large number of well-controlled subjects and more accurate measurement of sodium intake should be directed to find other factors affecting salt preference and sensitivity in order to decrease Na intake and related diseases. (*J Community Nutrition* 8(4): 185~192, 2006)

KEY WORDS: sodium intake · salt sensitivity · salt preference · food preference.

Introduction

As a principal cation in extra-cellular fluid, sodium plays an important role in a wide range of physiological phenomenon such as acid-base balance, fluid balance, nutrient transport, neural transmission and muscle contraction. Sodium overconsumption is one of the biggest problems of dietary habits in this country which uses large amounts of soybean paste, soy sauce and red pepper paste as main seasonings. An average Korean was reported to consume 15 − 20g of salt (equal to 6 − 8g of sodium) according to KNHANES (Korea National Health and Nutrition Examination Survey) 2000, while the daily sodium requirement is 200 − 300mg and the WHO recommendation of salt intake is 10g/day.

The perception of sodium chloride as salty taste stimulus not only elicits a sensory response, but also activates a variety of physiologic processes including stimulation of salivation, secretion of gastric enzymes and hormones, enhanced thermogenesis and alterations of cardiovascular functions (Matte 1997) such as high blood pressure, which is the major risk factor for several chronic diseases, namely stroke, other cardiovascular diseases and renal failure.

Among recommendations for blood pressure control including weight control and physically active lifestyle, sodium intake reduction has been suggested to be a key factor for the prevention as well as treatment. Intervention with salt intake reduction was proven to contribute greatly to public health.

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For example, reduction of sodium intake by 3g/day resulted in a 22% reduction of stroke incidence as well as about a 16% reduction of cardiovascular diseases (Law et al. 1991).

As one of the strategies to decrease the sodium intake in modern society, which is struggling with hypertension-related cardiovascular diseases, the issue of salty taste perception including sensitivity and preference deserves to be studied. While there have been many studies reporting on salty taste sensitivity and preference of the subjects in other countries in various areas, including gender difference (Frye, Demolar 1994), aging (Mojet et al. 2005), pregnancy (Bowen 1992) and mineralofluid loss (Leshem 1997), studies on factors affecting salty taste perception of the Korean subjects have been limited to the effect on blood pressure (Choi et al. 1997; Kim 1994), age (Kim, Paik 1992), area (Kim 1994; Kim et al. 1990) and stress state (Jun, Choi 2004). Therefore, the present study aimed to examine the effects of health-related lifestyles, dietary habits, food preferences and nutrient intakes on salty taste perception, namely sensitivity and preference in order to provide basic information for nutrition education focusing salt intake reduction of Korean.

Subjects and Methods

1. Subjects

Subjects of this study were 53 government employees who served as school dietitians or in the area of public health while studying in a courses for qualification of nutrition teachers in 2005 and 2006. None wore dentures and none were smokers. All subjects completed the questionnaire and sensory evaluation including salty taste detection threshold and preference for salty taste. A self-administered questionnaire contained questions regarding general characteristics, self diagnosis of stress, health-related lifestyle practices, dietary habits and food preferences. Data from 2005 and 2006 classes (Table 1) were pooled for the statistical analysis. Stress was assessed by a self-diagnosis sheet (Ministry of Health & Welfare, 1999). The participants were instructed to refrain from eating or drinking anything but water for at least 1 hour prior to being tested.

2. Methods

1) Determination of salty taste sensitivity

The concentration of sodium chloride solution for the determination of detection threshold of salty taste was 0.005%, 0.01%, 0.02%, 0.03%, 0.045%, 0.06% and 0.09%. Sodium chloride solution was made in de-ionized water and allowed to stand to reach room temperature for sensory evaluation after storage at 4℃. The taste threshold concentration was obtained by three-alternative forced choice trials modified from that of other authors (Hong et al. 2005; Kim 1993). Starting with the lowest concentration, subjects were required to distinguish the sodium chloride solution from de-ionized water, even though the subjects could not determine taste quality. The lower concentration was recorded as threshold concentration when the subjects succeeded in two consecutive trials. The detection threshold concentration was considered 0.09%, in case the subjects could not detect different tastes among three cups even at the highest sucrose concentration, 0.09%.

Table 1. General characteristics of the subjects

	2005	2006	Total	
Age (year)	35.57 ± 5.17[1)]	31.96 ± 3.16	34.0 ± 4.70	0.005*[1)]
Height (cm)	158.5 ± 5.03	158.0 ± 5.33	158.3 ± 5.11	0.697
Weight (kg)	55.13 ± 7.62	54.30 ± 7.91	54.77 ± 7.68	0.701
BMI (kg/m^2)	21.90 ± 2.54	21.71 ± 2.50	21.81 ± 2.50	0.790
Snacking/day	1.47 ± 0.68	1.557 ± 0.66	1.51 ± 0.67	0.600
Symptoms of stress				
Physical	3.63 ± 1.75	3.83 ± 1.78	3.72 ± 1.75	0.695
Behavioral	2.73 ± 1.86	2.13 ± 1.66	2.47 ± 1.78	0.226
Psychological	4.50 ± 2.00	3.65 ± 2.39	4.13 ± 2.19	0.165
Blood pressure (mmHg)				
Systolic	113 ± 13.8	110 ± 8.3	112.4 ± 12.6	0.529
Diastolic	76.7 ± 14.8	72.0 ± 8.1	75.5 ± 13.4	0.379
Salty taste threshold (%)	0.0213 ± 0.0182	0.0176 ± 0.0141	0.0197 ± 0.0165	0.420
Optimally-preferred salt concentration (%)	0.367 ± 0.086	0.344 ± 0.087	0.357 ± 0.087	0.339

[1)]Mean ± standard deviation, [2)]p value. *: significantly different at $p < 0.05$

2) Determination of salty taste preference

For the determination of optimally-preferred salt concentration, 900g, 18g, and 1500ml, respectively of bean sprout, kelp and de-ionized water were cooked to boiling at a medium heat and continued to boil for 5 minutes at low heat. After removing bean sprouts, the volume of bean sprout soup was measured and sodium chloride was added to make 0.15%, 0.20%, 0.25%, 0.30%, 0.35%, 0.4% and 0.6%. Bean sprout soup was stored at 4℃ and tasted at room temperature.

3) Blood pressure and nutrient intake

Daily nutrient intakes were analyzed by using CAN Pro 3.0 (Computer Aided Nutritional Analysis for Professionals, Ver 3.0, The Korean Nutrition Society), and blood pressure was determined using sphygmomanometer (Hico, Japan).

4) Statistical analysis

Collected data were processed for significance by using SPSS 14.0K for Windows. Age, stress level, body mass index, hours in watching TV, detection threshold concentration and the optimally-preferred concentration of sodium chloride were shown as mean ± standard deviation. Significant difference between two means was tested by Student's t-test and that among the three means was tested by multiple range test after analysis of variance. Categorical data were analyzed with Chi-square test and correlation between detection threshold concentration, the optimally-preferred sodium chloride concentration and other variables was analyzed by Pearson's correlation coefficient.

Results

Table 1 shows that there were no significant differences between the two groups in height, weight, body mass index, and number of physical, behavioral and psychological stress symptoms except that the subjects of the 2005 class were significantly older than those of the 2006 class. Accordingly, the data from the two groups were pooled for the statistical analysis. Detection threshold and optimally-preferred concentration of sodium chloride for the subjects in this study was determined to be 0.0197 ± 0.0165% and 0.357 ± 0.087%, respectively.

Regular physical examination, self-awareness of own health, weight changes for the past 5 years and family history of hypertension did not affect the salty taste detection threshold and the optimally-preferred salt concentration of the subjects (Table 2).

The subjects who had bread or cereal with milk as a breakfast had significantly higher optimally-preferred sodium chloride concentrations of the bean sprout soup than those who have a traditional Korean meal or uncooked food/rice cake (Table 3). Going to bed after midnight and skipping more than three meals per week tended to increase the salty taste detection threshold although it did not reach statistical significance (Table 3). Sleep quality, time to get up and rate of eating did not show any significant differences in either sensitivity or preference of salt taste.

Table 4 showed that the subjects who prefer jjigae to soup had significantly higher salty taste detection threshold than the others. Preference between fruits vs. vegetable and that between meat vs. fish as well as that between animal vs. plant source did not affect significantly either salty taste perceptions.

The subjects who answered to like salty food did not have increased salty taste detection threshold or the optimally-preferred concentration of sodium chloride compared to those who answered to have lower or average preference (Table 4).

Average intake of protein, phosphorus and sodium were above 125% of the recommendation and the nutrients that

Table 2. Salty taste threshold and maximally-preferred salt concentration according to general characteristics

	Salty taste detection threshold (%)		Optimally-preferred salt concentration (%)	
Regular physical examination				
Yes	0.017 ± 0.015 (32)[1)]	.198[2)]	0.352 ± 0.079 (32)	.606
No	0.023 ± 0.018 (21)		0.364 ± 0.099 (21)	
Self awareness of own health				
Fair	0.015 ± 0.015 (14)	.388	0.340 ± 0.104 (14)	.239
Average	0.021 ± 0.018 (34)		0.371 ± 0.077 (34)	
Bad	0.024 ± 0.009 (5)		0.310 ± 0.089 (5)	
Weight change for the past 5 years				
Gained	0.018 ± 0.013 (29)	.461	0.366 ± 0.089 (29)	.444
Maintained	0.021 ± 0.019 (19)		0.337 ± 0.091 (19)	
Lost	0.027 ± 0.022 (5)		0.380 ± 0.045 (5)	
Family history of hypertension				
Yes	0.020 ± 0.020 (28)	.896	0.370 ± 0.084 (28)	.250
No	0.019 ± 0.012 (25)		0.342 ± 0.089 (25)	

1) Mean ± standard deviation (number of subjects)
2) p value

Table 3. Salty taste threshold and optimally-preferred salt con-centration according to health-related lifestyle practice and dietary habits

	Salty taste detection threshold (%)		Optimally-preferred salt concentration (%)	
Sleep quality				
Good	0.020 ± 0.014 (44)[1]	.869[2]	0.360 ± 0.094 (44)	.506
Poor	0.021 ± 0.027 (9)		0.339 ± 0.033 (9)	
Time to go to bed				
Before midnight	0.018 ± 0.013 (46)	.057	0.355 ± 0.092 (46)	.804
After midnight	0.031 ± 0.029 (7)		0.364 ± 0.038 (7)	
Time to get up				
Before 7 am	0.018 ± 0.014 (44)	.204	0.363 ± 0.090 (44)	.277
After 7 am	0.026 ± 0.025 (9)		0.328 ± 0.067 (9)	
Skipping meals (> 3/week)				
Yes	0.024 ± 0.018 (27)	.060	0.370 ± 0.084 (27)	.242
No	0.015 ± 0.013 (26)		0.342 ± 0.089 (26)	
Rate of eating				
Fast	0.025 ± 0.021 (15)		0.387 ± 0.095 (15)	
Average	0.018 ± 0.016 (29)	.357	0.348 ± 0.082 (29)	.260
Slow	0.016 ± 0.010 (9)		0.333 ± 0.083 (9)	
Type of breakfast				
Traditional	0.020 ± 0.016 (22)		0.330 ± 0.072 (22)[a3)]	
Bread/milk/cereal	0.022 ± 0.023 (13)	.783	0.412 ± 0.087 (13)[b]	.021
Uncooked food/rice cake	0.018 ± 0.011 (18)		0.350 ± 0.089 (18)[a]	

1)Mean ± standard deviation (number of subjects)
2)p-value
3)Values with the same superscript are not significantly different at p = 0.05.

Table 4. Salty taste threshold and maximally-preferred salt con-centration according to food preference

	Salty taste detection threshold (%)		Optimally-preferred salt concentration (%)	
Food source				
Prefer plant (15)	0.021 ± 0.010[1]		0.357 ± 0.128	
Equally prefer plant and animal (17)	0.021 ± 0.023	.759[2]	0.374 ± 0.070	.564
Prefer animal (21)	0.018 ± 0.015		0.343 ± 0.051	
Favorite plant food source				
Prefer vegetable (25)	0.022 ± 0.019		0.356 ± 0.077	
Equally prefer vegetable and fruit (4)	0.020 ± 0.018	.667	0.325 ± 0.064	.732
Prefer fruits (24)	0.018 ± 0.013		0.363 ± 0.100	
Preference for soup vs. jjigae				
Soup (23)	0.017 ± 0.013		0.324 ± 0.071[a3)]	
Equally prefer soup and jjigae (8)	0.015 ± 0.014	.225	0.356 ± 0.068[ab]	.031*[3]
Jjigae (22)	0.024 ± 0.020		0.391 ± 0.097[b]	
Favorite animal food source				
Prefer fish (20)	0.017 ± 0.009		0.368 ± 0.110	
Equally prefer fish and meat (28)	0.022 ± 0.021	.468	0.343 ± 0.052	.422
Same (5)	0.015 ± 0.010		0.390 ± 0.134	
Preference for salty foods				
Yes (9)	0.020 ± 0.014	.956	0.372 ± 0.051	.558
No (44)	0.020 ± 0.017		0.353 ± 0.092	

1)Mean ± standard deviation (number of subjects)
2)p value
3)Values with the same superscript are not significantly different at p = 0.05.

Table 5. Nutrient intake and the proportion of underconsume and overconsume

	Daily intake	% Recommendation[1)]	Number of subjects with intake	
			Less than 75%[4)]	More than 125%
Energy (kcal)	1,638 ± 360	82.9 ± 18.0[2)]	20(37.7)	1(1.9)
Protein (g)	67.5 ± 27.0	149.4 ± 52.1	2(3.8)	32(60.4)
Fiber (g)	13.3 ± 9.55	57.9 ± 41.5[3)]	35(66)	4(7.5)
Calcium (mg)	589 ± 368	84.1 ± 52.5	30(56.6)	5(9.4)
Phosphorus (mg)	929 ± 269	132.7 ± 38.5	0(0)	27(50.9)
Iron (mg)	13.1 ± 5.84	93.8 ± 41.7	17(32.1)	8(15.1)
Sodium (mg)	3,605 ± 1.58	240.3 ± 105.3[3)]	0(0)	49(92.5)
Potassium (mg)	2,658 ± 1,026	56.6 ± 21.8	45(84.9)	1(1.9)
Zinc (mg)	8.59 ± 5.25	107.4 ± 65.6	18(34)	10(18.9)
Vitamin A (μg)	744 ± 362	114.4 ± 55.6	11(20.8)	17(32.1)
Thiamin (mg)	1.03 ± 0.45	86.1 ± 37.6	23(43.4)	6(11.3)
Riboflavin (mg)	1.13 ± 0.51	95.0 ± 42.8	19(35.8)	8(15.1)
Niacin (mg)	13.5 ± 4.90	96.4 ± 35.0	14(26.4)	9(17)
Ascorbic acid (mg)	108 ± 58.3	108.3 ± 58.3	17(32.5)	12(22.6)
Cholesterol (mg)	297 ± 119	98.9 ± 39.6		

1) Recommended intake according to Dietary Reference Intake for Koreans (2005)
2) Estimated energy requirement to Dietary Reference Intake for Koreans (2005)
3) Adequate intake to Dietary Reference Intake for Koreans (2005)
4) Number of subjects (%)

Table 6. Pearson's correlation coefficients between salty taste perception and sodium intake

	Salty taste threshold	Optimally -preferred salt concentration	Age	BMI	Physical stress	Behavioral stress	Psychological stress	Hours watching TV	Na intake	Na/ energy	Na/K
Salty taste threshold	1	.136	−.014	.067	−.053	.037	.211	−.234	.046	.165	.134
Optimally-preferred salt concentration	.136	1	.420*[1)]	−.041	−.178	−.251	−.081	−.025	−.047	.039	.086

1) Significantly correlated at $p < 0.05$

were consumed less than 75% of the recommendation were fiber and potassium (Table 5). Table 5 also showed that energy, fiber, calcium, potassium, zinc, thiamin and riboflavin were the nutrients that more than one third of the subjects consumed less than 75% of the recommendation, while protein, phosphorus and sodium were those of which more than one third of the subjects consumed more than 125% of the recommendation. Average sodium/potassium intake was 1.42 ± 0.47 for the subjects of this study.

Table 6 showed that there was a significant positive correlation between the optimally-preferred salt concentration and age, while there was no significant correlation between salt taste perceptions and sodium intake as well as sodium/energy intake or sodium/potassium intake. Body mass index, time spent in watching TV, and number of physical, behavioral and psychological stress symptoms did not have any significant relationship to either salty taste detection threshold concentration or the optimally-preferred salt concentration (Table 6).

Discussion

For the subjects of this study, detection threshold concentration of sodium chloride was determined to be 0.0197 ± 0.0165%, which is much lower than 0.057 − 0.065% reported for the 7 − 16 year-old children residing in an orphanage in Seoul and Kangnung areas (Kim 1994) but a little higher than 0.01637% reported for young women (Hong et al. 2005), suggesting that the sensitivity for salty taste keeps developing until it reaches the maximum in early adulthood and then declines with aging. James et al. (1997) also concluded that the taste sensitivity of 8 − 9-year-old males, although well developed, has not fully matured from the results that they had significantly higher thresholds for all 4 tastants (sucrose, sodium chloride, citric acid and caffeine) than adult females, for all tastants except caffeine than adult men, and for sucrose and sodium chloride than female children. This result is consistent to those reported by Kim et al. (1990) in that the detection threshold of the sodium chloride is much higher in 10 year-old children than in their own mothers.

For the subjects (average age = 34.0) in this study, optimally-preferred salt concentration determined with bean sprout soup was 0.357±0.087%, which is higher than 0.25 – 0.29% for female university students at the average age of 21.3 (Jun, Choi 2002) but lower than 0.489% for middle-aged women (Kim, Paik 1992) and 0.473% for normotensive children (Kim et al. 1993). While detection threshold concentration of salt is measured by actually the same method in various studies, salt preferences have been determined with different kinds of foods such as pop corn (Kanarek et al. 1995; Frye, Demolar 1994), mashed potatoes and bread (Shephard et al. 1984) and beef broth (Jun, Choi 2002; Choi et al. 1997; Kim, Paik 1992). How much the measurements of optimally-preferred salt concentration can be affected by different tools depending on studies is not known at this time.

In this study, there was no significant correlation between either salt sensitivity or salt preference and sodium intake as well as sodium/energy intake or sodium/potassium intake, while there was a significant positive correlation between salt preference and age. These results are consistent to other reports (Laucer et al. 1976; Matte 1987) that also found no significant correlation between the sensitivity to salt, measured as thresholds for detection or recognition of the quality of sodium chloride and supra-threshold intensity ratings for graded sodium chloride concentrations, and measures of salt preference.

Although there was no significant difference in salty taste sensitivity and preference according to body mass index or weight change for the past 5 years in the present study, the effect of obesity on taste perception has been the subject of many studies, primarily on sweet tastes. In overweight adults (Drewnowski et al. 1985) and overweight young subjects (Warwick, Schiffman 1990) hedonic responses are predominantly modified by sucrose. In the study to test the effect of swallowing vs. spiting of sucrose solutions, Eiber et al. (2002) showed that fear of swallowing influenced hedonic responses.

The result of this study was consistent with the other study (Yim et al. 2005) reporting that there was no significant correlation between salty taste sensitivity and blood pressure, even though different measurements were used for the taste sensitivity, namely recognition threshold vs. detection threshold, respectively in their study and this study.

No significant correlation between either salt perception or sodium intake and blood pressure may be partly due to all the subjects in this study had normal blood pressures. Park et al. (2000) reported that the sodium intake of the subjects with hypertension was lower than those with normal blood pressure, suggesting that hypertensive have higher concerns of health, have changed dietary habits directly by illness, or are sensitive to medical advice. Positive correlation between optimum gustation of salt and diastolic blood pressure was reported by other authors (Kim, Paik 1992).

The meaning that the subjects having bread or cereal with milk as breakfast rather than a Korean traditional meal consisting of rice and soup prefer significantly higher salt concentration of bean sprout soup is not clear at this time, but may present another reason to encourage, especially the young generation to 'enjoy a Korean traditional meal containing rice as a staple', as shown in dietary guidelines for children by the Ministry of Health & Welfare. The results that the subjects who prefer jjigae to soup had significant preference for salt may be related to the general assumption that jjigae contains more salt than soup.

The subjects who answered to like salty food did not have significantly higher optimally-preferred salt concentration compared to those who answered to have lower or average preference, suggesting that the assessment of salty taste preference by using a self-administered questionnaire may not be a valid determination.

No significant effect of stress on salty taste sensitivity or preference found in this study has also been reported by the other author (Jun, Choi 2004) who tested with the female university students and suggested that it may be partly due to the stress levels of subjects, which were in a normal range.

The proportion of the subjects who indicated consumption of more than 125% of adequate amount of sodium reached 92.5%. Therefore, the result of the present study is reassuring the significance of sodium overconsumption, especially considering that the subjects of this study were the most health-oriented group in Korea. On the other hand, sodium intake of the subjects in this study, which was 3,605mg/day was much less than that reported in the study with 25 – 60 year-old adults, which was 4,868.5mg/day (Son et al. 2005).

Studies on the correlation between sodium intake and salt preference have produced relatively confusing outcomes, with some reporting significant positive correlation and others finding none. Kim et al. (1990) also found no correlation between salt taste preference and sodium intake determined by urinary sodium excretion or dietary record, while other researchers (Kim, Paik 1987) reported a positive correlation between salty taste preference and urinary sodium excretion, suggesting that decreasing salty taste preference may be able to reduce intake of sodium, especially discretionary sodium.

The result of this study is consistent with that reported by Drewnowski et al. (1996) which observed that salt taste acuity and preference were unrelated to sodium intakes in young adults and in older respondents and factors other than taste may influence dietary sodium consumption. The common assumption that preference for elevated salt taste leads to higher salt intake remains to be clarified in future research by using more accurate methods to determine sodium intake, namely urinary sodium excretion rather than dietary recall. Matte (1997) also found a lack of consensus in the results of the studies comparing sodium intake and hedonic ratings, primarily due to the methods assessing sodium intake and preference.

Summary and Conclusion

Fifty three Korean middle-aged females were the subjects of the study to examine the effects of general characteristics, health-related lifestyles, dietary habits, food preferences and intake of nutrients including sodium on the salty taste perceptions. Sensitivity and preference for salty tastes were determined as detection threshold concentration and the optimally-preferred salt concentration, respectively and self-administered questionnaire was used to obtain the questions regarding general characteristics, self diagnosis of stress, health-related lifestyle practices, dietary habits and food preferences. Nutrient intake was determined by 24-hour dietary recall for two days.

For the subjects in this study, salty taste detection threshold was determined to be 0.0197% and optimally-preferred salt concentration determined with bean sprout soup was 0.357%. There was a significant positive correlation between the salt preference and age, while there was no significant correlation between either salt taste sensitivity or preference and sodium intake.

The mechanism by which having bread or cereal with milk as a breakfast instead of a traditional Korean meal and preference for jjigae to soup increased the optimally-preferred salt concentration of bean sprout soup remains to be explained in a further study. The subjects who answered to like salty food did not significantly increase salty taste detection threshold or the optimally-preferred salt concentration compared to those who answered to have lower or average preference, suggesting that the assessment of salty taste preference by using self-administered questionnaire may not be valid determination.

For additional information on the effects of drinking, smoking and exercise on the salty taste sensitivity and preference as well as clarification of the common assumption that preference for a stronger salty taste result in higher salt intake, further studies including a large number of well-controlled subjects and more accurate analysis of sodium intake are needed.

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