Noodle consumption is positively associated with incident hypertension in middle-aged and older Korean women

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BACKGROUND/OBJECTIVES: This study examined the association between refined grain consumption by subtype and the incidence of hypertension from the Korean Genome and Epidemiology Study data.

SUBJECTS/METHODS: In total, 5,018 participants (2,439 men and 2,579 women) from 40 to 69 years without hypertension were recruited at the beginning (2001-2002). Blood pressure and antihypertensive medication use were assessed biennially for the incidence of hypertension during the 8-year follow-up period (2009-2010). Hypertension was diagnosed as systolic blood pressure $\geq$ 140 mmHg or diastolic blood pressure $\geq$ 90 mmHg or antihypertensive medication use. Dietary intake including refined grains was assessed by a food frequency questionnaire at baseline and the follow-up (2005-2006). A multivariate Cox proportional hazard model was used to examine hazard ratios (HRs) and 95% confidence intervals (CIs) for incident hypertension according to refined-grain consumption.

RESULTS: A total of 1,377 cases of hypertension (710 men and 667 women) were newly ascertained. Frequent noodle consumers ($\geq$ 5 servings/week) among the women had a 2.3-fold higher risk of hypertension than infrequent noodle consumers after adjustment for potential confounders (HR = 2.31, 95% CI = 1.33-4.01, *P* for trend = 0.0001). However, no significant association was found among the men. The intake of other refined grain products such as white rice and breads was not associated with the incidence of hypertension.

CONCLUSION: Frequent noodle consumption was positively associated with a risk of incident hypertension in South Korean women.

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INTRODUCTION

Hypertension is a leading cause of stroke and kidney failure, and increases the risk of cardiovascular disease [1-3]. The increasing incidence of hypertension has been a public health concern around the world. The National Health and Nutrition Examination Survey 2011 to 2014 reported that the prevalence of hypertension among U.S. adults aged $\geq$ 20 years was 34% [4]. The Korean National Survey showed that the age-standardized prevalence of hypertension averaged 29% in South Korean adults aged $\geq$ 30 years in 2016 [5].

Appropriate diets may prevent the development of hypertension. In particular, the Dietary Approaches to Stop Hypertension (DASH) diet, which is mainly composed of whole grains, vegetables, low-fat dairy foods, and fruits, is well known to have a beneficial effect on hypertension [6,7].

Epidemiologic studies have shown that different types of grain products have various effects on health outcomes, including cardiovascular risk factors [8-10]. Previous studies have reported that increasing the consumption of whole-grain foods reduces blood pressure [10-12]. However, the studies on the association of refined grain intake with hypertension have had conflicting results [13,14]. Moreover, a prospective association between refined grain product consumption by subtype and incident hypertension has not been examined.

Traditionally, East Asian adults including Koreans consume greater amounts of carbohydrate, compared with the Western population [15,16]. Recently, the consumption of white rice, which used to be a main staple in the diet, has decreased, whereas the consumption of noodles and breads has more than doubled during the last 10 years in the Koreans' diet [17]. Therefore, this study aimed to reveal the association between

refined grain product consumption by subtype and the risk of developing hypertension during 8 years of follow-up using data from the Korean Genome and Epidemiology Study (KoGES).

SUBJECTS AND METHODS

Study population

This cohort study, as a part of KoGES, was conducted primarily to evaluate the association between lifestyle factors and genetic risk factors associated with the incidence of chronic diseases in Korean adults, which began in 2001 [18].

The cohort included 10,030 Korean adults from 40 to 69 years who lived in suburbs near the capital city. Baseline data were collected from 2001 to 2002, and follow-up surveys were conducted every 2 years over an 8-year period (2009-2010). Participants at baseline were asked to complete questionnaires on demographic information, lifestyle, medical history and health conditions; and blood pressure and medication use were assessed biennially.

A total of 5,012 were excluded from this study for the following reasons; 3,271 had hypertension at baseline, 111 had cardiovascular disease or cancer, 707 did not participate in the follow-up surveys, 207 had extraordinary energy intake (< 500 kcal or > 6,000 kcal) [13,19], 574 did not complete the food frequency questionnaire (FFQ), and 142 provided insufficient information. As a result, the data from 5,018 individuals (2,439 men and 2,579 women) were used for this study.

This study using secondary data from KoGES was approved by the Institutional Review Boards of the Korea Centers for Disease Control and Prevention and Kyung Hee University (KHSIRB-16-022).

Dietary assessment

Dietary assessment was done using a 103-item semi-quantitative FFQ with validation [20] at baseline (2001-2002) and at the follow-up survey (2005-2006). In the FFQs, the participants were asked about the frequency and portion sizes of their food consumption during the previous year. The frequency of the consumption of each food was classified into nine categories: never/seldom, once/month, 2-3 times/month, 1-2 times/week, 3-4 times/week, 5-6 times/week, once/day, 2 times/day, and 3 times or more/day. The portion sizes of the consumed foods were classified into three categories: 1/2 serving, 1 serving (standard), and ≥ 2 servings. The portion sizes were multiplied by the consumption frequencies for each food. The refined grains were classified into three groups: white rice, noodles, and breads. Noodles included ramen, chopped noodles, jangguk noodles, udon, buckwheat noodles, noodles with black bean sauce, and cold noodles. Breads included white bread, red bean bread, custard cream bread, cake, pizza and hamburger buns. The consumption of white rice was divided into five categories (never, 1 - < 2, 2 - < 3, 3, > 3 servings/day), because white rice is very frequently consumed among Koreans. The consumption of noodles was divided into five categories (never, 0 - < 1, 1 - < 3, 3 - < 5, ≥ 5 servings/week) and bread consumption was divided into four categories (never, 0 - < 1, 1 - < 3, ≥ 3 servings/week). Individual food consumption was expressed as food intake per week or day, and the total intake

of each food was summed. Fruit included twelve items; vegetables included twenty items; meats included seven items, including pork, beef, chicken and processed meat (ham, sausage, etc.); and dairy foods included milk, yogurt, and cheese. Nutrient intake was measured using the Korean Food Composition Table [21].

Definition of hypertension

Blood pressure was measured by trained technicians using mercury sphygmomanometers. Each individual underwent the measurement after at least five minutes of resting in a seated position (W.A. Baum Co. Inc., New York, USA). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded twice, and the average was taken for analysis. Hypertension was diagnosed as SBP ≥ 140 mmHg or DBP ≥ 90 mmHg or the use of antihypertensive medication. SBP and DBP were calculated at Korotkoff phase I and Korotkoff phase V, respectively [22].

Covariates

Demographic factors, socioeconomic status, and lifestyle factors were examined using structured questionnaires given by trained research staff. Educational level was classified into three groups: ≤ 6 years, 7 - ≤ 12 years, and > 12 years. Monthly household income was classified into four groups: < 1 million Korean Won (KW) (approx. < 890 US$ in 2018), 1 - < 2 million KW (approx. 890 - < 1,780 US$), 2 - < 3 million KW (approx. 1,780 - < 2,670 US$), and ≥ 3 million KW (≥ 2,670 US$). Smoking status was categorized into lifetime non-smoker, former smoker, and current smoker. Alcohol consumption was categorized into lifetime non-drinker, former drinker, and current drinker. Physical activity was evaluated using metabolic equivalent of task (MET) [23]. To obtain METs, the participants reported hours spent sleeping and five types of activities classified according to activity intensity. Height was measured to the nearest 0.1cm using a stadiometer (Aluminum anthropometer, Samhwa Instrument, Seoul, Korea), and body weight was measured to 0.1 kg in light clothes using Inbody 3.0 (Biospace Corp., Seoul, Korea). Body mass index (BMI) was defined as body weight divided by the square of height in meters (kg/m^2).

Statistical analyses

All data analyses were performed with SAS software version 9.4 (SAS Institute, Cary, NC, USA) [24]. Data were presented as means and standard deviations for continuous variables, and were presented as numbers and percentages for categorical variables. Differences between baseline characteristics according to the development of hypertension were examined with Chi-squared tests or Student's t-tests. Comparisons of variables according to noodle intake were examined with Chi-squared tests or generalized linear models. The hazard ratios (HRs) and 95% confidence intervals (CIs) for hypertension risk across noodle intake were calculated with Cox proportional hazard models. Survival analysis was performed separately for men and women. Age was adjusted in Model 1. The covariates in Model 1 plus educational level, household income, smoking status, alcohol intake, physical activity, and BMI were adjusted in Model 2. The covariates included in Model 2 plus nutrient intakes and food intakes were adjusted in Model 3. Variables for adjustment

were selected through potential confounders from the published scientific literature and the statistical approach [25].

For individuals who developed hypertension or were censored between baseline and the follow-up survey, noodle consumption was assessed based on the FFQ at baseline. For those who developed hypertension or were censored after the follow-up survey, noodle consumption was assessed based on the average of FFQ at baseline and FFQ at the follow-up.

The assumptions of proportional hazards were assessed using log-log plots [26] and Schoenfeld's residuals [27], and accepted. *P* values of < 0.05 were considered to be statistically significant for all tests.

RESULTS

Characteristics of subjects

The average follow-up period was 72.1 months, and the follow-up rate was 64%. During the follow-up period, 1,377

Table 1. Baseline characteristics of participants by hypertension status (n = 5,018)[1]

	Hypertension (n = 1,377)	Non-Hypertension (n = 3,641)	*P*-value[2]
Age (yrs)	53.6 ± 9.0	49.5 ± 8.1	< 0.0001
No. of participants (%)			0.0100
Men	710 (51.6)	1,729 (47.5)	
Women	667 (48.4)	1,912 (52.5)	
Resident area (%)			< 0.0001
Rural area (Ansung)	792 (57.5)	1,456 (40.0)	
Urban area (Ansan)	585 (42.5)	2,185 (60.0)	
Income level (Korean won/mo.) (%)			< 0.0001
< 1 million	572 (41.5)	930 (25.5)	
1 - < 2 million	364 (26.4)	1,126 (30.9)	
2 - < 3 million	214 (15.5)	812 (22.3)	
≥ 3 million	227 (16.5)	773 (21.2)	
Educational level (%)			< 0.0001
Elementary school (≤ 6 yrs)	529 (38.4)	853 (23.4)	
Middle/ high school (7-12 yrs)	699 (50.8)	2,182 (59.9)	
College or higher (> 12 yrs)	149 (10.8)	606 (16.6)	
Smoking status (%)			0.016
Never	756 (54.9)	2,161 (59.4)	
Former	225 (16.3)	548 (15.1)	
Current	396 (28.8)	932 (25.6)	
Alcohol consumption (%)			0.250
Never	601 (43.7)	1,659 (45.6)	
Former	91 (6.6)	207 (5.7)	
Current	685 (49.8)	1,775 (48.8)	
Activity (MET[3]-hours/day)	24.9 ± 15.9	22.7 ± 14.4	< 0.0001
Body mass index (kg/m²)	24.7 ± 3.1	23.9 ± 2.9	< 0.0001
Systolic blood pressure (mmHg)	120.2 ± 9.8	109.9 ± 10.8	< 0.0001
Diastolic blood pressure (mmHg)	79.3 ± 6.7	73.6 ± 7.8	< 0.0001
Nutrient intake			
Total energy (kcal/day)	1,975.8 ± 673.8	1,955.1 ± 614.2	0.3025
Percentage from energy			
Carbohydrate (%)	72.5 ± 7.3	71.1 ± 7.0	< 0.0001
Protein (%)	13.4 ± 2.4	13.7 ± 2.3	< 0.0001
Fat (%)	14.1 ± 5.4	15.2 ± 5.2	< 0.0001
Sodium (mg/day)	3,249.6 ± 1,684.2	3,160.5 ± 1,570.6	0.079
Food intake (servings/day)			
Fruit	3.2 ± 2.5	3.4 ± 2.3	0.005
Vegetable	3.6 ± 2.4	3.6 ± 2.3	0.998
Meat	0.5 ± 0.5	0.5 ± 0.5	0.026
Dairy	0.6 ± 0.7	0.7 ± 0.7	0.007
Grain	1.9 ± 1.2	1.9 ± 1.3	0.698

[1] Values are mean ± SD or numbers (percentages).
[2] Chi-squared tests for categorical variables or Student's *t*-tests for continuous variables were used to test differences in baseline characteristics. All *P*-values are significant at *P* < 0.05.
[3] MET: Metabolic equivalent of task

Table 2. Baseline demographic characteristics of a cohort of 5,018 Korean adults according to noodle consumption[1]

	Never	0 - < 1 serving/week	1 - < 3 servings/week	3 - < 5 servings/week	≥ 5 servings/week	P-value[2]
Men (n = 2,439)						
Participants No. (No. of cases)	191 (52)	657 (192)	1,012 (261)	377 (129)	202 (76)	
Age (yrs)	53.9 ± 9.2	51.8 ± 8.7	49.6 ± 8.1	49.3 ± 8.4	51.3 ± 8.4	< 0.0001
Resident area (%)						< 0.0001
Rural area (Ansung)	96 (50.3)	296 (45.1)	363 (35.9)	152 (40.3)	115 (56.9)	
Urban area (Ansan)	95 (49.7)	361 (55.0)	649 (64.1)	225 (59.7)	87 (43.1)	
Income level (Korean won /mo.) (%)						< 0.0001
< 1 million	62 (32.5)	192 (29.2)	203 (20.1)	85 (22.6)	60 (29.7)	
1 - < 2 million	66 (34.6)	197 (30.0)	310 (30.6)	106 (28.1)	61 (30.2)	
2 - < 3 million	31 (16.2)	135 (20.6)	231 (22.8)	82 (21.8)	36 (17.8)	
≥ 3 million	32 (16.8)	133 (20.2)	268 (26.5)	104 (27.6)	45 (22.3)	
Educational level (%)						< 0.0001
Elementary school (≤ 6 yrs)	53 (27.8)	120 (18.3)	153 (15.1)	54 (14.3)	46 (22.8)	
Middle/ high school (7-12 yrs)	100 (52.4)	410 (62.4)	591 (58.4)	235 (62.3)	118 (58.4)	
College or higher (> 12 yrs)	38 (19.9)	127 (19.3)	268 (26.5)	88 (23.3)	38 (18.8)	
Smoking status (%)						0.0034
Never	43 (22.5)	156 (23.7)	166 (16.4)	72 (19.1)	27 (13.4)	
Former	56 (29.3)	186 (28.3)	332 (32.8)	104 (27.6)	61 (30.2)	
Current	92 (48.2)	315 (48.0)	514 (50.8)	201 (53.3)	114 (56.4)	
Alcohol consumption (%)						< 0.0001
Never	46 (24.1)	150 (22.8)	186 (18.4)	72 (19.1)	29 (14.4)	
Former	30 (15.7)	77 (11.7)	82 (8.1)	24 (6.4)	22 (10.9)	
Current	115 (60.2)	430 (65.5)	744 (73.5)	281 (74.5)	151 (74.8)	
Activity (MET[3]-hours/day)	25.3 ± 17.0	24.0 ± 15.1	22.8 ± 14.8	23.6 ± 14.4	27.0 ± 17.8	0.0045
BMI (kg/m²)	22.8 ± 2.6	23.7 ± 2.9	24.1 ± 2.9	24.0 ± 2.9	24.1 ± 2.8	< 0.0001
Systolic blood pressure (mmHg)	113.5 ± 11.0	114.6 ± 10.5	113.2 ± 10.9	114.4 ± 10.9	116.0 ± 10.6	0.0038
Diastolic blood pressure (mmHg)	76.4 ± 6.9	76.9 ± 7.3	76.3 ± 7.6	76.9 ± 7.5	77.9 ± 7.1	0.0635
Women (n = 2,579)						
Participants No. (No. of cases)	446 (113)	1,022 (251)	821 (217)	195 (54)	95 (32)	
Age (yrs)	53.8 ± 9.0	50.9 ± 8.6	49.2 ± 8.1	48.5 ± 7.4	47.7 ± 7.8	< 0.0001
Resident area (%)						< 0.0001
Rural area (Ansung)	258 (57.9)	456 (44.6)	359 (43.7)	90 (46.2)	63 (66.3)	
Urban area (Ansan)	188 (42.2)	566 (55.4)	462 (56.3)	105 (53.9)	32 (33.7)	
Income level (Korean won /mo.) (%)						< 0.0001
< 1 million	211 (47.3)	350 (34.3)	239 (29.1)	64 (32.8)	36 (37.9)	
1 - < 2 million	120 (26.9)	319 (31.2)	233 (28.4)	47 (24.1)	31 (32.6)	
2 - < 3 million	64 (14.4)	189 (18.5)	190 (23.1)	49 (25.1)	19 (20.0)	
≥ 3 million	51 (11.4)	164 (16.1)	159 (19.4)	35 (18.0)	9 (9.5)	
Educational level (%)						< 0.0001
Elementary school (≤ 6 yrs)	226 (50.7)	401 (39.2)	241 (29.4)	57 (29.2)	31 (32.6)	
Middle/ high school (7-12 yrs)	201 (45.1)	546 (53.4)	503 (61.3)	124 (63.6)	53 (55.8)	
College or higher (> 12 yrs)	19 (4.3)	75 (7.3)	77 (9.4)	14 (7.2)	11 (11.6)	
Smoking status (%)						0.1493
Never	419 (94.0)	981 (96.0)	777 (94.6)	183 (93.9)	93 (97.9)	
Former	12 (2.7)	9 (0.9)	10 (1.2)	3 (1.5)	0 (0.0)	
Current	15 (3.4)	32 (3.1)	34 (4.1)	9 (4.6)	2 (2.1)	
Alcohol consumption (%)						< 0.0001
Never	346 (77.6)	710 (69.5)	540 (65.8)	122 (62.6)	59 (62.1)	
Former	16 (3.6)	19 (1.9)	23 (2.8)	1 (0.5)	4 (4.2)	
Current	84 (18.8)	293 (28.7)	258 (31.4)	72 (36.9)	32 (33.7)	
Activity (MET[3]-hours/day)	24.4 ± 15.6	22.4 ± 14.1	22.6 ± 13.9	22.3 ± 15.1	23.3 ± 14.6	0.1646
Body mass index (kg/m²)	24.3 ± 3.2	24.0 ± 3.0	24.7 ± 3.0	24.5 ± 2.9	24.8 ± 3.2	0.0001
Systolic blood pressure (mmHg)	112.7 ± 11.8	111.3 ± 12.3	111.2 ± 11.8	110.5 ± 11.7	112.8 ± 10.5	0.1065
Diastolic blood pressure (mmHg)	74.3 ± 7.7	73.3 ± 8.3	73.6 ± 8.2	73.4 ± 8.4	76.4 ± 7.1	0.0034

[1] Values are mean ± SD or numbers (percentages).
[2] Chi-square tests or generalized linear models were used to compare variables at baseline across noodle consumption categories.
[3] MET: Metabolic equivalent of task
All P-values are significant at P < 0.05.

Table 3. Nutrient and food intakes of a cohort of 5,018 Korean adults according to noodle consumption[1]

	Never	0 - < 1 serving/week	1 - < 3 servings/week	3 - < 5 servings/week	≥ 5 servings/week	P-value[2]
Men (n = 2,439)						
Participants No. (No. of cases)	191 (52)	657 (192)	1012 (261)	377 (129)	202 (76)	
Nutrient intake						
Total energy (kcal/day)	1,845.0 ± 562.0[a]	1,895.3 ± 614.5[a]	2,016.8 ± 531.1[b]	2,183.5 ± 630.7[c]	2,355.7 ± 763.2[d]	< 0.0001
Percentage from energy						
Carbohydrate (%)	71.8 ± 8.1[ac]	71.9 ± 6.8[a]	69.9 ± 6.8[b]	69.6 ± 6.6[b]	69.6 ± 6.6[bc]	< 0.0001
Protein (%)	13.7 ± 2.8[ab]	13.5 ± 2.3[a]	13.9 ± 2.2[b]	13.8 ± 2.0[b]	13.8 ± 2.0[ab]	0.012
Fat (%)	14.5 ± 5.6[a]	14.6 ± 4.9[a]	16.2 ± 5.0[b]	16.6 ± 5.0[b]	16.6 ± 5.0[b]	< 0.0001
Sodium (mg/day)	3,164.6 ± 1,997.5[a]	3,121.7 ± 1,542.1[a]	3,322.3 ± 1,496.2[ab]	3,585.3 ± 1,584.6[b]	4,012.5 ± 2,037.8[c]	< 0.0001
Food intake (servings/day)						
Fruit	2.6 ± 1.9	2.9 ± 2.2	3.0 ± 1.9	2.9 ± 1.8	2.9 ± 2.2	0.2473
Vegetable	3.1 ± 2.6[ac]	3.1 ± 1.8[a]	3.4 ± 1.9[bx]	3.7 ± 2.1[bc]	3.8 ± 2.2[bc]	< 0.0001
Meat	0.5 ± 0.4[a]	0.5 ± 0.4[a]	0.6 ± 0.4[b]	0.7 ± 0.5[c]	0.8 ± 0.7[c]	< 0.0001
Dairy	0.5 ± 0.6[a]	0.5 ± 0.6[a]	0.6 ± 0.6[a]	0.6 ± 0.6[a]	0.7 ± 0.9[a]	0.0108
Women (n = 2,579)						
Participants No. (No. of cases)	446 (113)	1022 (251)	821 (217)	195 (54)	95 (32)	
Nutrient intake						
Total energy (kcal/day)	1,792.8 ± 642.0[a]	1,821.4 ± 618.7[a]	1,960.8 ± 580.5[b]	2,081.7 ± 750.9[b]	2,174.2 ± 797.9[c]	< 0.0001
Percentage from energy						
Carbohydrate (%)	74.1 ± 7.6[a]	72.9 ± 7.2[b]	71.4 ± 6.7[c]	71.1 ± 6.5[c]	70.8 ± 7.2[c]	< 0.0001
Protein (%)	13.3 ± 2.5[a]	13.4 ± 2.3[a]	13.8 ± 2.3[b]	13.7 ± 2.1[ab]	13.7 ± 2.1[ab]	0.0043
Fat (%)	12.6 ± 5.6[a]	13.6 ± 5.3[b]	14.8 ± 5.0[c]	15.2 ± 4.8[c]	15.5 ± 5.6[c]	< 0.0001
Sodium (mg/day)	3,003.8 ± 1,638.8[ab]	2,853.7 ± 1,467.8[a]	3,108.7 ± 1,519.9[bc]	3,269.9 ± 1,813.4[cd]	3,751.7 ± 1,524.7[d]	< 0.0001
Food intake (servings/day)						
Fruit	3.5 ± 2.7[a]	3.6 ± 2.3[a]	4.0 ± 2.8[b]	4.0 ± 3.1[ab]	4.4 ± 2.6[ab]	0.0012
Vegetable	3.6 ± 3.0[ab]	3.5 ± 2.0[a]	4.0 ± 2.7[bc]	4.2 ± 2.4[bc]	4.9 ± 3.4[c]	< 0.0001
Meat	0.3 ± 0.5[a]	0.4 ± 0.4[a]	0.4 ± 0.4[b]	0.5 ± 0.4[b]	0.7 ± 0.9[c]	< 0.0001
Dairy	0.7 ± 0.8	0.7 ± 0.7	0.8 ± 0.8	0.7 ± 0.7	0.8 ± 0.8	0.6966

[1] Values are mean ± SD or numbers (percentages).
[2] Chi-squared tests or generalized linear models were used to compare variables at baseline across noodle consumption.
[a,b,c,d] Multiple comparisons are given by post-hoc Tukey's HSD test (*P* < 0.05).
All *P*-values are significant at *P* < 0.05.

cases of hypertension (710 men and 667 women) were recorded among 5,018 subjects. The baseline characteristics of the subjects, according to the development of hypertension during follow-up, are presented in Table 1. The subjects who acquired hypertension were older and more likely to be men, to live in a rural area, and to be exercisers compared to subjects who did not acquire hypertension. The subjects who acquired hypertension had lower income, were less likely to be educated, and were more likely to be current smokers than those who did not acquire hypertension. The subjects with hypertension had a higher BMI than those who did not acquire hypertension. Also, the energy intake from carbohydrates was higher, and fruit and dairy intake was lower, in subjects who had acquired hypertension compared with those without hypertension.

Characteristics of subjects according to noodle consumption

Among the men, the frequent noodle consumers (≥ 5 servings/week) were younger and more likely to have a higher household income and be current-drinkers, compared with infrequent noodle consumers or never consumers (all *P* < 0.05)

(Table 2). Among the women, frequent noodle consumers were younger, more likely to live in a rural area, to be current alcohol drinkers, and to be educated compared with infrequent noodle consumers or never consumers (all *P* < 0.05). Frequent noodle consumers among men and women had a higher intake of total energy, sodium, and energy from protein and fat, but a lower intake of energy from carbohydrates compared with infrequent noodle consumers or never consumers (all *P* < 0.05) (Table 3).

The risk of hypertension according to grain product consumption

Among the women, frequent noodle consumers (≥ 5 servings/ week) had a 2.3-fold higher risk of hypertension after adjusting for potential confounders (HR = 2.31, 95% CI = 1.33-4.01, *P* for trend = 0.0001) (Table 4). However, no significant association between noodle intake and risk of incident hypertension was observed in men. The consumption of other grain products, specifically white rice and breads, was not associated with the risk of developing hypertension.

Table 4. Hazard ratios (HRs) and 95% confidence intervals (CIs) for the risk of incident hypertension according to type of grain product consumption[1]

	Never	0 - < 1 serving/week	1 - < 3 servings/week	3 - < 5 servings/week	≥ 5 servings/week	P for trend[1]
Noodles						
Men (n = 2,439)						
Participants No. (No. of cases)	191 (52)	657 (192)	1,012 (261)	377 (129)	202 (76)	
Model 1	1.00	1.13 (0.83-1.53)	1.04 (0.77-1.41)	1.63 (1.18-2.25)	1.60 (1.13-2.28)	0.0001
Model 2	1.00	1.06 (0.78-1.45)	0.95 (0.70-1.28)	1.50 (1.08-2.07)	1.38 (0.97-1.96)	0.0028
Model 3	1.00	0.97 (0.68-1.37)	0.80 (0.57-1.13)	1.31 (0.90-1.90)	1.25 (0.82-1.92)	0.0751
Women (n = 2,579)						
Participants No. (No. of cases)	446 (113)	1,022 (251)	821 (217)	195 (54)	95 (32)	
Model 1	1.00	1.22 (0.97-1.52)	1.53 (1.22-1.93)	1.72 (1.24-2.38)	2.43 (1.63-3.61)	< 0.0001
Model 2	1.00	1.24 (0.99-1.56)	1.50 (1.19-1.89)	1.68 (1.21-2.34)	2.30 (1.54-3.42)	< 0.0001
Model 3	1.00	1.37 (1.05-1.79)	1.61 (1.22-2.12)	1.65 (1.09-2.48)	2.31 (1.33-4.01)	0.0001

	Never	0 - < 1 serving/week	1 - < 3 servings/week	≥ 3 servings/week	P for trend[1]
Bread					
Men (n = 2,439)					
Participants No. (No. of cases)	484 (161)	991 (292)	615 (155)	349 (102)	
Model 1	1.00	0.87 (0.72-1.06)	0.78 (0.62-0.97)	0.94 (0.73-1.21)	0.318
Model 2	1.00	0.88 (0.73-1.08)	0.82 (0.65-1.04)	1.05 (0.81-1.36)	0.912
Model 3	1.00	1.01 (0.79-1.29)	0.84 (0.62-1.12)	1.03 (0.73-1.45)	0.617
Women (n = 2,579)					
Participants No. (No. of cases)	470 (168)	1,073 (279)	675 (148)	361 (72)	
Model 1	1.00	0.88 (0.72-1.07)	0.92 (0.72-1.16)	0.86 (0.64-1.14)	0.356
Model 2	1.00	0.92 (0.76-1.12)	1.02 (0.81-1.30)	0.94 (0.70-1.26)	0.973
Model 3	1.00	0.99 (0.77-1.26)	1.15 (0.86-1.55)	0.96 (0.65-1.41)	0.716

	Never	1 - < 2 servings/day	2 - < 3 servings/day	3 servings/day	> 3 servings/day	P for trend[1]
White rice						
Men (n = 2,439)						
Participants No. (No. of cases)	799 (227)	828 (263)	162 (40)	467 (128)	183 (52)	
Model 1	1.00	1.08 (0.91-1.29)	0.91 (0.65-1.27)	1.04 (0.84-1.30)	1.03 (0.76-1.40)	0.9037
Model 2	1.00	1.08 (0.90-1.29)	0.93 (0.66-1.30)	1.05 (0.84-1.31)	0.96 (0.71-1.30)	0.9014
Model 3	1.00	1.32 (1.07-1.63)	0.99 (0.65-1.49)	1.12 (0.85-1.48)	1.00 (0.69-1.45)	0.9931
Women (n = 2,579)						
Participants No. (No. of cases)	1,331 (317)	811 (235)	114 (25)	256 (75)	57 (15)	
Model 1	1.00	1.09 (0.92-1.29)	1.09 (0.73-1.64)	1.14 (0.89-1.48)	1.19 (0.71-2.00)	0.1996
Model 2	1.00	1.08 (0.91-1.28)	1.09 (0.72-1.63)	1.10 (0.85-1.42)	1.08 (0.65-1.82)	0.3862
Model 3	1.00	1.06 (0.86-1.29)	0.76 (0.43-1.32)	1.13 (0.82-1.56)	0.75 (0.35-1.59)	0.9970

[1] Time-dependent Cox proportional hazard models were used to calculate the HRs and 95% CIs for incident hypertension according to grain product consumption. The median consumption values for each category were used as a continuous variable in the models to assess the statistical significance for trends for hypertension risk across categories.
Model 1 was adjusted for age.
Model 2 was adjusted for age (continuous), BMI (continuous), household income (< 1, 1 - < 2, 2 - < 3, ≥ 3 million), education level (≤ 6, 7 - < 12, > 12 y), smoking status (never, former, current), alcohol intake (never, former, current), and physical activity (continuous).
Model 3 was adjusted for covariates included in Model 2 plus intake of total energy, sodium, fruit, vegetables, meat, and dairy food.

DISCUSSION

This prospective study found that noodle consumption was inversely associated with the risk of incident hypertension in middle-aged and older Korean women, whereas the consumption of other refined grain products was not associated with the risk of incident hypertension. In women, frequent noodle consumers (≥ 5 servings/week) had a 2.3-fold higher risk of incident hypertension compared with never consumers after

adjustment for potential confounders. However, there was no significant association between noodle consumption and the risk of hypertension in men.

Similar to these findings, several studies have supported associations between refined grain consumption, including noodles, and risk of hypertension. A high intake of refined grain products including noodles was associated with a 69% greater risk of hypertension in a cross-sectional study of Tehran adults aged 18-74 years [28]. Another cross-sectional study, in an urban

South Indian population, showed that a higher intake of refined grain products including white flour was significantly associated with higher systolic blood pressure (+2.9% higher for the highest vs the lowest quartile) and diastolic blood pressure (+1.7%) [29]. In contrast, a prospective cohort study among U.S. female professionals reported that refined grain product consumption was not associated with the risk of hypertension in middle-aged and older women [10].

Several mechanisms have been proposed to explain the relationship between refined grain and the risk of hypertension. Diets such as the DASH diet or a Mediterranean-style diet, which are known to be inversely associated with hypertension [30,31], emphasize whole grain intake more than refined grains [32] and diversity of food intake for the prevention and management of hypertension. Generally, Koreans eat noodles along with kimchi or pickled radish, sometimes with steamed white rice. This type of dietary pattern increases the intake of refined carbohydrate but limits dietary diversity [33]. Furthermore, noodle dishes contain a very high amount of sodium, which may contribute to an increased risk of hypertension [14].

Refined grains including noodles are relatively low in nutrients because bran and germ are removed during the refining process [29], which has negative effects on hypertension. For example, whole grains are richer in nutrients including dietary fiber, potassium, magnesium, and folate, which have a beneficial effect on blood pressure [10-12]. A Cochrane review of 10 clinical trials reported that an increased consumption of fiber reduced SBP by 1.92 mmHg and DBP by 1.77 mmHg [34].

Interestingly, an inverse association between noodle intake and hypertension was shown in women only in this study. A gender difference has been observed in the link between hypertension and its risk factors [35]. Several hypotheses involving sex hormones have been proposed, although the underlying pathophysiological mechanisms are poorly understood [36-38]. For example, estrogen has been related to various favorable effects on cardiovascular metabolism, including vasorelaxation, inhibition of sympathetic nerves, and prevention of vascular remodeling [39], whereas testosterone has been positively associated with incident hypertension, exerting opposing effects [40]. Sex hormones seem to influence the activity of the renin-angiotensin system, and thus its regulation might be different between men and women [41].

Dietary factors in the development of hypertension may have a greater impact in women than in men. A randomized, crossover study in Australia reported that a diet of decreased Na and K supplementation led to a greater reduction in blood pressure in women than in men [42]. A prospective study conducted in South Korea found a positive association between fried food intake and the risk of incident hypertension in women but not in men [43], suggesting a gender difference in blood pressure response. Two clinical trials in the United States comparing the effect of antihypertensive therapy between men and women reported that the reduction of blood pressure was greater in women compared with men, and the number of subjects who achieved blood pressure control was higher among the women than the men [44,45]. Thus, gender differences should be considered in the establishment of dietary guidelines for the management and control of hypertension.

Unlike noodles, other refined grain products such as white rice and bread were not associated with risk of hypertension. White rice or bread intake might be more strongly associated with dyslipidemia or glucose abnormalities rather than blood pressure in the Asian population. High white rice intake has been associated with elevated triglyceride and reduced HDL cholesterol levels [46,47]. Also, white rice is the major contributor to dietary glycemic load, which leads to insulin resistance and glucose abnormalities [48]. Bread-dairy pattern has been associated with dyslipidemia (high total cholesterol and low HDL cholesterol) in Japanese men and women [49].

The study has some limitations. First, the present study examined only certain age groups, and only two areas near the capital city were selected for the study. Therefore, caution must be used in generalizing these findings to the entire population. Second, residual confounders cannot be ruled out in the analysis, although the association persisted with multivariate adjustment.

Despite these limitations, the present study has several strengths. This study used data from a large-scale population-based cohort study. The use of average values from the baseline and a follow-up FFQ in grain consumption minimized the random measurement error caused during the relatively long period of follow-up (8 years).

In conclusion, frequent noodle consumption ($\geq$ 5 servings/week) was associated with a higher risk of incident hypertension in Korean women only, whereas consumption of other types of refined grain foods were not associated with the risk of developing hypertension. These results suggest that decreasing the amount and proportion of refined grain products, including noodles, in the usual diet would be helpful for preventing and managing hypertension in the Korean population consuming a high amount of refined grain.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interests.

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