

Vegetable intake is associated with lower Frammingham risk scores in Korean men: Korea National Health and Nutrition Survey 2007-2009

Mi-Kyeong Choi¹ and Yun-Jung Bae^{2S}

¹Division of Food Science, Kongju National University, Yesan 32439, Korea

²Division of Food Science and Culinary Arts, Shinhan University, 95 Hoam-ro, Uijeongbu, Gyeonggi 11644, Korea

BACKGROUND/OBJECTIVES: Observational studies suggest that an association between vegetable consumption and coronary heart disease (CHD). However, the results are inconsistent. This study aimed to investigate the daily intake of vegetables on a national level and its effect on the risk of CHD risk, as determined by the Framingham Risk Score (FRS).

SUBJECTS/METHODS: This study was conducted a cross-sectional design of 2,510 male adults 40-64y of age who participated in the 2007-2009 Korean National Health and Nutrition Examination Survey. Daily intake of vegetable was assessed by 24-h recall, and the consumption frequency of vegetables was determined using a food frequency questionnaire. The odd ratio of CHD risk according to daily intake and frequency of vegetables was analyzed.

RESULTS: Total vegetable intake was inversely and significantly associated with the risk of CHD (Model 1: 4th vs. 1st quartile, OR = 0.74, 95% CI = 0.58-0.96, *P* for trend = 0.0015), and the significant relationship with CHD risk remained even after adjusting for potential confounders (Model 3: 4th vs. 1st quartile, adjusted OR [aOR] = 0.69, 95% CI = 0.49-0.95, *P* for trend = 0.0492). Subjects in the higher quartiles of non-salted vegetable intake had 31% lower odds of the risk of CHD compared to those in the lowest quartile after adjusting for various potential confounders in model 3 (aOR = 0.69; 95% CI = 0.49-0.97, *P* for trend = 0.0478). No significant associations between the frequency of vegetable intake (total, green, white and red vegetable) and the risk of CHD were found.

CONCLUSIONS: The major results of this study indicate that higher vegetable intake may help prevent CHD in Korean men.

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INTRODUCTION

Heart disease is the leading cause of death in South Korea. Heart and cerebrovascular diseases are caused not only by genetic factors but also by environmental factors such as lifestyle and dietary habits [1]. There have been a number of studies reporting relationships between dietary factors and coronary heart disease (CHD); specifically, carbohydrate, dietary fiber, and fat intake as well as nutrient composition have been reported to have an effect on CHD [2-4].

According to a critical review of CHD, there is convincing evidence that increasing the consumption of vegetables reduces the risk of chronic disease [5]. An intake of > 600 g vegetables and fruits a day reportedly decreases the risk of ischemic heart disease by 31% and ischemic stroke by 19% [6]. Epidemiological research has shown similar results, with prospective studies indicating that vegetable consumption is negatively associated with CHD [7-10]. A meta-analysis of cohort studies reported that > 5 servings of fruits and vegetables a day resulted in a pooled

relative risk of 0.83 (0.77-0.89, *P* < 0.0001) for CHD, compared with < 3 servings a day [11]. However, the relationship between vegetable intake and the risk of CHD is slightly different based on the types of vegetables or fruits and intake diversity [8,9]. An intake consisting of a variety of vegetables was significantly and negatively correlated with inflammatory markers and Framingham Risk Score (FRS) in a previous cross-sectional study [12].

Vegetables reportedly affect CHD risk factors such as hypertension, hypercholesterolemia, and diabetes [13]. The presence of potassium, magnesium, dietary fiber, phytosterols, and vitamins can decrease blood cholesterol, oxidative stress, and inflammation [14-17]. A meta-analysis of 14 studies conducted in Korea and Japan determined that eating raw vegetables significantly decreases the risk of stomach cancer (overall summary OR = 0.62, 95% CI = 0.46-0.85), while the consumption of pickled vegetables significantly increases the risk of stomach cancer (overall summary OR = 1.28, 95% CI = 1.06-1.53) [18]. Unlike vegetables that are not pickled, pickled vegetable intake

^S Corresponding Author: Yun-Jung Bae, Tel. 82-31-870-3572, Fax. 82-31-870-3519, Email. byj@shinhan.ac.kr

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increases the risk of breast cancer [19]. The results of a previous multivariable-adjusted regression analysis indicate that vegetable intake is negatively associated with the risk of stroke, adjusted for age, sex, body mass index (BMI), and family history of stroke (OR = 0.311, 95% CI = 0.100-0.963) [20]. Therefore, the effect of vegetable intake on chronic disease, particularly CHD, is expected to differ by type; however, studies regarding the relationship between vegetable intake and CHD risk in Koreans are limited, despite the consumption of a variety of vegetables in Korea, such as kimchi, pickled-vegetable and wild vegetables.

Therefore, research is needed to assess the intake of vegetables in Korean adult men and investigate its relationship with CHD; this is particularly important in adult men because of the highest prevalence of CHD in adult men than in adult women [21]. The purpose of this study was to evaluate the daily intake of vegetables by type and the effect on CHD risk, as determined by the FRS.

SUBJECTS AND METHODS

Study subjects

The Korea National Health and Nutrition Examination Survey (KNHANES) is a cross-sectional study that uses a rolling sampling design involving a complex, stratified, multistage, probability-cluster survey of a representative sample of the non-institutionalized civilian Korean population. The survey data are collected via a health interview, health examination (physical examination and clinical measurements), and nutrition survey.

The data sets used in this study originated from the fourth KNHANES (2007-2009). A total of 24,871 individuals from 6,000 households in 200 primary sampling units took part in the 2007-2009 KNHANES (2007, n = 4,594; 2008, n = 9,744; 2009, n = 10,533). We excluded participants aged < 40 years or > 64 years; women; those who reported implausible dietary intakes (< 500 kcal/d or > 5,000 kcal/d); those with a history of myocardial infarction, stroke, or angina; and those for whom we did not have data on blood pressure, cholesterol, high density lipoprotein (HDL)-cholesterol, or health interview questions required for the FRS (i.e., smoking and hypertension treatment). Finally, 2,510 participants were included in the analysis. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention, and written consent was obtained from all participants [22]. The subjects were divided into groups using quartile according to their vegetable intake amount (total vegetable, salted vegetable and non-salted vegetable), and their anthropometric characteristics, biochemical characteristics, demographic characteristics, and dietary factors were compared, while odds ratio related to CHD risk was analyzed.

General characteristics, anthropometrics, and biochemical variables

In the health interview, a questionnaire regarding sex, age, education status, household income, smoking history, alcohol intake, and exercise was administered by trained interviewers. Metabolic equivalent of task values (METs) were used to classify physical activity as low (< 600 MET-minutes/week), medium (\geq 600 to < 3,000 MET-minutes/week), or high (\geq 3,000 MET-

minutes/week). METs are multiples of the resting metabolic rates and were calculated using the short form (version 2.0, April 2004) of the International Physical Activity Questionnaire.

The health examination included anthropometric measurements (height, weight, BMI, and waist circumference), blood pressure measurements, and blood biomarker analyses (total cholesterol, triglycerides, glucose, and HDL-cholesterol). Height was measured within 0.1 cm, and weight was measured with a metric weight scale to the nearest 0.1 kg in light clothing without shoes. BMI was calculated as body weight (kg) divided by height squared (m^2). The waist circumference was measured at the smallest circumference between the rib cage and iliac crest with the subject in the standing position. Blood pressure measurements were taken 3 times, and the average of the second and third measurements for both systolic blood pressure (SBP) and diastolic blood pressure (DBP) were used. Fasting serum total cholesterol, triglycerides, glucose, and HDL-cholesterol were measured using an ADVIA 1650 Automatic Analyzer (Siemens, New York, USA) in 2007 and Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan) in 2008-9. There were differences in HDL-cholesterol levels because of different analysis methods and equipment owing to a change of the clinical inspection agency in 2007 and 2008-2009. Therefore, this study used the following conversion equations to correct these level differences:

- 1) Conversion equation (2007) = {(raw data \times 1.15) + 3.70} \times 0.86 + 2.98
- 2) Conversion equation (2008-2009) = (raw data \times 0.86) + 2.98

Dietary assessment survey for fruits and vegetables

Trained dietitians interviewed each participant to collect dietary data through 24-hour dietary recalls. Intakes of carbohydrate, protein, fat, and dietary fiber were determined. Total vegetable intake excluding processed foods such as canned food and paste were analyzed, and then divided into salted vegetables and non-salted vegetables. Based on previous study [23], salted vegetables included kimchis (Chinese cabbage kimchi, diced radish kimchi, young radish (Yulmoo) kimchi, etc.) and pickles (cucumber pickle, radish pickle, garlic pickle, onion pickle, etc.). Non-salted vegetables excluded potatoes, mushrooms, seaweeds and salted vegetables, and included leafy and stem vegetables (Chinese cabbage, spinach, leaf beet, curled mallow, lettuce, etc.), tuber vegetables (radish, carrot, onion, balloon flower, etc.) and fruit vegetables (cucumber, tomato, green pepper, etc.). Vegetable intake was also collected by food frequency questionnaire (FFQ). The FFQ was quantified using nine categories: "never or seldom", "once a month", "two to three times a month", "one to two times a week", "three to four times a week", "five to six times a week", "once a day", "twice a day" and "three or more times every day". The FFQ requested information regarding the participant's consumption frequency of 63 food items. FFQ did not inquire vegetable intake frequency with considerations how it is cooked, but surveying the total vegetable intake frequently by all cooking ways. Therefore, when analyzing FFQ data in this study, the vegetables were divided into green vegetable and white vegetable. Based on previous study [24], the individual food items in the green vegetable group include radish leaf, spinach, cucumber, and pepper; those in the white and red vegetable group include Korean cabbage, radish,

sprout, cabbage, carrot, pumpkin, and tomato. To classify the vegetable intake frequency, it was divided by quartile according to daily intake frequency of each vegetable kind.

Classification criteria for FRS

The FRS is based on the Framingham cohort study and acts as an index to predict 10-year CHD risk by scoring sex, age, smoking status, SBP, total cholesterol, and HDL-cholesterol and calculating a total score from these individual scores [25]. In this study, FRS was calculated with the standards suggested in the Adult Treatment Panel III guidelines [25]. Age (score range: 0-10) was categorized as 40-44, 45-49, 50-54, 55-59, and 60-64 years for scoring. HDL-cholesterol (score range: -1-1) was categorized as < 40 mg/dL, 40-49 mg/dL, 50-59 mg/dL, and \geq 60 mg/dL for scoring. Total serum cholesterol (score range: 0-8) was categorized as < 160 mg/dL, 160-199 mg/dL, 200-239 mg/dL, 240-279 mg/dL, and \geq 280 mg/dL for scoring. Smoking status (score range: 0-5) was categorized as smoker and non-smoker for scoring. SBP (score range: 0-3) was categorized as < 120 mmHg, 120-129 mmHg, 130-139 mmHg, 140-159 mmHg, and \geq 160 mmHg for scoring. The scoring for total serum cholesterol and smoking status differed by age group, while SBP was scored differently by the status of high blood pressure treatment.

Statistical analysis

All statistical analyses were performed using SAS software (version 9.3 SAS Institute Inc., Cary, NC, USA) through a "survey procedure". The participants' characteristics were compared according to the vegetable intake quartiles. Differences in anthropometric, biochemical and demographic characteristics, and dietary intake according to vegetable intake quartiles were evaluated using a PROC GLM for continuous variables and Chi-square tests for categorical variables. Multivariable logistic regression analysis was performed to estimate the odds ratio (OR) and 95% confidence interval (CI) of CHD risk according to the vegetable intake quartiles, using the lowest quartile as the reference. To observe the difference of FRS according to the kinds of vegetable intake, the confounding factors were selected referring to the previous study [12] reporting about vegetable intake and its relation with FRS. All statistical tests were two-sided, and a *P* value < 0.05 was considered significant.

RESULTS

General subject characteristics

The anthropometric, biochemical and demographic characteristics, and dietary intake by quartile of dietary vegetable intake are shown in Table 1. The median vegetable intake was < 246.8 g/d in the lowest quartile and \geq 516.0 g/d in the highest total vegetable intake quartile. No difference was observed in FRS among the total vegetable intake quartiles. Age was significantly higher in the lowest quartiles of total vegetable intake (*P* = 0.0032), however, BMI showed to be the lowest (*P* = 0.0157). Waist circumference, SBP and DBP were not significantly different among the total vegetable intake quartiles. Also, biochemical and demographic characteristics were not significantly different among the total vegetable intake quartiles. The

total energy intake and carbohydrate, protein and fat intakes were significantly higher in the higher quartiles of total vegetable intake (*P* < 0.0001, respectively).

The anthropometric, biochemical and demographic characteristics, and dietary intake by quartile of dietary salted vegetable intake and non-salted vegetable intake are shown in Table 2, 3. No differences were observed in FRS among the salted vegetable intake or non-salted vegetable intake quartiles. However, in the case of serum indices, serum triglyceride was significantly higher in the highest quartiles of salted vegetable intake (*P* = 0.0394)

Relationships between vegetable intake and CHD risk

The relationships between vegetable intake and the risk of CHD are shown in Table 4. No significant association between salted vegetable intake and the risk of CHD was found. Total vegetable intake was inversely and significantly associated with the risk of CHD (Model 1: 4th vs. 1st quartile, OR = 0.74, 95% CI = 0.58-0.96, *P* for trend = 0.0015), and the significant relationship with CHD risk remained even after adjusting for potential confounders (Model 3: 4th vs. 1st quartile, OR = 0.69, 95% CI = 0.49-0.95, *P* for trend = 0.0492). Subjects in the higher quartiles of non-salted vegetable intake had 31% lower odds of the risk of CHD compared to those in the lowest quartile after adjusting for various potential confounders in model 3 (adjusted OR [aOR] = 0.69; 95% CI = 0.49-0.97, *P* for trend = 0.0478).

The relationships between vegetable intake frequency and the risk of CHD are shown in Table 5. No significant associations between total vegetable intake frequency, green and white vegetable intake frequency and the risk of CHD were found.

DISCUSSION

In the present study, the effect of vegetable intake on CHD risk, as determined by the FRS, was evaluated in Korean men using nationwide data; as a result, the intakes of total vegetables and non-salted vegetable significantly decreased CHD risk. And, no significant associations between vegetable intake frequency and the risk of CHD were found.

Previous reviews have reported that diet leads to intermediary biological mechanisms such as inflammatory processes, oxidative stress, and increased homocysteine concentrations, which increase the risk of CHD [26]. The nutrients and non-nutritive components in vegetables are likely to be important for controlling the risk of disease. Vegetables can increase the ability to control blood vessel enlargement, prevent platelet aggregation, and decrease inflammatory markers [27,28].

In this study, there was no meaningful difference of metabolic indicators in blood between groups divided by vegetable intake. The Korean diet is primarily composed of plant food, accounting for 79.4% (1,143.1 g) of the total daily food intake in people aged > 1 year old [22]. The ratio of intake that is plant food increases with older age (82.6%, 40-49 years; 85.1%, 50-64 years), and older age is considered a risk factor in the calculation of the FRS. In addition, in Korea, vegetables are taken through various cooking ways in daily meals. According to a research based on 2005 KNHANES it is reported for those above

Table 1. Characteristics of participants according to total vegetable intake

	Vegetable intake (n = 2,510)				P-value
	Quartile 1 (n = 659)	Quartile 2 (n = 642)	Quartile 3 (n = 593)	Quartile 4 (n = 616)	
Vegetable intake (g/d)					
Median	177.4	309.9	433.2	650.9	-
Range	0-≤ 246.8	> 246.8-≤ 370.1	> 370.1-≤ 516.0	> 516.0-≤ 2689.6	-
CHD risk indicators					
Framingham risk score	10.7 ± 0.1	10.4 ± 0.1	10.7 ± 0.1	10.7 ± 0.1	0.1365
Anthropometric characteristics					
Age (yrs) ¹⁾	50.8 ± 0.3	49.3 ± 0.3	49.6 ± 0.3	49.8 ± 0.3	0.0032
BMI (kg/m ²)	24.1 ± 0.1	24.2 ± 0.1	24.3 ± 0.1	24.6 ± 0.1	0.0157
Waist circumference (cm)	85.3 ± 0.4	85.5 ± 0.4	85.9 ± 0.4	86.2 ± 0.4	0.2648
SBP (mmHg)	121.0 ± 0.8	119.3 ± 0.7	120.1 ± 0.7	120.5 ± 0.7	0.3834
DBP (mmHg)	80.7 ± 0.5	79.6 ± 0.5	80.0 ± 0.5	80.1 ± 0.5	0.4562
Biochemical characteristics					
Triglyceride (mg/dl)	164.2 ± 5.0	166.1 ± 6.2	176.0 ± 6.7	187.3 ± 8.6	0.0801
Cholesterol (mg/dl)	193.4 ± 1.6	191.2 ± 1.7	192.9 ± 1.5	194.1 ± 1.6	0.6119
HDL-cholesterol (mg/dl)	45.1 ± 0.4	45.6 ± 0.5	44.6 ± 0.5	45.3 ± 0.5	0.4877
Glucose (mg/dl)	104.5 ± 1.2	102.4 ± 1.0	102.8 ± 1.1	103.2 ± 1.3	0.5673
Demographic characteristics					
Education (%)					
≤ Elementary	18.9	14.5	14.2	18.3	0.1712
Middle/High	54.1	53.2	53.0	52.9	
≥ College	27.1	32.3	32.8	28.8	
Household income (%)					
Quartile 1 (Low)	31.3	24.7	22.3	22.6	0.0544
Quartile 2	22.1	24.3	26.1	27.8	
Quartile 3	23.0	25.4	23.3	23.4	
Quartile 4 (High)	23.6	25.6	28.3	26.2	
Physical activity ²⁾ (%)					
Low	48.0	46.4	44.5	39.1	0.0638
Moderate	48.1	49.5	49.9	54.2	
High	4.0	4.1	5.6	6.7	
Smoker (%)					
Never	15.0	17.0	15.6	16.0	0.9089
Past	38.8	39.6	41.1	41.6	
Current	46.2	43.4	43.3	42.4	
Frequency of alcohol (%)					
None	15.1	14.1	13.2	13.3	0.9525
≤ 1 time/month	18.4	17.1	17.9	18.0	
2-4 times/month	25.1	24.9	22.7	25.0	
≥ 2 times/week	41.4	44.0	46.3	43.8	
Dietary factors					
Energy (kcal/d)	1,882.4 ± 29.0	112.6 ± 32.1	2,244.0 ± 30.3	2,588.2 ± 35.4	< 0.0001
Carbohydrate (g/d)	299.9 ± 4.5	338.9 ± 5.3	352.0 ± 4.6	401.4 ± 5.8	< 0.0001
Protein (g/d)	62.7 ± 1.3	74.5 ± 1.4	82.3 ± 1.4	99.6 ± 1.7	< 0.0001
Fat (g/d)	31.6 ± 1.0	35.5 ± 1.0	41.6 ± 1.2	51.0 ± 1.4	< 0.0001
Fiber (g/d)	5.8 ± 0.2	7.6 ± 0.2	8.9 ± 0.2	12.8 ± 0.3	< 0.0001
Sodium (mg/d)	3,957.6 ± 97.0	5,416.2 ± 109.0	6,396.6 ± 123.0	8,596.6 ± 168.4	< 0.0001
% Carbohydrate	65.9 ± 0.7	65.7 ± 0.6	64.5 ± 0.6	63.8 ± 0.6	0.0595
% Protein	13.4 ± 0.2	14.3 ± 0.2	14.7 ± 0.2	15.4 ± 0.2	< 0.0001
% Fat	14.7 ± 0.33	14.8 ± 0.3	16.1 ± 0.3	17.1 ± 0.4	< 0.0001

Data represent age-adjusted mean or prevalence (%) ± SE, except for age.

¹⁾ Unadjusted values.

²⁾ Defined as low (< 600 MET-minutes per week), moderate (≥ 600 to < 3,000 MET-minutes per week), and high (≥ 3,000 MET-minutes per week) levels of physical activity

Table 2. Characteristics of participants according to salted-vegetable intake

	Salted-vegetable intake (n = 2,510)				P-value
	Quartile 1 (n = 660)	Quartile 2 (n = 591)	Quartile 3 (n = 648)	Quartile 4 (n = 611)	
Vegetable intake (g/d)					
Median	43.6	108.0	180.4	323.9	-
Range	0-≤ 77.7	> 77.7-≤ 144.0	> 144.0-≤ 231.0	> 231.0-≤ 1017.9	-
CHD risk indicators					
Framingham risk score	10.7 ± 0.1	10.6 ± 0.1	10.6 ± 0.1	10.7 ± 0.1	0.6933
Anthropometric characteristics					
Age (yrs) ¹⁾	50.1 ± 0.3	49.8 ± 0.3	49.5 ± 0.3	50.2 ± 0.3	0.2344
BMI (kg/m ²)	24.3 ± 0.1	24.1 ± 0.1	24.2 ± 0.1	24.5 ± 0.1	0.0807
Waist circumference (cm)	86.2 ± 0.4	85.2 ± 0.4	85.4 ± 0.4	85.9 ± 0.4	0.2509
SBP (mmHg)	120.1 ± 0.7	120.9 ± 0.8	119.5 ± 0.7	120.7 ± 0.6	0.3954
DBP (mmHg)	80.0 ± 0.5	80.7 ± 0.6	79.5 ± 0.5	80.3 ± 0.5	0.3598
Biochemical characteristics					
Triglyceride (mg/dl)	166.1 ± 6.2	161.3 ± 5.0	182.8 ± 7.6	181.5 ± 7.4	0.0394
Cholesterol (mg/dl)	192.5 ± 1.6	192.7 ± 1.8	190.4 ± 1.5	196.1 ± 1.6	0.0860
HDL-cholesterol (mg/dl)	44.5 ± 0.4	46.4 ± 0.5	44.1 ± 0.5	45.6 ± 0.5	0.0032
Glucose (mg/dl)	102.8 ± 1.1	102.7 ± 1.2	104.1 ± 1.1	103.3 ± 1.4	0.7681
Demographic characteristics					
Education (%)					
≤ Elementary	16.3	15.3	14.0	20.3	0.0073
Middle/High	48.8	55.5	54.2	54.8	
≥ College	34.9	29.1	31.7	25.0	
Household income (%)					
Quartile 1 (Low)	24.5	23.6	26.0	26.7	0.2081
Quartile 2	23.0	25.9	22.5	29.0	
Quartile 3	24.8	25.8	23.3	21.4	
Quartile 4 (High)	27.7	24.7	28.1	22.9	
Physical activity ²⁾ (%)					
Low	47.4	48.1	43.2	39.6	0.0100
Moderate	49.2	48.5	50.2	53.7	
High	3.3	3.4	6.6	6.7	
Smoker (%)					
Never	17.0	14.6	15.7	16.2	0.9276
Past	38.4	40.6	41.4	40.8	
Current	44.7	44.8	42.9	43.0	
Frequency of alcohol (%)					
None	15.4	14.6	12.8	12.8	0.7137
≤ 1 time/month	16.7	17.4	16.9	20.3	
2-4 times/month	25.4	25.1	25.1	22.1	
≥ 2 times/week	42.4	42.9	45.2	44.7	
Dietary factors					
Energy (kcal/d)	2,120.7 ± 35.0	2,166.8 ± 33.5	2,170.9 ± 31.6	2,358.2 ± 34.6	< 0.0001
Carbohydrate (g/d)	324.6 ± 4.8	339.0 ± 5.5	343.5 ± 4.6	383.0 ± 5.7	< 0.0001
Protein (g/d)	74.2 ± 1.5	77.3 ± 1.5	79.0 ± 1.6	88.0 ± 1.6	< 0.0001
Fat (g/d)	39.0 ± 1.3	39.4 ± 1.2	38.5 ± 1.1	42.5 ± 1.3	0.0896
Fiber (g/d)	7.1 ± 0.2	7.6 ± 0.2	8.8 ± 0.2	11.5 ± 0.3	< 0.0001
Sodium (mg/d)	4,408.8 ± 105.4	5,259.9 ± 130.8	5,997.1 ± 111.2	8,438.5 ± 168.5	< 0.0001
% Carbohydrate	63.4 ± 0.7	64.3 ± 0.6	65.5 ± 0.6	66.5 ± 0.6	0.008
% Protein	14.1 ± 0.2	14.4 ± 0.2	14.4 ± 0.2	14.9 ± 0.2	0.0054
% Fat	16.0 ± 0.4	15.9 ± 0.3	15.2 ± 0.3	15.6 ± 0.3	0.1847

Data represent age-adjusted mean or prevalence (%) ± SE, except for age.

¹⁾ Unadjusted values.

²⁾ Defined as low (< 600 MET-minutes per week), moderate (≥ 600 to < 3,000 MET-minutes per week), and high (≥ 3,000 MET-minutes per week) levels of physical activity

Table 3. Characteristics of participants according to non-salted-vegetable intake

	Non-salted-vegetable intake (n = 2,510)				P-value
	Quartile 1 (n = 653)	Quartile 2 (n = 645)	Quartile 3 (n = 602)	Quartile 4 (n = 610)	
Vegetable intake (g/d)					
Median	57.3	149.6	246.6	417.0	-
Range	0 ≤ 104.5	> 104.5 ≤ 193.0	> 193.0 ≤ 331.2	> 311.2 ≤ 2444.0	-
CHD risk indicators					
Framingham risk score	10.8 ± 0.1	10.6 ± 0.1	10.5 ± 0.1	10.7 ± 0.1	0.3641
Anthropometric characteristics					
Age (yrs) ¹⁾	50.8 ± 0.3	49.7 ± 0.3	49.8 ± 0.3	49.3 ± 0.3	0.0022
BMI (kg/m ²)	24.1 ± 0.1	24.2 ± 0.1	24.3 ± 0.1	24.6 ± 0.1	0.0866
Waist circumference (cm)	85.3 ± 0.4	85.6 ± 0.4	85.7 ± 0.4	86.3 ± 0.4	0.2898
SBP (mmHg)	121.2 ± 0.7	120.4 ± 0.7	119.6 ± 0.8	119.9 ± 0.6	0.4189
DBP (mmHg)	80.8 ± 0.5	80.4 ± 0.5	79.7 ± 0.6	79.5 ± 0.5	0.1773
Biochemical characteristics					
Triglyceride (mg/dl)	180.0 ± 7.7	168.1 ± 5.7	168.4 ± 5.6	176.7 ± 7.2	0.4824
Cholesterol (mg/dl)	195.1 ± 1.6	192.5 ± 1.5	191.7 ± 1.6	192.3 ± 1.5	0.4557
HDL-cholesterol (mg/dl)	45.1 ± 0.4	46.0 ± 0.5	44.9 ± 0.5	44.5 ± 0.4	0.1671
Glucose (mg/dl)	104.5 ± 1.2	102.4 ± 1.0	102.3 ± 1.1	103.6 ± 1.5	0.4633
Demographic characteristics					
Education (%)					
≤ Elementary	20.4	14.7	16.9	13.8	0.0047
Middle/High	55.9	53.9	51.1	52.4	
≥ College	23.7	31.4	32.0	33.7	
Household income (%)					
Quartile 1 (Low)	34.0	24.0	21.6	21.4	< 0.0001
Quartile 2	24.4	21.7	27.9	26.2	
Quartile 3	21.5	25.1	23.6	24.9	
Quartile 4 (High)	20.1	29.1	26.9	27.6	
Physical activity ²⁾ (%)					
Low	46.2	44.6	44.9	42.2	0.7162
Moderate	48.5	51.5	49.7	51.9	
High	5.3	3.9	5.3	5.9	
Smoker (%)					
Never	15.1	14.2	20.1	14.2	0.0963
Past	38.3	41.7	39.0	42.2	
Current	46.6	44.0	41.0	43.6	
Frequency of alcohol (%)					
None	15.6	11.7	12.8	15.4	0.2332
≤ 1 time/month	20.5	16.3	18.0	16.6	
2-4 times/month	21.2	26.4	26.7	23.4	
≥ 2 times/week	42.7	45.6	42.5	44.6	
Dietary factors					
Energy (kcal/d)	1,907.1 ± 29.4	2,098.0 ± 32.1	2,229.3 ± 29.4	2,600.8 ± 37.7	< 0.0001
Carbohydrate (g/d)	314.3 ± 5.0	334.9 ± 5.0	353.3 ± 4.8	390.2 ± 5.7	< 0.0001
Protein (g/d)	63.2 ± 1.4	74.1 ± 1.4	82.5 ± 1.3	99.8 ± 1.7	< 0.0001
Fat (g/d)	31.5 ± 1.1	34.1 ± 0.9	41.1 ± 1.1	53.2 ± 1.4	< 0.0001
Fiber (g/d)	6.6 ± 0.2	8.0 ± 0.2	8.7 ± 0.1	12.0 ± 0.3	< 0.0001
Sodium (mg/d)	4,863.1 ± 138.5	5,594.8 ± 135.6	6,286.2 ± 133.7	7,509.8 ± 160.1	< 0.0001
% Carbohydrate	67.5 ± 0.7	65.5 ± 0.6	64.9 ± 0.6	61.9 ± 0.6	< 0.0001
% Protein	13.3 ± 0.2	14.2 ± 0.1	14.9 ± 0.2	15.4 ± 0.2	< 0.0001
% Fat	14.4 ± 0.3	14.4 ± 0.3	16.1 ± 0.3	17.8 ± 0.3	< 0.0001

Data represent age-adjusted mean or prevalence (%) ± SE, except for age.

¹⁾ Unadjusted values.

²⁾ Defined as low (< 600 MET-minutes per week), moderate (≥ 600 to < 3,000 MET-minutes per week), and high (≥ 3,000 MET-minutes per week) levels of physical activity

Table 4. Multivariate odd ratios (ORs) and 95 % confidence intervals (CIs) of CHD risk by vegetable intakes: The 24-hour recall data

	Quartile 1	Quartile 2	Quartile 3	Quartile 4	P-trend
Total vegetable					
Median (g/d)	192.69	316.40	433.65	659.12	-
Case	391	242	264	274	-
Model 1					
OR	1	0.62	0.75	0.74	0.0015
95% CI	Ref.	0.49, 0.79	0.59, 0.94	0.58, 0.96	
Model 2					
OR	1	0.68	0.75	0.69	0.0538
95% CI	Ref.	0.49, 0.94	0.54, 1.04	0.49, 0.95	
Model 3					
OR	1	0.67	0.75	0.69	0.0492
95% CI	Ref.	0.47, 0.93	0.54, 1.04	0.49, 0.95	
Salted vegetable					
Median (g/d)	48.69	111.65	182.50	323.71	-
Case	360	288	247	276	-
Model 1					
OR	1	0.86	0.75	0.81	0.1439
95% CI	Ref.	0.67, 1.10	0.58, 0.97	0.63, 1.05	
Model 2					
OR	1	0.82	0.77	0.66	0.0873
95% CI	Ref.	0.59, 1.15	0.55, 1.09	0.47, 0.91	
Model 3					
OR	1	0.83	0.78	0.66	0.0937
95% CI	Ref.	0.59, 1.15	0.55, 1.09	0.48, 0.92	
Non-salted vegetable					
Median (g/d)	64.20	155.68	254.33	437.30	-
Case	370	285	273	243	-
Model 1					
OR	1	0.73	0.83	0.68	0.0267
95% CI	Ref.	0.57, 0.94	0.65, 1.07	0.51, 0.89	
Model 2					
OR	1	0.90	1.07	0.69	0.0518
95% CI	Ref.	0.65, 1.24	0.77, 1.50	0.49, 0.98	
Model 3					
OR	1	0.89	1.07	0.69	0.0478
95% CI	Ref.	0.64, 1.23	0.76, 1.50	0.49, 0.97	

Model 1: Unadjusted model; Model 2: Adjustment for age, alcohol intake frequency, smoking status, waist circumference and energy intake; Model 3: Model 2 + education status and household income

7 years old, vegetable intake is 335.9 g (26.2% of total food intake), and while the age increases the proportion of vegetable intake among total food intake [29]. In this study, quartile 1 group actually did show low vegetable intake amount, the age was the highest among 4 groups. In the case of quartile 1 group plant food or vegetable took the highest proportion of total food intake (data not shown), so it seemed like there were not much difference shown for the metabolism indicators due to biological activity strength plant food or vegetable had.

Koreans reportedly eat more pickled (or salted) vegetables, which are preserved by soaking and storing in vinegar or brine [30], than fresh vegetables [22]. In Korea, pickling can be used for kimchi, while kimchi made using salt (traditional fermented

Table 5. Multivariate odd ratios (ORs) and 95 % confidence intervals (CIs) of CHD risk by vegetable intakes frequency: The FFQ data

	Quartile 1	Quartile 2	Quartile 3	Quartile 4	P-trend
Total vegetable					
Median (frequency/d)	2.99	4.36	5.31	6.86	-
Case	346	301	252	272	-
Model 1					
OR	1	0.80	0.72	0.85	0.0848
95% CI	Ref.	0.62, 1.03	0.56, 0.93	0.66, 1.10	
Model 2					
OR	1	0.78	0.69	0.82	0.1946
95% CI	Ref.	0.56, 1.10	0.49, 0.97	0.59, 1.13	
Model 3					
OR	1	0.78	0.69	0.81	0.1850
95% CI	Ref.	0.56, 1.10	0.49, 0.97	0.59, 1.33	
White and red vegetable					
Median (frequency/d)	2.34	3.59	4.40	5.56	-
Case	316	317	287	251	-
Model 1					
OR	1	0.84	0.84	0.82	0.4140
95% CI	Ref.	0.65, 1.08	0.65, 1.09	0.64, 1.06	
Model 2					
OR	1	0.91	0.77	0.78	0.3508
95% CI	Ref.	0.64, 1.28	0.56, 1.07	0.55, 1.10	
Model 3					
OR	1	0.91	0.77	0.77	0.3465
95% CI	Ref.	0.64, 1.28	0.56, 1.07	0.55, 1.09	
Green vegetable					
Median (frequency/d)	0.31	0.63	0.91	1.50	-
Case	350	261	285	275	-
Model 1					
OR	1	0.91	0.86	0.97	0.6204
95% CI	Ref.	0.70, 1.16	0.68, 1.09	0.76, 1.24	
Model 2					
OR	1	0.72	0.69	0.83	0.1598
95% CI	Ref.	0.50, 1.04	0.49, 0.98	0.59, 1.15	
Model 3					
OR	1	0.72	0.69	0.82	0.1540
95% CI	Ref.	0.50, 1.03	0.49, 0.98	0.59, 1.15	

Model 1: Unadjusted model; Model 2: Adjustment for age, alcohol intake frequency, smoking status, waist circumference and energy intake; Model 3: Model 2 + education status and household income

cabbage) accounts for 5.7% of daily dietary intake and is the second most commonly consumed food in Korea [22]. In addition, it is reported that *jangajji*, which is preserved in salt or soy sauce, is highly consumed in Korea [31]. Both the Koreans and Japanese eat vegetables preserved in salt, such as kimchi and *jangajji*. According to the International Study of Macro and Micro-Nutrients and Blood Pressure, the main food sources of sodium (Na) in Japan are soy sauce (20.0%), fruits and vegetables preserved in salt (e.g., *jangajji*) (9.8%), and miso soup (9.7%) [32]. Overconsumption of Na is a dietary habit that is suggested to increase the risk of CHD, as reported by a

meta-analysis of 14 cohort studies [33]. Excessive Na intake increases blood volume; then, adrenomedullary hormones interfere with blood vessel contraction, which increases peripheral vessel resistance, leading to high blood pressure [34].

In this study, the intakes of total vegetables and non-salted vegetables were significantly and negatively correlated with CHD risk. On the other hand, in the case of salted vegetable, there was no significant relation with CHD risk. In the European Prospective Investigation into Cancer and Nutrition-Italy cohort study, which was a 7.85-year follow up study, the total intake of fruits and vegetables was not associated with CHD risk, but the intake of leafy vegetables was a strong factor for decreased CHD risk [35]. These results indicate that the type of vegetable intake and the relationship with CHD risk can differ by country, which may be related with the different diet patterns in each country. Especially, in this study, vegetable was divided into non-salted vegetable and salted vegetable to consider the effect of sodium intake on metabolism indicators related to CHD risk, and as a result salted vegetable did not show meaningful relation with CHD. According to the study of Jaacks *et al.* [36], dietary patterns such as low intakes of wheat products and high-fat cakes, and high intakes of beans and pickled vegetables is related with the increase of LDL cholesterol. In addition, in a study conducted on Korean men, fruits and non-pickled vegetable intake significantly has negative correlation with blood pressure, while sodium and kimchi intake significantly has positive correlation [37]. According to these kinds of preceding researches, it can be considered to recommend higher intake of total vegetable including mainly non-salted vegetable to prevent CHD, since sodium intake from non-salted vegetable is relatively lower. This suggestion through present study reflect the nutritional recommendations of the European Society of Cardiology [38] and American Heart Association [39], which recommend eating fruits and vegetables to decrease CHD risk. Therefore, strategies recommending vegetables to prevent CHD and additional specific research are necessary.

This study has several limitations. First, the present study only included a quantitative evaluation of the relationship between vegetable intake and CHD risk, while a qualitative evaluation of fruit and vegetable intake (e.g., servings, regularity, and variety) and CHD risk should be conducted. However, it is meaningful that, to the best of our knowledge, this is the first study conducted in Korea to analyze the relationship between different types of vegetable intake and CHD risk using nationwide data. Koreans especially eat vegetables in various ways in their daily basic meals, and this study is meaningful since it is suggesting the benefit related to health according to not only vegetable intake amount but also by its type. Second, owing to the cross-sectional design, a cause and effect relationship could not be determined. Retrospective method based on 24 hours was used to collect dietary intake data, so accurate reflection of the subject's intake condition may have been difficult. However in this study, FFQ data was also used to analyze the relation of vegetable intake frequency and risk of CHD, so the limitation was supplemented. Third, FRS is developed based on US population, and previous studies pointed out that CHD risk might be over or underestimated when it the Risk Score is used on other population that are

not US [40,41]. There is no prospective cohort study verifying the validity of FRS in Korea, so it is considered that systematic and long-term research on this is necessary.

In conclusion, total vegetable intake was inversely and significantly associated with the risk of CHD, and the significant relationship with CHD risk remained even after adjusting for potential confounders. Subjects in the higher quartiles of non-salted vegetable intake had 31% lower odds of the risk of CHD compared to those in the lowest quartile after adjusting for various potential confounders. These results indicate that higher vegetable intake may help decrease CHD risk in Korean men.

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