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일부 산업체 근로자의 Sodium섭취에 관한 연구*

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Sodium Intakes of Some Industrial Workers

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국 문 초 록

본 연구는 산업체 근로자의 Sodium섭취 실태를 파악하므로서 효율적인 식사관리와 건강관리의 기초자료를 얻고자 서울 시내 H타이어 공장에 근무하는 건강한 성인남자 40명을 대상으로 3일간의 식사분석과 뇨분석을 행한 것이다.

열량섭취는 1일 평균 3,185±813 (mean±SD) kcal 였으며 영양소 섭취량은 당질이 541.8±144.5g, 단백질이 127.2±61.0g, 지방질이 56.8±42.7g이었고 총 열량의 68%, 16%, 16%를 차지했다. 식사분석에 의한 Sodium섭취량은 225.3±75.2mEq(13.2±4.4g Nacl)였으며 뇨중의 Sodium 배설량은 232.8±63.8 mEq(13.7±3.5g NaCl)였다. 주요 음식의 1회 순섭취량에 대한 Sodium섭취는 국종류에서 가장 많았으며 1일 섭취하는 식사의 Sodium분포는 밥에서 6.9%, 국 35.7%, 반찬류 49.4%, 식탁에서사용하는 조미료로서 5.1%, 간식에서 2.9%이었다. 당질섭취와 Sodium섭취, 단백질 섭취와 Sodium섭취 사이에는 강한 양의 상관을 보였다.

KEY WORDS : sodium intake · sodium excretion.

Introduction

As an indispensable component of the homeostatic systems, sodium plays a key role in the control of acid-base balance, water balance and osmolarity in the body fluids, However epidemiological studies indicate an association between sodum intake and the prevalence of hypertension.

Ambard and Beaujard[1] pointed out that man consumes more salt than is needed physiologically. Further Meneely[2] suggested sodium intakes might be dependent on cultural and geographical factors rather than on physiological needs. Several investigators reported high sodium intakes of Koreans[3-5]. Some indicated that typical Korean diets high in carbohydrate and less protein, mi-

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ght lead to increase sodium consumption[6]. The Korean national dietary survey conducted in 19 86, presented carbohydrate consumption of whole population was 71.4% of total energy[7].

In recent years, the leading causes of death in Korea are known to be cardiovascular diseases, one of whose primary risk factors is hypertension[8]. Hence public interest in dietary treatment of hypertension should be concerned, because of the role of excess dietry sodium in the development of hypertension.

Sodium intakes of Koreans among different groups have been investigated. However information on sodium intakes of Korean workers in an industry is limited.

The objectives of this study were to collect analytical data for sodium consumption and excretion in normal healthy Korean industrial workers. The data from this study will provide the core informations needed for planning the food management in the industrial food service organizations for the workers

Subjects and Methods

46 healthy male workers were recruited from the H tire company in seoul, Korea. All these men lived in the dormitory and ate all three meals for three consecutive days in the dormitory cafeteria. Weight, height and blood pressure were taken from each subject by a trained nurse. Urine samples were collected for one day. Creatinine was determined and used to assess completeness of 24-h urine collection. If urinary creatinine level was below 800mg, the 24-h urine collection was considered incomplete and excluded from this study. Thus 6 subjects were excluded, judged from the result of urine analysis.

Diet

Food consumption was calculated by weighing the food items before and after eating. Each subject prepared a duplicate composite of all food they consumed during three twenty-four hour periods. 100g of composites were transported to the lab and homogenized and aliquots were kept frozen at $-25\ ^{\circ}C$ for further analysis. Information on snacks eaten between meals was obtained by 24-h dietary recall. The subjects were asked to recall food items, in addition to manufacturing company of snacks. Same types of food items eaten between meals were purchased, prepared and kept frozen for analysis. Table salts were weighed, given to the subjects, calculated the residue and recorded the weight consumed.

Analysis

During the study periods, polyethylene bottle containing 10g of boric acid was provided to each subject. 24-h urinary collection was made starting on the second day of food consumption. Various food items and urine were analyzed for sodium content by use of an atomic absorption spectrophotometer(Hitachi 170-30).

Statiatics

Data were expressed as mean± SD. Correlation coefficients were used to establish relationships among all variables. The variables studied were carbohydrate intake, protein intake, sodium intake and blood pressure.

Results and Discussion

The number, age, weight, height, blood pressure of subjects are shown in Table 1. Subjects were between the age of 20−35 yrs. Average height and weight of subjects were similar to those of men in Korean national nutrition survey conducted in 1986. Average systolic blood pressure was 120.3± 12.6mmHg and diastolic blood pressure averaged 75.8± 7.5mmHg.

Table 1. Blood pressure, weight, height and age of the subjects

Age years	No. of subject	Weight kg	Height cm	S.B.P[2] mmHg	D.B.P[3] mmHg
20-25	11	64.2± 4.9[1]	171.0± 5.0	118.6± 8.0	75.3± 5.2
26-30	27	64.1± 4.7	171.5± 3.5	120.6± 14.3	75.7± 8.5
31-35	2	63.5± 2.5	1680 ± 0.0	125.0± 0.0	80.0± 0.0
Mean		64.1± 4.7	170.6± 4.1	120.3± 12.6	75.8± 7.5

1) Mean± S.D.
2) S.B.P. : Systolic blood pressure
3) D.B.P. : Diastolic blood pressure

Table 2. Activity category of subjects

Classification	No. of subject	Percentage %
Moderate	13	32.5
Heavy	17	42.5
Very heavy	10	25.0
Total	40	100.0

Table 2 presents activity category of subjects[9] 42.5% of all subjects were engaged in heavy activity while 32.5% of the subjects were engaged in moderate activity. The rest were engaged in very heavy activity.

The average food energy intakes of subjects were 3,815± 813 kcal/day. Mean daily intakes of carbohydrate, protein and fat were 541.8± 144.5g, 127.2± 61.0g and 56.8± 42.7g, providing 68%, 16 %,and 16% of total energy respectively(Table 3). In addition, subjects consumed average 976± 148g/meal.

As shown in Table 4, mean sodium intake for all subjects for three days was 225.3± 75.2mEq/day(13.2± 4.4g NaCl/day). The intake level exceeded the values of other reported intakes for Westerners[10)11)]. Furthermore the sodium intake level of workers in this study slightly exceeded that of Japanese workers found in Japanese nutritional survey[12]. Japanese workers consumed 12. 1g NaCl/day. Other reported intakes for Koreans were generally high. Lee et al[4] analyzed nutrition survey for residents in a fishing village and reported their average daily intake of salt as 23. 4g. Similarly Jun[13] estimated mean intakes of 22 g NaCl/day from normal Korean adult subjects. On the other hand, Kim and cocoworkers[14] demonstrated that normal adult subjects reduced

Table 3. Average nutrient intakes of the subjects

Days	Energy kcal	Carbohydrate g	Protein g	Fat g
1st	3264± 851[1]	545.8± 140.7	116.0± 30.4	68.6± 26.1
2nd	3277± 774	510.1± 138.3	149.8± 66.8	70.9± 58.7
3rd	3001± 779	571.1± 148.2	115.3± 43.5	29.7± 14.7
Average	3185± 813	541.8± 144.5	127.2± 61.0	56.8± 42.7
% of total Calorie		68	16	16

1) Mean± S.D(n=40)

Table 4. Dietary intakes and urinary excretion of sodium of the subjects

	Intake			Excretion		
	Na		NaCl	Na		NaCl
	mEq/day	g/day	g/day	mEq/day	g/day	g/day
1st day	223.6± 70.9[1)]	5.16± 1.64	13.1± 4.2	–	–	–
1nd day	197.3± 62.9	4.54± 1.45	11.5± 3.7	232.8± 63.8	5.40± 1.36	13.7± 3.5
3rd day	256.5± 79.6	5.91± 1.82	15.0± 4.6	–	–	–
Average	225.3± 75.2	5.19± 1.73	13.2± 4.4	232.8± 63.8	5.40± 1.36	13.7± 3.5

1) Mean± S.D.(n=40)

Table 5. Distribution of subjects by the level of salt intakes

Level of total salt intake[1)] g/day	No.of subject	Percentage of total subjets %
3-5	1	2.5
6-8	1	2.5
9-11	11	27.5
12-14	12	30.0
15-17	12	30.0
18-20	3	7.5

1) Average intake of salt was 13.2± 4.4g/day.

their salt intake after having been educated, suggesting effective nutrition education is needed to decrease sodium intake of general population. Despite the fact our subjects in this study were workers with excessive sweating, their sodium intake was not so high as expected, when compared with other observations for Koreans. In fact, subjects in this study were not trained to reduce their salt intake. Possibly workers were adapted to their working environment, since they had worked for more than one year. More research should be done to elucidate the mechanism involved in this area.

When subjects were distributed by the level of salt intakes(Table 5), 67.5% of subjects consumed more than 12g salt/day. Furthermore 7.5% of subjects took more than 18g/day.

In the present study, the daily urinary sodium excretion was estimated to be 232.8± 63.8mEq (13.7± 3.5g NaCl). Caggiula et al[15] reported that normal subjects excreted 149.4mEq of urinary sodium while Suh[5] also estimated the urinary sodium excretion of male adult to be 250.3± 107.

Table 6. Distribution of food sources in the dietary sodium intake

Days		Boiled rice	Soup	Side dish	Table salt	Between meal
1st		354.0± 93.1	1798.4± 1027.8	2515.5± 939.1	292.5± 597.9	170.3± 296.6
mg	%	6.9	35.05	49.03	5.7	3.3
2nd		338.3± 96.9	1520.8± 718.6	2281.4± 947.1	238.9± 595.5	159.1± 232.0
mg	%	7.5	33.5	50.3	5.3	3.5
3rd		386.4± 102.0	2241.4± 1162.4	2885.5± 1016.9	266.8± 459.0	120.0± 197.3
mg	%	6.5	38.0	48.9	4.5	2.0
Mean± S.D.		359.4± 98.1	1849.2± 1027.9	2559.2± 999.5	266.1± 556.6	150.3± 247.1
mg	%	6.9	35.7	49.4	5.1	2.9

0mEq. Our findings were similar to Suh's.

Daily intake of sodium from dietary analysis was estimated to be 5.16± 1.64g on the first day and 4.54± 1.45g on the second day of study periods. However, the amount of sodium excreted in the urine was 5.40± 1.36(Table 4). Thus daily intake of sodium by the daily urinary excretion of this ion is not agreeable to that from dietary analysis. This difference may be due to the fact that urinary samples for analysis in this study were obtained from the second day of food collection periods. Previously Sasaki et al[16] reported that urinary sodium excretion reflected the amount of dietary sodium ingested two or three days before. It may be further suggested that more 24-hour urinary collections were made to estimate the accurate and reliable sodium intake, due to the time lag between ingestion and excretion of urinary sodium. According to De Wardner[17], it was assumed 85% of sodium was excreted in the urine. Based on this assumption it was estimated to be the average daily NaCl intake of the subjects at 16.14g/day in the study. Hence average sodium intakes of our subjects were in the range of 13−16g.

Sodium intake was significantly corrlated with carbohydrate consumption in this study($P<0.001$)(Fig. 1). This finding is agreeable to Kim's [6]. Furthermore data in figure 2 showed a significant positive correlation existed between protein intake and sodium intake, which is conflicted with Yi's[18]. However this result is consistent with other investigators'[6][19]. The result indicated that animal protein source may contain high amount of sodium, contributing to increase sodium intake. Therefore animal protein source should be given special consideration to reduce sodium intake, especially in hypertensive patients.

When main food sources were concerned,

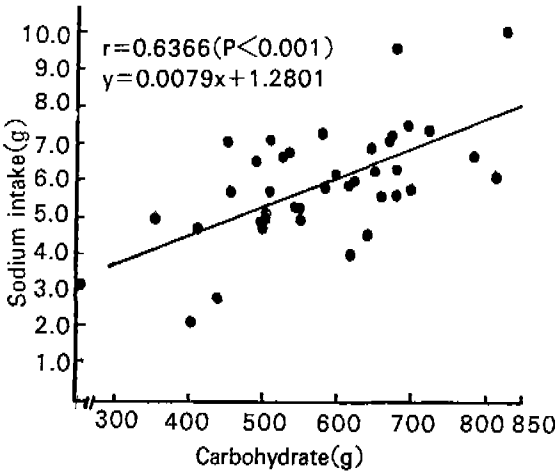

Fig. 1. Carrelation between carbohydrate and sodium intake.

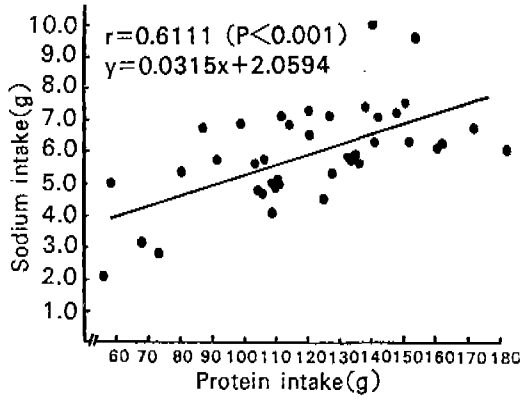

Fig. 2. Correlation between protein and sodium intake.

amount of average intake of sodium from one serving size was calculated(Fig. 3). In soup group, beef soup was found to contain the highest amount of sodium. Conversely sodium content in chicken soup was the lowest. In the part of side dish, seasoned buckwheat and vegetable was the source of the highest amount of sodium. In cabbage kimchi, subjects took average 387.9± 146.2mg of sodium from one serving size while daily sodium intake from kimchi was 1,080.2± 458.1mg(2.74g NaCl)(Fig. 3).

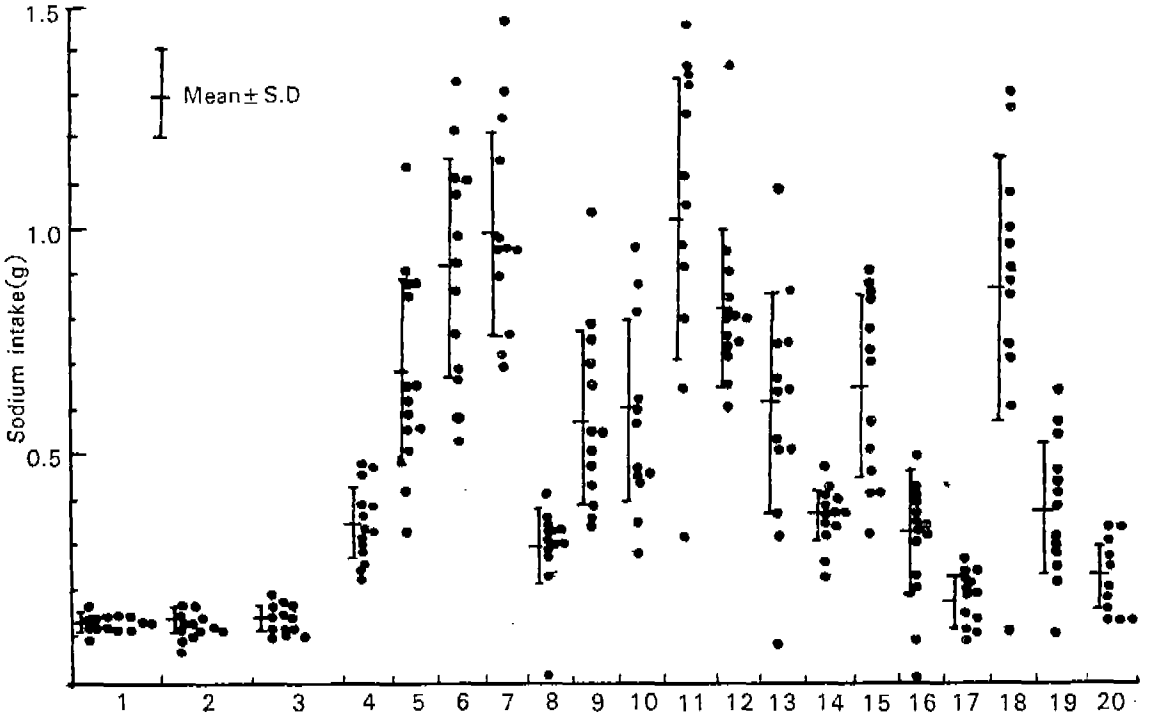

Fig. 3. Amount of average intake of sodium from one serving size in main food.

*Food items
1. Cooked rice with barley
2. Cooked rice with soybean
3. Cooked rice with small red bean
4. Soybean sprout soup
5. Cabbage with soybean paste soup
6. Sea mustard with chicken soup
7. Sea mustard with beef soup
8. Chicken soup
9. Potato with soybean paste soup
10. Sea mutard with clam soup
11. Beef soup
12. Seasoned pork with vegetable
13. Seasoned Spanish mackerel with raddish
14. Seasoned spinach boiled
15. Seasoned Alaska pollack
16. Seasoned soybean sprout
17. Fried hair tail
18. Seasoned buckwheat and vegetable
19. Kimchi, cabbage
20. Kagduki kimci, raddish

In addition, amounts of sodium in the different food sources for three days were analyzed and compared. Table 6 provides information on the sodium content in various food composites. These data suggested that side dishes contributed the highest amount of sodium. Of side dishes kimchi was the most important source of sodium for our subjects.

Generally it has been known that the major source of sodium is from kimchi. Results in this study showed that sodium content of kimchi and other side dishes per 100g were high. However subjects did not take kimchi a lot at a time on the table. Therefore, kimchi did not contribute mostly. On the other hand, soup group is the major contributor to increase sodium intake on the table. Thus it would be more relevant and prudent to reduce sodium consumption by limiting frequency and amount of soup intake.

Summary

The present study was undertaken to evaluate

the sodium consumption and excretion in forty healthy male workers of a tire company in Seoul area. The average food energy intakes of the subjects were 3,815± 813 (mean± SD) kcal/day. Mean daily intakes of carbohydrate, protein and fat were 541.8± 144.5g, 127.2± 61.0g and 56.8± 42.7g, providing 68%, 16% and 16% of total energy, respectively. Mean sodium intake for three days was 225.3± 75.2mEq(13.2± 4.4g NaCl) and the urinary excretion of sodium in 24 hours was 232.8± 63.8mEq(13.7± 3.5g NaCl). The main food source of sodium intake from one serving of each meal was soup group. In this study sodium intake was significantly associated with protein and carbohydrate consumption.

Results suggest that it can be more relevent and prudent to reduce sodium consumption by limiting frequency and amount of soup intake.

Literature Cited

1) Ambard L, Beaujard E. Cause of aterial hypertension. *Arch Gen Med 1* : 520-525, 1904
2) Meneely GR. Editoreal. *Am J Med 16* : 1-3, 1954
3) Lee SW, Chun KS, Lee JD, Lee SH, Lee BH. A study on the salt intake of Koreans. *Korenan J Intern Med 11* : 715-720, 1968
4) Lee KY, Ham JR, Kim YH, Kim HS. Nutrition survey in a Korean fishing area. *Korean J Nutr 8* : 109-117, 1975
5) Suh SK. Sodium(salt) intake-urinary excretion and its reference to hypertension in Korea. *Human Science 4* : 833-862, 1980
6) Kim KY, Lee KY, Shin TS. Effect of sodium chloride intake related to the composition of the diet. *Korean J Nutr 6* : 253-260, 1973
7) Ministry of health and social affairs, Republic of Korea. *Nation-wide nutritional Survey.* Seoul, 1986
8) Ministry of health and social affairs, Republic of Korea. *Yearbook of health and social statistics 33* : 258-259, 1987
9) Korea institute for population and health. *Recommended dietary allowances for Koreans.* 4th ed. Gomunsa. 1985
10) Pieten PI, Wong O, Altschul AM. Electrolyte output blood pressure and family history of hypertension. *Am J Clin Nutr 34* : 997-1005, 1979
11) Dahl LK. Salt intake and salt need. *N Engl J Med 258* : 1152-1157, 1958
12) Department of health promotion and nutrition. *Japanese ministry of public health.* 3rd ed. 83-86, Jeil publishing Co LTD, 1985
13) Jun KY. Sodium, potassium and chloride concentration in serum and urine and volume of 24 hours urine in normal Korean adults. *Sudo Medical School J 1* : 149-164, 1964
14) Kim KS, Shin DC, Lee SJ. A study on the salt intake and urinary sodium excretion by group educated regarding low salt diet. *Korean J Nutr 13* : 187-194, 1980
15) Caggiula AW, Wing RR, Nowwalk MP, Milas NC, Lee S, Lang H. The measurement of sodium and potassium intake. *Am J Clin Nutr 42* : 391-398, 1986
16) Sasaki N, Kiguji T. *Salt and nutrition.* 13-14, Jeil publishing Co LTD, 1980
17) De Wardner HE. The kidney. Little, Brown and Company, Boston, 3rd ed. 71, 1967
18) Yi SY. Studies on electrolyte and nitrogen metabolism of the Korean. *Korean J Intern Med 8* : 717-731, 1965
19) Park TS, Lee KY. A study on the sodium and potassium intake and their metabolism of university student in Korea. *Korean J Nutr 18* : 201-208, 1985