



Contents lists available at ScienceDirect

Journal of Ethnic Foods

journal homepage: <http://journalofethnicfoods.net>

Original article

Consumption of kimchi, a salt fermented vegetable, is not associated with hypertension prevalence

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ARTICLE INFO

Article history:

Received 17 October 2014

Received in revised form

12 November 2014

Accepted 24 November 2014

Available online 6 December 2014

Keywords:

adults
hypertension
kimchi consumption
Korean
sodium intake

ABSTRACT

Background: The aim of this study was to investigate the association between hypertension and kimchi, a salt-fermented vegetable, intake.**Methods:** This study was based on the data from the Korea National Health and Nutrition Examination Survey conducted in 2007, 2008, 2009, 2010, 2011, and 2012. In the final analysis, a total of 20,114 Korean adults (men = 7,815, women = 12,299) was included. Daily energy, nutrient, and kimchi intake were assessed using 24-hour dietary recall. The odds ratios for hypertension, according to groups of quintiles of kimchi consumption by gender, were assessed using logistic regression and multivariable models.**Results:** Out of 20,114 participants, 11.3% were newly diagnosed as having hypertension. Although participants with higher consumption of kimchi were more likely to have an older age, higher blood pressure, and a higher BMI, as well as higher consumption of calories and sodium, there was no significant difference in the distribution of prevalence of hypertension across quintiles of kimchi consumption in men and women. In multivariate models by gender, higher consumption of kimchi was not associated with a higher prevalence of hypertension (odds ratio = 0.87; 95% confidence interval = 0.70–1.08 for ≥ 216.5 g/day vs. < 39.2 g/day; p for trend = 0.7532, in men; odds ratio = 1.04; 95% CI = 0.80–1.34 for ≥ 145.1 g/day vs. < 19.5 g/day; p for trend = 0.2875, in women).**Conclusion:** High consumption of kimchi was not associated with an increased prevalence of hypertension in humans. Our results suggested that high potassium intake due to high consumption of kimchi may have helped neutralize the effect of elevated sodium intake on blood pressure levels.

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1. Introduction

Many types of fermented foods are prepared in Korea, including kimchi, which is one of the most famous foods made from fermented vegetables and is becoming popular globally. Kimchi has been consumed as a traditional Korean side dish for nearly 2000 years. There are more than 160 different types of kimchi, depending on vegetables, other food ingredients, preparation methods, and region, of which cabbage kimchi has been consumed most widely. Addition of other ingredients and fermentation byproducts of lactic

acid bacteria promotes the fermentation process, eventually leading to eradication of putrefactive and pathogenic bacteria, and also increases the health benefits and functionalities of kimchi [1–4]. Accordingly, kimchi can be considered a vegetable probiotic food that enhances health benefits in a similar manner to yogurt as a dairy probiotic food [1]. Kimchi is also an important source of vitamins, minerals, dietary fibers, and other nutrients with low calorie (18 kcal/100 g) and low fat (0.5 g/100 g) [5]. As kimchi has been one of world's famous fermented foods with many health benefits, the Korean government has set up the World Institute of Kimchi in order to systematically help other nations understand kimchi [6].

Although kimchi has become more popular globally because of its health benefits, functionalities, and taste, recently, a concern about high salt intake accompanied with high consumption of kimchi has arisen [7,8]. The average sodium intake of Koreans was reported to be more than 5,000 mg/day, which is one of the highest intake levels worldwide [8–10]. Since almost all Koreans consume kimchi as a side dish daily and as kimchi is a salt-fermented food, it

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<http://dx.doi.org/10.1016/j.jef.2014.11.004>

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can be one of the main contributors of sodium to Korean diet [8]. High salt intake is one of the major risk factors for hypertension [11]. Hypertension is a major public health concern in developed countries, as it is one of the leading risk factors for mortality, including stroke, heart, and renal diseases [12,13]. Even a small reduction in the mean blood pressure of a population can lead to a decrease in cardiovascular morbidity and mortality [14]. Therefore, for prevention and management of hypertension, the American Heart, Lung and Blood Institute recommends adherence to the DASH (Dietary Approaches to Stop Hypertension) diet—a diet based on low intake of sodium and fat, and high intake of fruits and vegetables [12,14]. The European Society of Hypertension also recommends a decrease in the intake of sodium and fat, and an increase in the consumption of vegetables and fruits to lower blood pressure levels [15]. According to the recommendations for prevention and treatment of hypertension, kimchi has both good and harmful effects because it is a salt-fermented vegetable.

Therefore, there are still areas of uncertainty about the association between excess consumption of kimchi and an increased risk of hypertension. The aim of the present study was to investigate any direct, independent relationship between the prevalence of hypertension and consumption of kimchi, using data from the Korea National Health and Nutrition Examination Survey (KNHANES), a nationally representative survey conducted in the Republic of Korea.

2. Materials and methods

This study was based on the data from 2007, 2008, 2009, 2010, 2011, and 2012 KNHANES, which were the fourth and fifth KNHANES, provided by the Korea Centers for Disease Control and Prevention (KCDC). From the fourth round, KNHANES was conducted throughout the year to reduce any seasonal bias on diet. The sample for KNHANES was selected using a stratified, multistage, cluster-sampling design with proportional allocations based on the National Census Registry. The 2007, 2008, 2009, 2010, 2011, and 2012 KNHANES database comprised data of 4,594, 9,744, 10,533, 8,958, 8,518, and 8,058 individuals, respectively, out of a total of 550,405 participants. Individuals who participated in the nutritional survey were considered ($n = 45,031$). Among them, those aged 19–64 years were included ($n = 25,323$). We excluded participants using the following exclusion criteria: (1) pregnant women ($n = 204$); (2) individuals with no blood pressure data ($n = 1,738$); (3) individuals reporting unrealistic daily total energy intakes (<500 kcal or $>6,000$ kcal) ($n = 188$), as per other studies with similar study designs [16,17].

Additionally, we excluded those who were diagnosed with or were receiving treatment for hypertension ($n = 3,079$) at the time of the survey, in order to reduce any causal relationship. As a result, 20,114 individuals were included in the final analysis (men = 7,815 and women = 12,299).

The study was conducted in accordance with the Ethical Principles for Medical Research Involving Human Subjects, as defined by the Helsinki Declaration. All study participants provided written informed consent for the survey. Moreover, de-identified data were used in the study.

2.1. Measurements

KNHANES included well-established questions to determine the demographic and socioeconomic characteristics of the participants. Questions on age, gender, education level, income, physical activity, smoking habits, and alcohol consumption were incorporated. Daily energy and nutrient intakes were assessed using 1-day 24-hour recall. Height and weight of participants were measured, with

participants wearing light clothing and no shoes. The body mass index (BMI) was calculated as weight (in kilograms) divided by height (in meters squared). Moreover, well-trained observers manually measured blood pressure using a mercury sphygmomanometer (Baumanometer; Baum, Copiague, NY, USA). Hypertension was defined as having a systolic pressure of 140 mmHg (or higher) or a diastolic pressure of 90 mmHg (or higher) following the standard established by the KCDC.

Kimchi intake was calculated from the 24-hour recall data. A total of 7,815 men and 12,299 women were categorized into separate quintiles. As per education levels, participants were categorized into four groups: those who finished elementary school, middle school graduates, high school graduates, and college graduates or those with higher degrees. According to income, participants were categorized into the following quartiles: lowest, low, high, and highest (as defined by the KCDC). Based on alcohol consumption habits, they were categorized into four groups: non-drinkers, those drinking less than once a month, those drinking once a month (less than heavy drinker), and heavy drinkers. A “heavy drinker” was defined as someone consuming alcohol twice or more per week and having at least seven drinks per occasion (for men) or five drinks per occasion (for women). As per the smoking status, the participants were categorized as nonsmoker, ever-smoker, and current smoker (2 groups: <1 pack per day and ≥ 1 pack per day) groups. Based on physical activity, participants were categorized into four groups: no exercise with irregular walking, regular walking, regular moderate-level activity and regular vigorous-level activity. Menopausal status in women participants was categorized as either “yes” or “no”.

2.2. Statistical analyses

Means and standard errors of continuous variables were calculated according to quintile groups by gender. Proportions of each covariate in categorical variables were calculated for each group. The difference between groups was tested using a generalized linear model for continuous variables and chi-square test for categorical variables. The odds ratios (ORs) for hypertension according to quintile of kimchi intake were assessed using logistic regression after adjusting for age by gender. The multivariate model was additionally adjusted for BMI, fasting glucose, triglycerides, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, energy and sodium intakes, smoking, alcohol consumption, physical activity, education, income, receiving education for hypertension, survey year (for men and women), menopause (for women only), chronic disease status (those diagnosed with or taking medication(s) for the management of diabetes, stroke, myocardial infarction, angina pectoris, chronic renal failure, and cancers vs. those not), and potassium intake. For the missing data of covariates such as smoking (9.72%), alcohol consumption (1.85%), physical activity (1.95%), educational level (1.62%), income (1.53%), and blood index (2.68%; glucose, triglyceride, and cholesterol levels), we created a missing variable in the multivariate models. Tests for linear trends across categories were conducted by treating the median of each category as a continuous variable. All analyses were performed using SAS statistical software (version 9.2; SAS Institute Inc., Cary, NC, USA).

3. Results

Out of 20,114 participants, 11.3% were newly diagnosed with hypertension. Baseline characteristics according to quintiles of kimchi consumption by gender are shown in Table 1. There was no significant difference in the distribution of prevalence of hypertension across quintiles of kimchi consumption in men and women.

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