



Original article

Sodium intake and prevalence of hypertension, coronary heart disease, and stroke in Korean adults



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ABSTRACT

Background: Despite all the research that has been conducted so far on the correlation between sodium intake and hypertension, coronary heart disease, and stroke, the results thereof have no consistency.

Methods: By utilizing the data of the Korea National Health and Nutrition Examination Survey conducted by the Korea Centers for Disease Control and Prevention, we carried out a more systematic investigation on sodium intake and prevalence rates in Korean adults. Sodium intake per kilogram, on which sodium intake is divided by weight, was applied to a model as a variable and the data has been separately analyzed according to sex. The total number of observed values after outlier elimination was 27,346, including 10,936 men and 16,410 women.

Results: It was found that there is a positive correlation between sodium intake and prevalence rates of coronary heart disease, while potassium intake has a negative correlation with prevalence rates of hypertension and stroke.

Conclusion: In order to control the effect of sodium on diseases, attention must also be paid to the influence of potassium on diseases as a covariate, and it is considered that additional research should be made regarding the role of potassium in studying the impact of sodium on health in the future.

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1. Introduction

With many research results announcing that sodium intake has a positive correlation with hypertension and cardiovascular disorders, it seems that the correlation between sodium intake and prevalence rates of such diseases have largely been revealed in the scientific circle. Based on this, the World Health Organization (WHO) is recommending a reduction of daily sodium intake to 2,000 mg. However, only a few countries show a lower than average sodium intake for adults than the WHO's recommendation [1]. In Korea, the average sodium intake for adults is about 4,293.4 mg, which is more than twice of the WHO recommendation despite sodium reduction projects, and 81% of adults take more sodium than the WHO recommends [2]. It is a similar situation in other nations: the percentage of people who eat more sodium than the WHO's recommendation is 86.2% for the US, 44% for Mexico, 89.1% for France, and 83.4% for the UK. Indeed, excessive intake of sodium is a global issue [3].

For ethical food, sodium intake is quite important in any country. Sodium channels play a critical role in life support of the human body and it is an essential ingredient when bringing out flavor in food [4]. As shown in Kwon et al [5], many Korean ethical foods such as *kimchi*, sauces, soups, and side dishes need sodium to have flavor, and nutritionists are very sensitively responding to Koreans' sodium intake. Some scholars worry that if the current trend of sodium intake continues [2], it would have a negative impact on the average life span of the Korean people due to cardiovascular disease, etc.

Several research results have recently been published which show that for people without cardiovascular disease, less sodium intake increases their death rate from cardiovascular disease. The research by Stolarz-Skrzypek et al [6] revealed that when daily excretion of sodium in urine was 100 mmol (about 2,300 mg) more, systolic blood pressure increased by about 1.7 mmHg, but it had no correlation with a high risk of hypertension and cardiovascular disease. Rather, less sodium excretion led to a higher death rate from cardiovascular disease. Cohen et al [7] assumed that the group of people whose daily sodium intake is less than 2,300 mg, have a 1.37 times higher death rate from cardiovascular disease than its counterpart whose sodium intake is more than

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2,300 mg. In addition, Alderman [8] explained that less sodium intake by 1,725 mg to 2,300 mg reduces blood pressure by 1–2 mmHg, and less sodium intake reduces stroke and heart attacks by dropping blood pressure. Therefore, he argues that although limitation on sodium intake could be helpful to health by dropping blood pressure, we have to recognize the fact that such a limitation is not expected to extend a human's life expectancy. Also, through the study on the risk of stroke and intake of potassium, which is known to be involved in sodium excretion, Bazzano et al [9] drew a result that the risk of stroke increases with less potassium intake. In addition, in the result of their recent study on nutritional epidemiologic survey of *kimchi*, Korea's representative fermented food and prevalence rate of hypertension, Song and Lee [10] found that there is no correlation between high consumption of *kimchi* and the prevalence rate of hypertension.

As mentioned in the above, although many studies have been made so far regarding sodium intake and the prevalence rate and incidence rate of hypertension, coronary heart disease, and stroke, the results thereof remain inconsistent. Furthermore, Korean people show the so-called "Korean Paradox", by which people have a low prevalence rate of hypertension and death rate from cardiovascular disease despite their high sodium intake [11,12]. Study on such a Korean Paradox now draws the attention of many people. Therefore, we have to carry out a more systematic assessment on the health risk developed by sodium through comparing differences in prevalence rates of hypertension, coronary heart disease, and stroke according to sodium intake of Korean adults.

In the present research, we will examine the impact of sodium intake on the prevalence rates of hypertension, coronary heart disease, and stroke by utilizing the data of the Korea National Health and Nutrition Examination Survey (KNHANES) which assessed health and nutrient intakes of the whole nation. Considering the fact that required individual sodium intake would vary according to their weight, the value was calculated by dividing daily sodium intake by weight and used as a sodium intake variable.

2. Data and methods

In order to estimate the odds ratio of sodium intake on hypertension, coronary heart disease, and stroke in Korean adults, we used the data of the KNHANES on which the source data is provided by the Korea Centers for Disease Control and Prevention. The KNHANES assesses the status of health and nutrient intake of Korean people and an annual survey has been conducted since 2007, the 1st year of Stage 4. The present research utilized survey data of 6 years, from 2007 to 2012 (Stage 4 and 5 of the KNHANES) and only the observed values for ages 20–79 years were used [13,14]. Observed values with less than 400 kcal or more than 6,000 kcal of daily energy intake or the values with less than 500 mg or more than 30,000 mg of daily sodium intake or the values with less than 500 mg or more than 30,000 mg of daily potassium intake were considered to be an outlier and eliminated. The total number of observed values after outlier elimination was 27,346, including 10,936 men and 16,410 women.

The odd ratios of risk factors on hypertension, coronary heart disease, and stroke were calculated by the use of the logit model. The logit model is the analyzing method mainly used when the dependent variable is binary variable such as prevalence of disease [15].

The model included the prevalence of hypertension, coronary heart disease, and stroke as dependent variables and individual variables (age, employment status, income level, education level,

etc.), health practice variables (obesity, smoking, drinking, etc.), and health condition variables (prevalence of dyslipidemia and diabetes) were included as control variables. Since variables on sodium and potassium intakes control nutrient intakes from food intake and the health impact thereof could be influenced by blood concentrations, the variables were divided into four quartile groups according to the amount of daily nutrient intake per kilogram and then applied to the model. All statistical analyses made in the present research used IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY: IBM Corp) [16].

3. Results and discussion

3.1. Status of sodium intake and prevalence rates of hypertension, coronary heart disease, and stroke for Koreans

Daily sodium intake for Koreans has gradually increased from 2007 to 2010, but since 2011, the figure has dropped. The average sodium intake per day over the 6 years of survey period was 4,934.4 mg, around 2.5 times more than 2,000 mg, the recommended amount of sodium intake for Koreans. There was a huge difference between men and women in sodium intake: men took 5,498.33 mg to 6,047.36 mg of sodium by year, while women took 3,942.49 mg to 4,341.27 mg. Above all, men took about 1.4 times more sodium than women per day.

Individual weight makes a difference in the amount of food intake and this leads to differences in nutrient intake. Excessive intake of sodium is known to be a risk factor for health and in order to analyze the risks of sodium, it should be considered that proper amount of intake would vary according to individual weight. Therefore, by using the daily sodium intake variable with respect to individual weight, the impact on health variables was analyzed. The overall average of daily sodium intake compared with weight was 78.7 mg/kg/d and men showed a higher figure than women. Although men took 1.4 times more sodium than women daily, the figure dropped to 1.2 times when considering weight.

When it comes to the amount of daily sodium intake compared with the total energy the individual had for a day, it was revealed that a person intakes about 2.59 mg of sodium for 1 kcal of energy intake on average. When comparing the level of sodium intake, which considered individual energy intake by gender, men recorded 2.68 mg/kcal in 2007, the initial survey year, but it decreased to 2.51 mg/kcal in 2012. The figure for women also dropped from 2.57 mg/kcal in 2007 to 2.48 mg/kcal in 2012. Based thereon, we may recognize that the diet of Koreans has gradually changed into a low-sodium one thanks to the spread of sodium reduction projects.

The prevalence rate of hypertension was 21.17% for both men and women on a 6-year average, and the figure is on the rise from 17.35% since 2007. An increasing trend of prevalence rate of hypertension is more significant for men than women: prevalence rate of hypertension for men has increased by about 9.44% over 6 years from 16.78% in 2007 to 26.34% in 2012, while the figure for women has risen by about 8.67%, from 17.73% in 2007 to 25.06% in 2012. The average prevalence rate of coronary heart disease is 2.31% and it shows an increasing trend over 6 years. The annual average increase of prevalence rate of stroke was 1.43% over the recent 6 years, and the prevalence rate of stroke showed less fluctuation than that of hypertension or coronary heart disease.

Basic statistics of daily sodium intake compared with weight by quartile groups are shown in Tables 1 and 2. The first quartile group, who had the least amount of daily sodium, took 2,007.24 mg of sodium a day and the number increased to 3,519.18 mg for the

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