Effect of 'rice' pattern on high blood pressure by gender and obesity: using the community-based KoGES cohort

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Abstract

Objective: The present study aimed to examine the association between dietary pattern and the risk of high blood pressure (BP) and to estimate the attenuated effect by gender and obesity on the association using data from a prospective cohort study in Korea.

Design: Prospective study. Diet was assessed using a validated 103-item FFQ and was input into factor analysis after adjustment for total energy intake.

Setting: Community-based Korean Genome Epidemiology Study (KoGES) cohort.

Participants: Healthy individuals (n 5151) without high BP at recruitment from the community-based cohort study.

Results: Dietary pattern was not associated with the risk of high BP regardless of the type of covariates, with the exception of the 'rice' pattern. The effect of the 'rice' pattern was observed in both men ($P_{trend} = 0.013$) and women ($P_{trend} < 0.001$), but the statistical significance remained only in women after adjustment for confounders ($P_{trend} = 0.004$). The positive association of the 'rice' pattern with high BP risk was attenuated by obesity. After stratification by gender and obese status, in particular, the harmful effect of the 'rice' pattern was predominantly observed in obese women ($P_{trend} < 0.001$) only.

Conclusions: This longitudinal study in Korean adults found a positive association of the 'rice' pattern with long-term development of incident high BP, predominantly in women. The association is likely to be attenuated by gender and obese status.

The prevalence of raised blood pressure (BP) is 22 % in adults aged 18 years or above worldwide[1], and its harmful effect on CVD and related mortality has already been supported by large prospective epidemiological studies[2]. According to the Joint National Committee's 7th report[3], a healthy lifestyle needs to be adopted for the prevention and management of BP, including weight reduction, consumption of foods rich in K and Ca, dietary Na reduction, physical activity and modification of alcohol consumption. The Dietary Approaches to Stop Hypertension (DASH) diet plan is the most popular to reduce the prevalence of high BP.

Several meta-analyses[4,5] and a large cross-sectional study (INTERMAP)[6] have reported the association between intake of single nutrients and BP, but the results are not consistent. Because people consume complex combinations of foods, it is difficult to assess the independent effects of single nutrients or foods. Therefore, dietary pattern analysis has been performed recently to evaluate the effect of food/nutrient intake on chronic diseases including high BP[7]. Although the adaptation of the DASH diet plan for reducing BP has been supported by several prospective studies and intervention trials, its beneficial effect remains controversial. In particular, the traditional dietary items and cooking methods of Asian populations were shown to result in more complicated and varied relationships between dietary factors and BP compared with those in Western populations[8–14].

Although the main issue of dietary factors to prevent high BP has traditionally focused on fat intake, especially saturated fat, dietary carbohydrate intake may play a substantial role in the risk of high BP for Asians, because they traditionally consume large amounts of rice as a staple food. The effects of a carbohydrate-rich diet and high

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refined-grain consumption on the risk of high BP have been observed in obese Korean women[15] and South Indians[16], respectively. Clinical trials using polyunsaturated fat to replace saturated fat have reduced the incidence of CVD, but use of carbohydrates to replace saturated fat did not decrease the incidence[17,18]. On the other hand, evidence from prospective observational studies indicates that carbohydrates from whole grains could reduce CVD when they replace saturated fat[19].

Regarding the effect of diet on the risk of high BP by ethnic variation, it is valuable to consider the attenuated effect by aetiological characteristics including gender and obesity[20,21]. Therefore, the aim of the present study was to examine the association between dietary pattern and the risk of high BP and to evaluate the attenuated effect on the association by gender and obesity using a prospective cohort study.

Methods

Study population

Data from participants in the community-based Korean Genome Epidemiology Study (KoGES), which is a cohort study in Korea, were used to investigate the effect of dietary and environmental factors on chronic diseases. Detailed information on the study procedure has been described previously[22]. Briefly, 10 038 (urban area, *n* 5020; rural area, *n* 5018) participants were recruited from 2001 to 2003 for baseline examinations. Follow-up examinations were then performed every 2 years.

Detailed information on the selection of participants for the current study is presented in Fig. 1. Among these 10 038 participants, we excluded thirty-nine participants who were under 40 or over 70 years of age at baseline recruitment and those for whom no information was available on BP (*n* 16), history of hypertension (*n* 4) or total daily energy intake (*n* 318). As well as those who had a history of chronic disease (including hypertension and hypertension medication use, diabetes mellitus, hyperlipidaemia, CVD and cancer; *n* 2289), participants were also excluded who reported implausible total daily energy intake (≤3357 or ≥16 736 kJ (≤800 or ≥4000 kcal) for males, ≤2092 or ≥14 644 kJ (≤500 or ≥3500 kcal) for females; *n* 208). Participants who had been diagnosed with high BP at baseline (*n* 1383) were excluded to eliminate a latent period bias. After exclusions, 5781 individuals were included as our study population. Of these, 630 did not participate in any follow-up through the first to the fourth after the baseline examination. Finally, 5151 healthy individuals were analysed.

Definition of blood pressure incidence

BP measurements were performed at each follow-up examination. Systolic BP (mmHg) and diastolic BP (mmHg) were measured repeatedly in both arms while the participant was in a sitting posture. The mean value of repeated measurements was used to determine high BP, defined as systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg according to the WHO criteria.

To define the incidence of high BP, we took cases who were first diagnosed with high BP through the first to the fourth follow-up. The detailed process to define event (high BP) and non-event (normal BP) participants is presented in Fig. 1.

Socio-economic and lifestyle factors

To analyse factors affecting the risk of high BP, socio-economic and lifestyle factors were surveyed. General factors included age, gender, education level (<elementary, middle school, high school, ≥college), monthly average household income in US dollars (<1000, 1000–1999, 2000–3999, ≥4000), occupation (office, non-office, housework), marital status (yes/no), family history of hypertension (yes/no), BMI in kg/m^2 (<23, 23–24·9, 25–29·9, ≥30) and waist circumference (males, <90 cm; females, <85 cm). Lifestyle factors included drinking status (non-current *v.* current), total alcohol consumption (g/d), smoking status (non-current *v.* current), absolute number of cigarettes smoked (packs/year), physical activity (yes/no) and total energy intake (quartiles).

Dietary intake assessment

Dietary intake information was measured using the semi-quantitative FFQ developed for KoGES[23]. This FFQ consisted of 103 items concerning the individual's food intake over the past year. The frequency of consumption for each item was divided into nine categories: 'never or seldom', 'once a month', '2–3 times a month', '1–2 times a week', '3–4 times a week', '5–6 times a week', 'once a day', 'twice a day' and 'three times or more a day'. For a semi-quantitative approach, one serving size was classified into less (0·5 times), reference amount and higher (1·5 times). The duration of seasonal variety of fruit intake was divided into four categories (3, 6, 9 and 12 months). Validity of the developed FFQ was then conducted. The correlation coefficient for nutrients ranged from 0·23 (vitamin A) to 0·64 (carbohydrate).

Dietary pattern derivation

Factor analysis was used to derive dietary patterns and determine factor loadings for daily intake of 103 individual food items. These factors were rotated with varimax rotation to maintain uncorrelated factors and enhance interpretability. We examined both scree plots and factors to determine which set of factors most closely described food consumption patterns after adjusting for total energy intake. The factor score for each pattern was calculated by summing the intake of all food groups weighted by their factor loadings. A factor score was then calculated for each
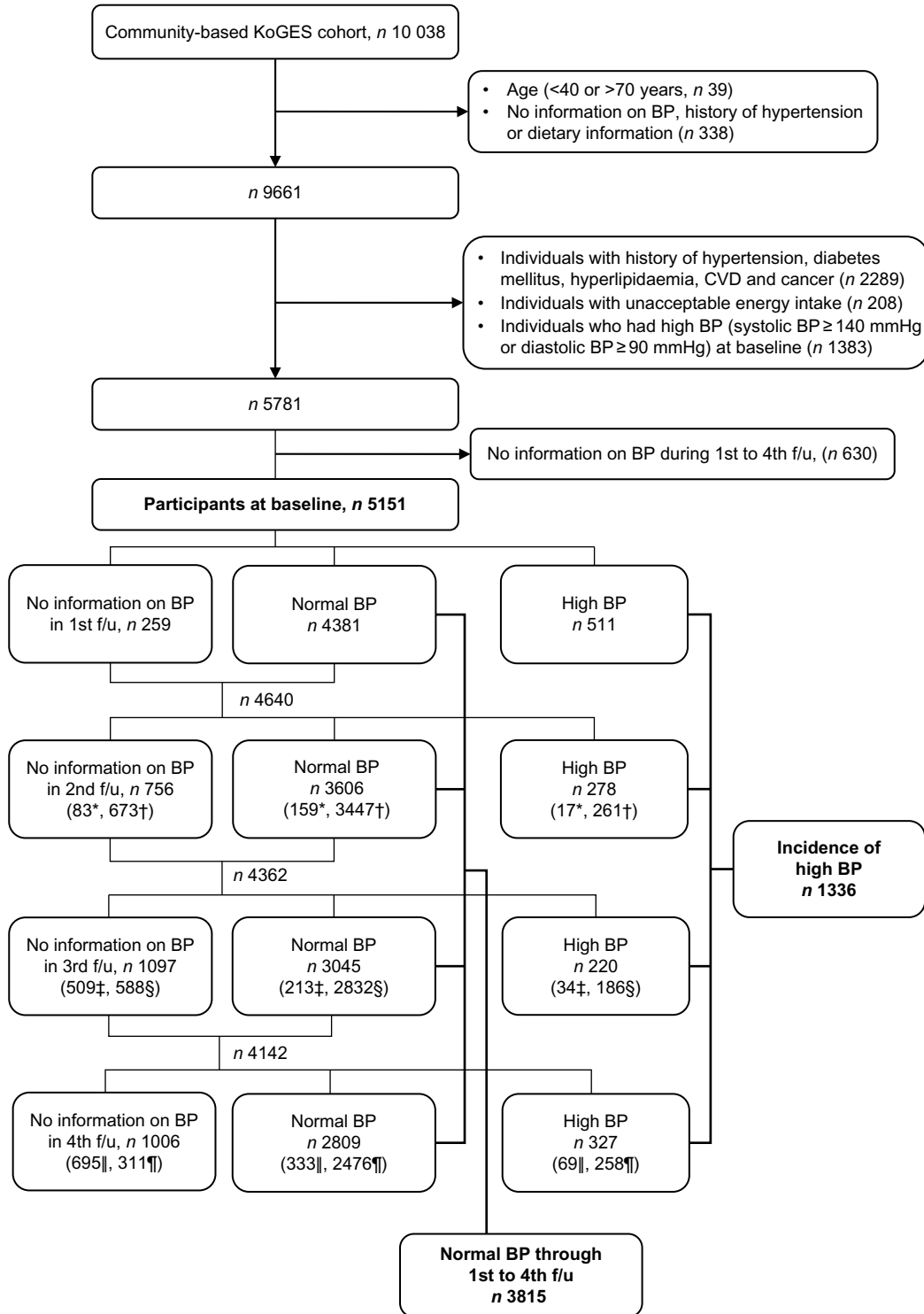
Community-based KoGES cohort, *n* 10 038

- Age (<40 or >70 years, *n* 39)
- No information on BP, history of hypertension or dietary information (*n* 338)

n 9661

- Individuals with history of hypertension, diabetes mellitus, hyperlipidaemia, CVD and cancer (*n* 2289)
- Individuals with unacceptable energy intake (*n* 208)
- Individuals who had high BP (systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg) at baseline (*n* 1383)

n 5781

No information on BP during 1st to 4th f/u, (*n* 630)

Participants at baseline, *n* 5151

No information on BP in 1st f/u, *n* 259 | Normal BP *n* 4381 | High BP *n* 511

n 4640

No information on BP in 2nd f/u, *n* 756 (83*, 673†) | Normal BP *n* 3606 (159*, 3447†) | High BP *n* 278 (17*, 261†)

n 4362

No information on BP in 3rd f/u, *n* 1097 (509‡, 588§) | Normal BP *n* 3045 (213‡, 2832§) | High BP *n* 220 (34‡, 186§)

n 4142

No information on BP in 4th f/u, *n* 1006 (695‖, 311¶) | Normal BP *n* 2809 (333‖, 2476¶) | High BP *n* 327 (69‖, 258¶)

Incidence of high BP *n* 1336

Normal BP through 1st to 4th f/u *n* 3815

Fig. 1 Flow diagram showing the selection of participants for the present study. *From individuals who had not participated in the 1st f/u. †From individuals who had participated in the 1st f/u. ‡From individuals who had not participated in the 2nd f/u. §From individuals who had participated in the 2nd f/u. ‖From individuals who had not participated in the 3rd f/u. ¶From individuals who had participated in the 3rd f/u (KoGES, Korean Genome Epidemiology Study; BP, blood pressure; f/u, follow-up)

participant for each of the four factors, in which standardized intake for each of the 103 foods was weighted by its factor loadings and summed. From these analyses, five dietary patterns with the highest loadings (absolute loading > 0·30) were identified and named according to the highest loading food. The following dietary patterns were defined: (i) 'fruit' pattern with high fruit score; (ii) 'vegetable' pattern with high score for oyster mushroom, onion, other mushroom, perilla leaf, leek/parsley, spinach and courgette; (iii) 'high-protein' pattern with high score for *sashimi* (flounder, crab, tuna, *urogu*, etc.), pork roast (ribs, sirloin, etc.), grits, roast beef, pork belly and eel; (iv) 'coffee' pattern with high score for sugar, coffee and coffee creamer; and (v) 'rice' pattern with low score for unrefined cereal but high score for refined rice, *nabak* kimchi/ *dongchimi* and *kakdugi* (see online supplementary material, Supplemental Table S1).

Statistical analysis

General and lifestyle factors according to each dietary pattern score were presented using frequency or mean and SD. Pearson correlation analysis was performed to examine the correlation between each dietary pattern and nutrients. To examine the effect of each dietary pattern on the risk of high BP, the Cox proportional hazards model was performed after adjustment for covariates that were associated with high BP in this study population; including age, gender, education level, monthly average household income, family history of hypertension, BMI, waist circumference and total energy intake. To evaluate the attenuated effect of obesity and gender on the association between the 'rice' pattern and high BP risk, we analysed the association between the 'rice' pattern and high BP risk after stratifying by obesity (BMI < 25 kg/m^2 *v.* BMI ≥ 25 kg/m^2) for both genders. All analyses were performed using the statistical software package SAS version 9.3. Statistical significance was considered at $P < 0.05$.

Results

Characteristics of dietary patterns

The characteristics of participants for each dietary pattern are shown in Table 1. Elderly participants were more likely to belong in the group of individuals with high 'fruit' and 'rice' pattern scores but with low 'high-protein' and 'coffee' pattern scores. Men were likely to rank high for the 'high-protein', 'coffee' and 'rice' patterns. However, women had high scores for the 'fruit' and 'vegetable' patterns. Participants who had an education level of more than high school and those who reported relatively high family income (more than $US 2000/month) had high scores for the 'high-protein' pattern, but low scores for the 'rice' pattern. Office workers had high scores for the 'high-protein' and 'coffee' patterns, while blue-collar workers had high scores for the 'rice' pattern. Participants with a family history of hypertension had higher scores for the 'high-protein' pattern but lower scores for the 'rice' pattern compared with those without such history. No significant difference was observed among scores for the different dietary patterns according to BMI, but abdominal obesity was observed in participants with high scores for the 'fruit' and 'rice' patterns but low scores for the 'high-protein' pattern. Current drinkers had high scores for the 'high-protein' pattern but low scores for the 'fruit' pattern. Higher scores for the 'high-protein', 'coffee' and 'rice' patterns but lower scores for the 'fruit' and 'vegetable' patterns were observed in current smokers compared with those in non-smokers. Current exercisers were likely to have low scores for the 'rice' pattern.

Correlations between nutrients and dietary patterns

The results of correlation coefficients between nutrients and each dietary pattern are presented in Table 2. The 'fruit' pattern showed a high correlation with vitamin C ($r = 0.68$), K ($r = 0.30$) and fibre ($r = 0.26$). The 'vegetable' pattern was correlated with overall vitamins (ranged from $r = 0.25$ for niacin to $r = 0.55$ for vitamin A and folate) and minerals (ranged from $r = 0.31$ for P to $r = 0.49$ for Fe). The 'high-protein' pattern had positive correlations with protein, fat, retinol, niacin and cholesterol levels. However, the 'coffee' pattern showed no correlation with any nutrient. The 'rice' pattern also had no correlation with any nutrient, with the exception of Na ($r = 0.28$).

Association of ecological and lifestyle factors with the risk of high BP

The average follow-up time was 6·2 years and ranged from 1·4 to 8·7 years. The risk of high BP increased with age ($P_{trend} < 0.001$) and in women (hazard ratio = 0·65, 95 % CI 0·57, 0·76; Table 3). Education level ($P_{trend} < 0.001$) and family income ($P_{trend} < 0.001$) were negatively associated with high BP risk. Family history of hypertension showed increased risk of high BP (hazard ratio = 1·50, 95 % CI 1·30, 1·73). Both general obesity ($P_{trend} < 0.001$) and abdominal obesity (hazard ratio = 1·54, 95 % CI 1·33, 1·77) were associated with increased risk of high BP. However, lifestyle factors such as drinking, smoking, exercise and total energy intake showed no significant association with the risk of high BP.

Effect of dietary patterns on the risk of high blood pressure

No association was shown for each dietary pattern with the risk of high BP regardless of the type of covariates, with the exception of the 'rice' pattern (Table 4). The effect of the 'rice' pattern was observed in both men ($P_{trend} = 0.013$) and women ($P_{trend} < 0.001$) after adjusting for age. After adjusting for all confounding factors, its statistical

Table 1 Characteristics of participants in each dietary pattern. Korean adults (n 5151) from the community-based KoGES cohort

| | 'Fruit' pattern | | | | 'Vegetable' pattern | | | | 'High-protein' pattern | | | | 'Coffee' pattern | | | | 'Rice' pattern | | | |
| | Q1 | | Q5 | | Q1 | | Q5 | | Q1 | | Q5 | | Q1 | | Q5 | | Q1 | | Q5 | |
	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %	Mean or n	SD or %
Age (years)	49·5	8·1	51·5	8·8	50·3	8·7	50·7	8·4	54·0	8·8	47·3	6·7	51·8	8·6	49·2	8·1	47·6	6·9	53·0	8·8
Sex (male)	683	66·3	334	32·4	631	61·3	364	35·3	345	33·5	643	62·4	430	41·7	673	65·3	334	32·4	628	60·9
Education (≥10 years)	582	56·7	402	39·3	523	51·1	474	46·2	324	31·6	672	65·4	443	43·3	598	58·5	702	68·2	324	31·6
Income ($US/month)																				
<1000	256	24·8	391	37·9	332	32·2	318	30·9	451	43·8	157	15·2	344	33·4	249	24·2	135	13·1	470	45·5
1000–1999	310	30·1	307	29·8	304	29·5	296	28·7	300	29·1	304	29·5	317	30·8	307	29·8	282	27·3	315	30·5
2000–3999	350	34·0	248	24·1	311	30·2	300	29·1	222	21·6	414	40·2	282	27·4	363	35·2	464	45·0	180	17·4
≥4000	103	9·99	57·0	5·53	66·0	6·41	100	9·71	40·0	3·88	142·0	13·8	75·0	7·27	101	9·80	145	14·1	41·0	3·97
Blue-collar worker	728	70·6	586	56·8	732	71·1	564	54·8	632	61·4	653	63·3	630	61·1	722	70·0	467	45·3	797	77·2
Married (yes)	962	93·3	920	89·2	949	92·1	952	92·4	920	89·3	972	94·3	941	91·3	965	93·6	964	93·4	930	90·1
Family history of hypertension (yes)	169	16·4	145	14·1	167	16·2	157	15·2	136	13·2	177	17·2	138	13·4	168	16·3	206	20·0	121	11·7
BMI (kg/m²)	24·1	2·9	24·3	3·1	23·9	3·1	24·2	3·0	24·1	3·2	24·3	2·9	23·7	2·9	24·1	3·0	24·2	3·0	23·9	3·0
<23	344	33·4	365	35·4	409	39·7	361	35·1	393	38·2	336	32·6	424	41·1	364	35·3	351	34·0	409	39·6
23–24·9	315	30·6	273	26·5	273	26·5	291	28·3	257	25·0	308	29·9	276	26·8	301	29·2	295	28·6	278	26·9
25–29·9	337	32·7	347	33·7	320	31·1	339	32·9	331	32·1	350	34·0	306	29·7	329	31·9	352	34·1	317	30·7
≥30	35·0	3·39	46·0	4·46	28·0	2·72	39·0	3·79	49·0	4·76	36·0	3·49	25·0	2·42	37·0	3·59	34·0	3·29	28·0	2·71
Abdominal obesity*	212	20·6	297	28·9	216	21·0	259	25·2	281	27·3	189	18·4	237	23·1	194	18·9	182	17·7	278	27·0
Current drinker	626	60·7	391	37·9	562	54·6	463	45·0	384	37·3	651	63·1	441	42·8	570	55·3	492	47·8	2505	0·0
Current smoker	384	37·3	185	17·9	353	34·3	217	21·1	211	20·5	351	34·0	175	17·0	453	43·9	150	14·5	401	38·9
Regular exerciser	316	30·7	247	24·0	248	24·1	341	33·1	247	24·0	352	34·1	307	29·8	241	23·4	415	40·3	192	18·6

KoGES, Korean Genome Epidemiology Study; Q1, quintile 1; Q5, quintile 5.
Results are presented as mean and SD for age and BMI (kg/m²); and as n and % for all other variables including BMI groups.
*Criteria for abdominal obesity used waist circumference for males and females ≥90 cm and ≥85 cm, respectively.

Table 2 Correlation of nutrients with each dietary pattern after adjusting for total energy intake

	'Fruit' pattern	'Vegetable' pattern	'High-protein' pattern	'Coffee' pattern	'Rice' pattern
Protein (g)	−0·02	0·22	0·26	−0·03	−0·11
Fat (g)	−0·07	0·04	0·35	0·07	−0·15
Sugar (g)	0·07	−0·05	−0·22	−0·02	0·09
Fiber (g)	0·26	0·49	−0·14	−0·05	0·02
Ca (mg)	0·09	0·48	0·12	0	−0·14
P (mg)	0·03	0·31	0·09	−0·02	−0·14
Fe (mg)	0·16	0·49	0·08	−0·02	−0·11
K (mg)	0·30	0·47	0·05	0·08	−0·02
Na (mg)	−0·02	0·41	0·03	0·04	0·28
Zn (ug)	0	0·17	0·23	−0·06	−0·06
Vitamin A (RE)	0·10	0·55	0·15	0·01	0·10
Retinol (µg)	0·03	0·18	0·32	−0·02	−0·25
Carotene (µg)	0·10	0·54	0·10	0·01	0·15
Thiamin (mg)	0·12	0·18	0·17	−0·03	0·06
Ribloflavin (mg)	0·06	0·32	0·25	−0·01	−0·11
Niacin (mg)	0·06	0·25	0·29	0·11	−0·08
Vitamin C (mg)	0·68	0·37	0·05	0·01	0·10
Vitamin B$_6$ (mg)	0·18	0·40	0·16	0·01	0·03
Folate (µg)	0·24	0·55	0·07	−0·04	0
Vitamin E (mg)	0·18	0·34	0·15	0·06	−0·09
Cholesterol (mg)	0·04	0·24	0·39	0·01	−0·19

RE, retinol equivalents.

Table 3 General characteristics of participants according to high blood pressure status. Korean adults (*n* 5151) from the community-based KoGES cohort

	High BP		At risk				
	n	%	*n*	%	HR	95 % CI	*P*$_{trend}$
Age (years)							<0·001
40–49	623	46·6	3098	60·1	Ref.	–	
50–59	340	25·5	1174	22·8	1·26	1·10, 1·46	
60–69	373	27·9	879	17·1	1·95	1·66, 2·29	
Female	668	50·0	2735	53·1	0·65	0·57, 0·76	
Education							<0·001
<Elementary	502	37·6	1405	27·3	Ref.	–	
Middle school	316	23·7	1209	23·5	0·90	0·77, 1·05	
High school	376	28·1	1779	34·5	0·72	0·61, 0·86	
≥College	134	10·0	734	14·3	0·58	0·46, 0·73	
Income ($US/month)							<0·001
<1000	535	40·0	1484	28·8	Ref.	–	
1000–1999	359	26·9	1546	30·0	0·72	0·62, 0·83	
2000–3999	324	24·3	1612	31·3	0·72	0·61, 0·85	
≥4000	94	7·0	434	8·4	0·75	0·59, 0·95	
Occupation							
Office worker	97	7·3	463	9·0	Ref.	–	
Non-office worker	884	66·2	3180	61·7	0·99	0·80, 1·24	
Housework	351	26·3	1490	28·9	1·00	0·78, 1·30	
Married	1199	89·8	4722	91·7	0·95	0·79, 1·14	
Family history of hypertension(yes)	248	18·6	822	16·0	1·50	1·30, 1·73	
BMI (kg/m^2)							<0·001
<23	384	28·7	1853	36·0	Ref.	–	
23–24·9	346	25·9	1441	28·0	1·23	1·06, 1·42	
25–29·9	541	40·5	1685	32·7	1·51	1·30, 1·76	
≥30	64	4·8	171	3·3	1·64	1·22, 2·20	
Abdominal obesity*	440	32·9	1126	21·9	1·54	1·33, 1·77	
Alcohol intake (current, yes)	645	48·3	2505	48·6	1·06	0·94, 1·21	
Smoking status (current, yes)	370	27·7	1346	26·1	1·08	0·90, 1·30	
Physical activity (yes)	334	25·0	1448	28·1	0·93	0·82, 1·06	
Total energy intake (kJ)							0·076
≤6389 (≤1527 kcal)	354	26·5	1287	25·0	Ref.	–	
6393–7648 (1528–1828 kcal)	324	24·3	1288	25·0	1·01	0·87, 1·18	
7653–9109 (1829–2177 kcal)	311	23·3	1289	25·0	1·10	0·94, 1·29	
≥9113 (≥2178 kcal)	347	26·0	1287	25·0	1·14	0·98, 1·33	

KoGES, Korean Genome Epidemiology Study; BP, blood pressure; HR, hazard ratio; Ref., reference category.
Adjusted for age, gender, education, occupation, married, income, BMI, waist circumference and family history of hypertension.
*Criteria for abdominal obesity used waist circumference for males and females ≥90 cm and ≥85 cm, respectively.

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Table 4 Cox proportional hazard rate ratios for high blood pressure according to quintile of dietary pattern by gender. Korean adults (n 5151) from the community-based KoGES cohort

| | Males (n 2416) | | | | | | | | | | Females (n 2735) | | | | | | | | | |
| | | Q2 | | Q3 | | Q4 | | Q5 | | | | Q2 | | Q3 | | Q4 | | Q5 | | |
	Q1	HR	95 % CI	HR	95 % CI	HR	95 % CI	HR	95 % CI	P_{trend}	Q1	HR	95 % CI	HR	95 % CI	HR	95 % CI	HR	95 % CI	P_{trend}
'Fruit' pattern																				
No. of cases	187	136		142		99		104			80	112		131		165		180		
Model 1	Ref.	0·84	0·67, 1·05	1·08	0·87, 1·35	0·99	0·77, 1·26	1·17	0·92, 1·49	0·141	Ref.	1·09	0·82, 1·46	1·00	0·75, 1·32	1·07	0·82, 1·39	1·14	0·88, 1·48	0·371
Model 2	Ref.	0·88	0·70, 1·11	1·15	0·91, 1·46	1·01	0·78, 1·30	1·13	0·89, 1·45	0·223	Ref.	1·20	0·89, 1·62	1·09	0·81, 1·47	1·18	0·88, 1·57	1·13	0·86, 1·48	0·628
'Vegetable' pattern																				
No. of cases	167	151		133		115		102			108	111		135		130		184		
Model 1	Ref.	1·07	0·86, 1·33	1·17	0·93, 1·47	1·07	0·85, 1·36	1·13	0·89, 1·45	0·314	Ref.	0·83	0·64, 1·08	0·85	0·66, 1·09	0·75	0·58, 0·96	1·03	0·81, 1·30	0·783
Model 2	Ref.	1·02	0·81, 1·27	1·22	0·97, 1·54	1·07	0·84, 1·36	1·09	0·85, 1·40	0·259	Ref.	0·90	0·68, 1·17	0·92	0·71, 1·19	0·84	0·64, 1·09	1·16	0·91, 1·47	0·344
'High-protein' pattern																				
No. of cases	114	125		136		120		173			205	149		120		109		85		
Model 1	Ref.	0·89	0·69, 1·15	0·94	0·73, 1·21	0·77	0·59, 1·00	0·93	0·72, 1·19	0·393	Ref.	0·88	0·71, 1·09	0·86	0·68, 1·08	0·91	0·72, 1·16	0·99	0·77, 1·29	0·736
Model 2	Ref.	0·92	0·71, 1·19	0·94	0·72, 1·22	0·83	0·63, 1·09	1·00	0·77, 1·29	0·903	Ref.	0·93	0·75, 1·16	0·97	0·76, 1·23	1·06	0·82, 1·36	1·15	0·88, 1·50	0·389
'Coffee' pattern																				
No. of cases	102	124		134		121		187			146	171		152		119		80		
Model 1	Ref.	1·38	1·06, 1·79	1·44	1·12, 1·87	1·18	0·91, 1·54	1·30	1·02, 1·65	0·248	Ref.	1·18	0·95, 1·47	1·25	0·99, 1·57	0·94	0·74, 1·20	1·07	0·81, 1·41	0·768
Model 2	Ref.	1·39	1·06, 1·82	1·39	1·07, 1·80	1·21	0·92, 1·57	1·27	1·00, 1·62	0·315	Ref.	1·18	0·94, 1·49	1·25	0·99, 1·58	0·95	0·74, 1·22	1·10	0·83, 1·45	0·894
'Rice' pattern																				
No. of cases	73	114		120		161		200			130	132		127		137		142		
Model 1	Ref.	1·20	0·90, 1·62	1·03	0·77, 1·38	1·34	1·02, 1·77	1·36	1·04, 1·78	0·013	Ref.	1·02	0·80, 1·30	1·19	0·93, 1·52	1·37	1·07, 1·75	1·71	1·34, 2·19	<0·001
Model 2	Ref.	1·11	0·82, 1·50	1·03	0·76, 1·39	1·31	0·97, 1·75	1·22	0·92, 1·62	0·084	Ref.	0·94	0·73, 1·22	1·07	0·83, 1·38	1·13	0·87, 1·46	1·36	1·05, 1·77	0·004

KoGES, Korean Genome Epidemiology Study; Q1, quintile 1; Q2, quintile 2; Q3, quintile 3; Q4, quintile 4; Q5, quintile 5; HR, hazard ratio; Ref., reference category.
Model 1, HR adjusted for age; Model 2, HR adjusted for age, education, income, family history of hypertension, BMI, waist circumference and total energy intake.

Table 5 Association between the 'rice' pattern and risk of high blood pressure after stratification by obesity using BMI. Korean adults (n 5151) from the community-based KoGES cohort

| | All participants | | | | | | Normal weight (BMI <25 kg/m²) | | | | | | Obesity (BMI ≥25 kg/m²) | | | | | |
| | Normal (n 731) | | | Obesity (n 605) | | | Males (n 389) | | | Females (n 342) | | | Males (n 279) | | | Females (n 326) | | |
	Total (%)	HR	95 % CI	Total (%)	HR	95 % CI	Total (%)	HR	95 % CI	Total (%)	HR	95 % CI	Total (%)	HR	95 % CI	Total (%)	HR	95 % CI
Q1	13.8	Ref.		16.9	Ref.		7.7	Ref.		20.8	Ref.		15.4	Ref.		18.1	Ref.	
Q2	17.8	1.12	0.86, 1.46	19.2	1.00	0.76, 1.32	16.2	1.61	1.03, 2.50	19.6	0.78	0.55, 1.11	18.3	0.84	0.55, 1.27	19.9	1.15	0.80, 1.66
Q3	20.3	1.20	0.92, 1.56	16.4	0.97	0.73, 1.29	19.5	1.30	0.84, 2.02	21.2	1.05	0.75, 1.49	15.8	0.82	0.53, 1.27	16.9	1.04	0.71, 1.52
Q4	23.3	1.27	0.97, 1.66	21.3	1.23	0.94, 1.63	24.7	1.57	1.02, 2.43	21.6	0.99	0.69, 1.41	23.3	1.09	0.73, 1.64	19.3	1.29	0.88, 1.88
Q5	24.9	1.13	0.87, 1.48	26.5	1.58	1.21, 2.07	31.9	1.40	0.92, 2.13	17.0	0.92	0.63, 1.34	27.2	1.13	0.76, 1.68	25.8	2.04	1.41, 2.96
P_{trend}		0.299			<0.001			0.342			0.688			0.182			<0.001	

KoGES, Korean Genome Epidemiology Study; HR, hazard ratio; Q1, quintile 1; Q2, quintile 2; Q3, quintile 3; Q4, quintile 4; Q5, quintile 5; Ref., reference category.
Adjusted for age, education, income, family history of hypertension and total energy intake.

significance was shown only in women ($P_{trend} = 0.004$). The positive association between the 'rice' pattern and the risk of high BP was attenuated by obesity ($P_{trend} = 0.299$ in normal-weight and $P_{trend} < 0.001$ in obese participants). On the other hand, after stratification by gender and BMI (<25 *v.* ≥ 25 kg/m²), the harmful effect of the 'rice' pattern on high BP risk was predominantly observed in obese women ($P_{trend} < 0.001$), but not in obese men ($P_{trend} = 0.182$; Table 5).

Discussion

The present community-based cohort study showed that the 'rice' pattern was positively associated with the risk of high BP. The 'rice' pattern was characterized by low scores of unrefined cereals in Korea but high scores of refined rice and various types of kimchi with high salt. After adjusting for all confounding factors, its statistical significance was shown only in women. The positive association was attenuated by obesity. On the other hand, the harmful effect of the 'rice' pattern on the risk of high BP was predominantly observed in obese women, but not in obese men, suggesting an attenuated effect of gender and obesity on the association.

The 'fruit' pattern scored higher in females, homemakers or unemployed persons, and those with abdominal obesity, but scored lower in current drinkers or current smokers compared with their counterparts in our study. Almost all ecological characteristics showed the opposite trend between the 'high-protein' pattern and 'rice' pattern except for gender and current smoking status. Individuals with high scores for the 'coffee' pattern were males, office workers and current smokers. Strong socio-economic gradients have been observed in dietary patterns identified in several studies, showing that higher incomes and education levels are usually associated with higher scores for healthy eating indices and healthy dietary patterns, but smoking, alcohol consumption and physical inactivity are related to unhealthy dietary patterns[24,25].

In the present study, the effect of the 'rice' pattern on high BP risk could be considered according to two factors: (i) dietary Na intake and (ii) consumption of foods with high glycaemic index or high glycaemic load. First, the 2013 US Institute of Medicine report acknowledged the overall association between Na intake and BP based on previous studies[26]. Koreans consume 2.4-fold higher Na (4800 mg) than the daily intake recommended by WHO[27]. The top five foods contributing to Na intake are kimchi (20.0 %), salt (17.5 %), soya sauce (8.7 %), salt-fermented soya paste (6.4 %) and ramen (4.4 %)[28]; these foods scored highly in the 'rice' pattern in our study (see online supplementary material, Supplemental Table S1). A cross-sectional study (Korean National Health and Nutrition Examination Survey 2009–2011) recommended low salt intake for Koreans to prevent and

control adverse BP[29], and this is supported by our prospective study. The American Heart Association and the US Centers for Disease Control and Prevention have criticized the J- or U-shaped relationship between Na intake and hypertension risk[30], suggested that excessive salt intake is associated with hypertension. In the present study, it was suggested that the 'rice' pattern could increase Na intake and effect increased risk of high BP. Second, dietary carbohydrate intake has received considerable research attention because of a positive association of diets with high glycaemic index or high glycaemic load with risks of obesity, metabolic syndrome, diabetes and CHD[31]. A cross-sectional study[32] suggested that the percentage of energy from carbohydrates and intake of refined grains are associated with Korean metabolic syndrome. Although several prospective studies worldwide have shown that dietary glycaemic index or glycaemic load is associated with high incidence of CHD, type 2 diabetes and stroke[33,34], to the best of our knowledge, no prospective study has reported the effect for Korean adults.

Due to ethnic variations, our results revealed that the 'rice' pattern rich in refined carbohydrates was positively associated with the risk of high BP in Korean adults, predominantly in women, consistent with the results of previous studies[15,33,35–37]. Gender differences in dietary practices among those who consumed high-carbohydrate diets showed differential effects on blood pressure in the present study, similar to the results by Song *et al.*[32]. The risk of metabolic disease might be related to female sex hormones, implying a presumably higher susceptibility of women than men to the risk of hypertension[20,38]. Pathophysiological mechanisms, the renin–angiotensin system, sex hormones and increased immune inflammatory factors might have greater impacts on women than on men[39,40]. Although there are many different pathophysiological and social reasons why such impacts might be greater for women, the gender-specific effect of the 'rice' pattern on high BP risk could suggest that reducing refined rice intake might be one approach to reduce the risk in women.

Obesity is not only a chronic condition, but also an important biological risk factor for non-communicable diseases. Diet has been widely identified as a factor in the prevention of obesity[21]. As an extended line of gender-specific effect, the risk of high BP for women with high score for the 'rice' pattern remained only for obese women, suggesting that the effect of the 'rice' pattern on high BP risk could be attenuated by obesity and gender. Obesity and insulin resistance are not caused by excessive dietary fat intake, but by carbohydrate intake that exceeds energy needs[41]. In the present study, increased TAG level was observed in participants with high scores for the 'rice' pattern (data not shown), and this is consistent with the results by Parks and Hellerstein[42]. The Nurses' Health Study has shown that the effect of carbohydrate intake on the risk of some components (TAG and HDL-cholesterol) of the

metabolic syndrome is stronger in women with high BMI levels[43].

The current study has notable strengths as it is the first prospective study to evaluate the effect of dietary pattern on the risk of high BP for Koreans who traditionally consume large amounts of rice as a staple food. To avoid latent period bias and evade a possible bias due to changes in lifestyle factors which could be caused by uncomfortable symptoms even without any diagnosis of high BP, our analysis was examined after excluding individuals who were diagnosed with high BP at baseline. Finally, we performed advanced analyses to evaluate the attenuated effect of gender and obesity on the association between dietary pattern and the risk of high BP.

Nevertheless, the study has several limitations. First, although assessment of our dietary patterns was based on indices that operationalized various (food) items and derived their information from validated FFQ, it had an inherent methodological limitation, due to self-report bias or recall bias, to reflect the general diet of our study population. Second, our FFQ might not have adequately covered changing dietary habits because dietary assessment was performed only once at baseline. Third, our study results cannot be generalized to other populations, especially populations with a low-carbohydrate staple diet, but could be considered in Asians who traditionally consume large amounts of high-carbohydrate food as their staple diet.

Conclusion

In conclusion, based on the present longitudinal study in Koreans, a positive association of the 'rice' pattern was found with long-term development of incident high BP, predominantly in women. In addition, the association is likely to be attenuated by gender and obese status; the harmful effect of the 'rice' pattern on the risk of high BP was not observed in normal-weight women but was only shown in obese women. These results could be viewed as discouraging in terms of the appropriate dietary modifications following the current guidelines and recommendations for the prevention of high BP.

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wrote the manuscript and had primary responsibility for the final content of the manuscript; and all authors read and approved the final manuscript. *Ethics of human subject participation:* This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Institutional Review Board of Kangwon National University Hospital. Written informed consent was obtained from all subjects.

Supplementary material

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