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Associations between dietary patterns and hypertension among Korean adults: the Korean National Health and Nutrition Examination Survey (2008-2010)

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Abstract

The objective of this study is to identify the dietary patterns associated with the risk of hypertensions among Korean adults using data from the Korean National Health and Nutrition Examination Survey (KNHANES, 2008-2010). This study analyzes data from 11,883 subjects who participated in the health and nutrition survey, aging from 20 to 64 years. We performed factor analysis based on the weekly mean intake frequencies of 36 food groups to identify major dietary patterns. We identified three major dietary patterns in both sexes, namely "traditional", "western" and "dairy and carbohydrate" patterns. Participants in the highest quartile of western pattern scores had significantly higher blood pressure, serum total cholesterol, and triglyceride levels than those in the lowest quartile. Although not statistically significant, a trend (P for trend = 0.0732) toward a positive association between the western dietary pattern and hypertension risk was observed after adjustments for age, sex, education, income, body mass index (BMI), smoking, physical activity, and energy intake. The dairy and carbohydrate pattern was inversely related with BMI and blood pressures and positively associated with serum high-density lipoprotein (HDL)-cholesterol. After adjusting the age, sex, education, income, BMI, smoking, physical activity and energy intake, the dairy and carbohydrate pattern showed inverse associations with hypertension prevalence (OR = 0.64, 95% CI = 0.55-0.75; P for trend < 0.0001). Intakes of fiber, sodium, and antioxidant vitamins were significantly higher in the top quartile for the traditional pattern than in the lowest quartile for the traditional pattern (P for trend < 0.0001). Intakes of fiber (P for trend < 0.0001), calcium (P for trend < 0.0001), retinol (P for trend = 0.0164), vitamin B_1 (P for trend = 0.001), vitamin B_2 (P for trend < 0.0001), niacin (P for trend = 0.0025), and vitamin C (P for trend < 0.0001) were significantly increased across quartiles for the dairy and carbohydrate pattern whereas sodium (P for trend < 0.0001) intake was decreased for this pattern. In conclusion, the dairy and carbohydrate pattern may be associated with a reduced risk of hypertension whereas the western pattern may be associated with an increased risk of hypertension among Korean adults.

Key Words: Dietary pattern, Korean adults, hypertension, nutrient intake, odd ratio

Introduction

Hypertension plays a major etiologic role in the development of ischemic heart disease, cerebrovascular disease, and cardiac and renal failure, and it is a significant risk factor for mortality and disability rates throughout the world [1-3]. The hypertension prevalence rate of Korean adults was 28.9% in the 2010 Korean National Health and Nutrition Examination Survey (KNHANES) [4]. Physical inactivity, obesity, smoking, a family history of hypertension, and an unhealthy diet may be contributing factors for the higher prevalence of hypertension [5,6]. Data on the association of dietary factors with the risk of hypertension have been accumulating [7,8].

A variety of studies have been implemented to explain the correlations between dietary patterns and cardiovascular diseases and hypertension [9-11]. High intakes of fruits, vegetables, cereals, fishes, nuts, low-fat dairy products and poultry in addition to relatively low intakes of fat and sugars appeared to be effective in lowering blood pressures and hypertensions [12,13]. Furthermore, a dietary pattern with frequent intakes of fruits and dairy products significantly decreased blood pressure among Chinese [14]. On the other hand, it has been reported that the increased "western" dietary pattern is typically associated with the increased prevalence of chronic diseases such as coronary heart diseases [15], type 2 diabetes [16], cancer [17], and obesity [18] worldwide. The Dietary Approaches to Stop Hypertension (DASH) dietary pattern, which is rich in fruit, vegetables, and low-fat dairy products and limits saturated fat, red meat, and sweets is a success in hypertension control [19]. Since hypertension is a cardiovascular disease risk factor, several prospective cohort studies have shown associations between dietary patterns and CVD. A cohort study in Japan also demons-

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trates that a dietary pattern with high meat intakes was closely related to an increased risk of cardiovascular diseases [20]. Hypertension and dyslipidemia were the risk factors implicated in various cardiovascular events [21,22] and the association of hypertension and dyslipidaemia has been reported [21]. In several dietary pattern studies, dyslipidemia had been found to be associated with unhealthy dietary patterns [23,24]. To date, numerous studies have reported associations of dietary patterns with blood lipid profiles and/or blood pressures in various patient populations, including groups with cardiovascular disease, metabolic syndrome, and hypertension in Korea [23,25,26].

It has been reported that the typical consumptions of sodium is 3 times greater than the adequate amount of 1.5 g per day and the total fat intakes in Korea increased significantly from 7.2% of total calories in 1969 to 18.5% of total calories in 2007 with an increase in animal fat consumption [27]. Generally, a Korean dietary pattern rich in vegetables, particularly salted vegetables instead of fresh vegetables, may result in high prevalence of hypertension. However, none of the dietary patterns showed any statistical associations of these patterns with hypertension.

The aim of this study is to examine the associations between major dietary patterns and hypertension as well as related blood lipid profiles among the represented Korean adult population that participated in the 2008-2010 KNHANES.

Subjects and Methods

Study population and data sets

This study is based on data from the Korean National Health and Nutrition Examination Survey (KNHANES; 2008-2010) which was conducted by the Korea Ministry of Health and Welfare. The KNHANES was a nationwide representative study that consisted of three sections: a health and behavior interview, a health examination, and a dietary survey. A total of 29,235 individuals were selected for the health interview. A stratified, multi-staged probability sampling design was used in this survey, which has been described in detail previously [4]. Among the population, 12,234 subjects aged 20 to 64 years participated in the health examination survey and the dietary survey. We excluded those who had missing values in the food-frequency questionnaire (FFQ) and dietary intakes of more than 5,000 kcal or less than 500 kcal per day. Therefore, a total of 11,883 subjects were analyzed in the present study.

Assessment of general and anthropometric measurements

Socio-demographic factors such as age, gender, education, income, and residence were collected using a self-reported general questionnaire. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared (kg/m^2). The smoking status and physical activity data were collected using health-related questionnaires. The alcohol consumption data were collected using the FFQ. Blood pressure was measured three times with a phygmomanometer. Three measurements were made on subjects at 5-minutes intervals, and the average of the second and third blood pressure readings was used in the analysis. Investigators were trained to measure blood pressure and administer the questionnaire before conducting the survey. Blood samples were collected after fasting for at least 8 hours. Serum total cholesterol (TC), high-density lipoprotein (HDL)-cholesterol, low-density lipoprotein (LDL)-cholesterol, and triglycerides (TG) were analyzed by a certified laboratory.

Definition of hypertension

The information on hypertension was collected with the self-reported questionnaire only. We counted subjects as having hypertension only if they answered "yes" to the question "if a physician had diagnosed their blood pressure as being ≥140/90 mmHg (either systolic or diastolic)" or "if they reported using an antihypertensive medicine".

Assessment of dietary patterns

The FFQ was used in the present study, and factor analysis was conducted to derive dietary patterns from the food consumption frequencies. According to the similarities in food nutrient profiles and culinary usage, the 63 food items in the FFQ were categorized into 36 food groups to reduce the complexity of the data (Table 1). This regrouping of food items was based on the previous study with modification, including a combination of beer and soju into "alcohol" and cake and bread into "bread" [11]. Principal component factor analysis was used to identify dietary patterns, with the factors rotated by orthogonal transformation. To determine the retained number of factors, we considered components with eigenvalue greater than 1.6 and scree plot results. Factor names reflecting the food groups have more than 0.20 loadings. Factor scores were categorized into quartiles according to the distribution of the study subjects. Because the FFQ included only frequency of consumption and did not include portion sizes; nutrient intakes were analyzed using a 24-hour recall, which is the most appropriate method for estimating the mean intakes for groups.

Statistical methods

All statistical analyses were conducted using SAS (version 9.2; SAS Institute, Cary, NC, USA). Dietary patterns based on the 36 food groups from the FFQ were identified with a principal components analysis (eigenvalue > 1.6, varimax rotation) using factor analysis. Mean levels of continuous variables were estimated using the generalized linear model. The chi-square test was used to compare proportions across the groups of categorical variables. Logistic regression analysis was used to determine the

Table 1. Food groups and food items used in dietary pattern analysis

Food group	Food items
Cereal	Rice, barley
Rice cake	Rice cake
Instant noodles	Ramyun
Noodles	Noodles
Bread	Bread
Snack	Snack
Tofu	Tofu
Beans	Beans, soy milk
Potatoes	Potatoes
Sweet potatoes	Sweet potatoes
Beef	Beef
Chicken	Chicken
Pork	Pork
Ham sausage	Ham sausage
Eggs	Eggs
Blue-backed fish	Mackerel, tuna
White flesh fish	Yellow fish, pollack
Anchovy	Anchovy
Boiled fish	Fish paste
Cuttlefish	Squid
Shellfish	Clam
Salted fish	Salted fish
Cabbage radish	Cabbage, radish
Green vegetables	Spinach, cucumber, red pepper, carrot, pumpkin, dried radish greens
White vegetable	Bean sprouts, cabbage
Mushroom	Mushroom
Brown seaweeds	Brown seaweeds
Dried laver	Dried laver
Fruits	Tomato, persimmon, pear, watermelon, strawberry, melon, citrus, peach, banana, grapes, apple
Dairy products	Milk, yoghourt, ice cream
Carbonated beverage	Carbonated beverage
Coffee	Coffee
Tea	Tea
Alcohol	Beer, soju, red wine
Fast food	Hamburger, pizza
Fat oils	Fat oils

association of dietary patterns with the risk of hypertension. The odds ratios (OR) were estimated for each quartile compared with the lowest quartile of each dietary pattern as the reference. Model 1 was adjusted according to age and sex. Model 2 was adjusted for education and income status in addition to the adjustments made in Model 1. Model 3 was adjusted for BMI, smoking status, physical activity, and energy intake in addition to the adjustments made in Model 2. All analyses were performed with $P < 0.05$ considered statistically significant.

Results

Dietary patterns

Using factor analysis, we first classified three major dietary patterns among Korean adults. The factor-loading matrix for the dietary patterns identified in the study subjects is shown in Table 2. The first factor was characterized by tofu, beans, fruit, vegetables, and fishes, and was named the "traditional pattern". The "western pattern" (Factor 2) was characterized by high intakes of hams, sausages, fast foods, fats and oils, carbonated beverages, meats (pork, chicken, and beef), noodles, and alcohols and then negatively loaded with cereals and beans. Factor 3 was characterized by a high consumption of rice cakes, breads, snacks, sweet potatoes, and dairy products and a low consumption of alcohol, and it was named the "dairy and carbohydrate" pattern.

Table 2. Factor-loading matrix for 3 major dietary patterns identified by principal component analysis

Food group	Factor1	Factor2	Factor3
	Traditional	Western	Dairy and carbohydrate
Green vegetables	0.68	-	-
White vegetables	0.58	-	-
Mushroom	0.55	-	-
White flesh fish	0.54	-	-
Brown seaweeds	0.50	-	-
Blue-backed fish	0.48	0.21	-
Tofu	0.48	-	-
Shellfish	0.46	-	-
Fruits	0.46	-	0.40
Anchovy	0.45	-	-
Potatoes	0.42	-	0.22
Dried laver	0.42	-	-
Cabbage radish	0.39	-0.25	-
Ham sausage	-	0.57	0.22
Fast food	-	0.55	0.32
Fat oils	-	0.53	-
Carbonated beverage	-	0.53	-
Instant noodles	-	0.52	-
Chicken	0.33	0.51	-
Pork	0.34	0.48	-
Beef	0.38	0.38	0.21
Boiled fish	0.31	0.36	-
Noodles	-	0.36	-
Alcohol	-	0.33	-0.50
Bread	-	0.29	0.53
Snack	-	0.33	0.49
Dairy products	0.25	-	0.48
Rice cake	-	-	0.47
Sweet potatoes	0.30	-	0.38
Eggs	0.36	0.24	0.22
Cuttlefish	0.34	0.27	-
Salted fish	0.27	-	-
Cereal	0.24	-0.54	-
Beans	0.22	-0.48	-
Coffee	-	-	-0.25
Tea	-	-	-
Variance explained (%)	4.43	3.63	2.14

Values are factor loading: absolute values < 0.20 are not shown for simplicity.

Table 3. General characteristics of the subjects by dietary patterns

	Pattern 1 : Traditional			Pattern 2 : Western			Pattern 3 : Dairy and carbohydrate		
	Q1	Q4	*P*-value oftrend[1]	Q1	Q4	*P*-value oftrend	Q1	Q4	*P*-value oftrend
N	2,970	2,971		2,970	2,971		2,970	2,971	
Sex (%)									
Male	35.4	38.6	0.0587	21.9	53.3	< 0.0001	67.5	18.1	< 0.0001
Female	64.7	61.4		78.1	46.7		32.5	81.9	
Age (yrs)[2]									
Age	42.7 ± 12.9	43.0 ± 11.1	0.0055	51.5 ± 9.5	34.7 ± 9.4	< 0.0001	46.2 ± 10.6	38.4 ± 11.6	< 0.0001
Education (%)									
Middle school or less	34.9	20.4	< 0.0001	50.7	8.5	< 0.0001	36.3	12.6	< 0.0001
High school graduation	35.9	43.9		31.3	46.7		39.2	40.8	
College or more	29.2	35.7		18.1	44.9		24.6	46.7	
Income (%)									
Low	18.9	6.9	< 0.0001	15.7	8.0	< 0.0001	13.6	7.4	< 0.0001
Mid-low	28.9	21.7		27.7	24.0		27.3	23.1	
Mid-high	28.9	32.1		27.2	33.9		30.5	31.6	
High	23.4	39.4		29.4	34.0		28.6	37.9	
BMI (%)									
< 18.5	6.2	4.7	0.0003	2.4	6.5	< 0.0001	3.4	7.2	< 0.0001
18.5-25	63.3	64.9		65.2	65.3		60.0	71.3	
25 ≤	30.5	30.4		32.5	28.2		36.7	21.5	
Smoking status (%)									
Never	65.5	63.5	0.1361	81.1	48.3	< 0.0001	35.5	81.3	< 0.0001
Former	12.1	13.4		10.5	14.0		18.7	9.3	
Current	22.5	23.1		8.5	37.7		45.8	9.4	
Physical activity (%)									
Yes	85.5	91.7	< 0.0001	82.9	94.4	< 0.0001	90.1	91.0	< 0.0001
No	14.5	8.3		17.1	5.7		9.9	9.0	
Residence (%)									
Urban	62.8	71.3	< 0.0001	63.4	71.9	< 0.0001	60.6	75.4	< 0.0001
Rural	37.2	28.7		36.6	28.1		39.4	24.6	

[1] By chi-square test.
[2] Means ± SD, *P* from general linear regression for continuous variable.

General characteristics of the subjects by dietary patterns

Table 3 shows the general characteristics of all the subjects according to the three dietary patterns. Subjects with higher traditional pattern scores were older and had higher education, higher income, and higher physical activity levels than those with a lower traditional pattern scores. Subjects with higher western pattern scores were more likely to be males, younger, current smokers, and more physically-active than the group with the lower western pattern score. Participants with higher dairy and carbohydrate pattern scores were more likely females with a higher education. Subjects with higher western pattern scores in all three groups tended to live in urban areas rather than in rural areas.

Mean blood pressure and blood profiles across quartiles of dietary patterns

Table 4 shows mean blood pressure and blood profiles according to the quartile for each dietary pattern. The adjusted mean diastolic blood pressure (DBP) increased accordingly to the quartile in the traditional pattern. Compared with subjects in the lowest quartile, subjects in the highest quartile of the traditional pattern showed higher DBP (P for trend = 0.0015). The adjusted mean systolic blood pressure (SBP), DBP, TC, HDL-cholesterol, and TG levels were increased according to the quartile in the western pattern. Subjects in the highest quartile of the western dietary pattern had higher SBP (P for trend < 0.0001), higher DBP (P for trend < 0.0001), higher TC (P for trend < 0.0001), higher HDL (P for trend < 0.0001), and higher TG (P for trend = 0.0321) compared with participants in the lowest quartile. For the dairy and carbohydrate pattern, the adjusted mean SBP, DBP, HDL, and TG value were decreased with the quartile, but the adjusted mean serum LDL-cholesterol value increased with the quartile. Compared with participants in the lowest quartile of the diary and carbohydrate pattern, those in the highest quartile had lower SBP (P for trend < 0.0001),

lower DBP (P for trend < 0.0001), lower HDL (P for trend < 0.0001), lower TG (P for trend < 0.0001), and higher LDL (P for trend < 0.0001).

Association of each dietary pattern with hypertension

Table 5 presents the association of each dietary pattern with hypertension. A significant relationship between hypertension

Table 4. Blood pressure and blood profiles according to the quartiles of factor score for each dietary pattern

	Quartile of dietary pattern score				*P*-value[2] for trend
	1 (lowest) Means ± SE[1]	2 Means ± SE	3 Means ± SE	4 (highest) Means ± SE	
Pattern 1 : Traditional					
Systolic blood pressure (mmHg)	116.1 ± 0.3	116.2 ± 0.3	116.3 ± 0.3	116.0 ± 0.3	0.9420
Diastolic blood pressure (mmHg)	76.1 ± 0.2	76.9 ± 0.2	76.9 ± 0.2	77.0 ± 0.2	0.0015
Serum total cholesterol (mg/dl)	187.3 ± 0.8	186.8 ± 0.8	185.2 ± 0.8	186.4 ± 0.8	0.1336
Serum HDL-cholesterol (mg/dl)	51.5 ± 0.3	51.3 ± 0.3	51.8 ± 0.3	52.0 ± 0.3	0.1515
Serum LDL-cholesterol (mg/dl)	111.6 ± 1.5	111.9 ± 1.6	109.3 ± 1.6	109.7 ± 1.7	0.3306
Serum triglyceride (mg/dl)	140.3 ± 2.3	141.3 ± 2.3	139.1 ± 2.4	142.0 ± 2.4	0.7173
Pattern 2 : Western					
Systolic blood pressure (mmHg)	115.3 ± 0.4	115.6 ± 0.3	116.1 ± 0.3	117.4 ± 0.3	< 0.0001
Diastolic blood pressure (mmHg)	75.9 ± 0.3	76.2 ± 0.2	76.9 ± 0.2	77.5 ± 0.2	< 0.0001
Serum total cholesterol (mg/dl)	184.0 ± 0.9	184.6 ± 0.8	188.0 ± 0.8	188.9 ± 0.8	< 0.0001
Serum HDL-cholesterol (mg/dl)	50.3 ± 0.3	51.2 ± 0.3	52.1 ± 0.3	52.7 ± 0.3	< 0.0001
Serum LDL-cholesterol (mg/dl)	111.0 ± 1.8	110.0 ± 1.6	110.5 ± 1.6	111.8 ± 1.6	0.7771
Serum triglyceride (mg/dl)	135.0 ± 2.6	141.0 ± 2.4	142.5 ± 2.3	143.3 ± 2.4	0.0321
Pattern 3 : Dairy and carbohydrate					
Systolic blood pressure (mmHg)	117.8 ± 0.3	116.4 ± 0.3	115.1 ± 0.3	114.4 ± 0.4	< 0.0001
Diastolic blood pressure (mmHg)	78.2 ± 0.2	76.8 ± 0.2	75.7 ± 0.2	75.3 ± 0.3	< 0.0001
Serum total cholesterol (mg/dl)	187.1 ± 0.8	186.9 ± 0.8	185.9 ± 0.8	185.7 ± 0.8	0.4176
Serum HDL-cholesterol (mg/dl)	52.8 ± 0.3	50.4 ± 0.3	51.0 ± 0.3	52.1 ± 0.3	< 0.0001
Serum LDL-cholesterol (mg/dl)	106.6 ± 1.6	114.8 ± 1.6	111.3 ± 1.6	111.8 ± 1.7	< 0.0001
Serum triglyceride (mg/dl)	156.8 ± 2.4	138.6 ± 2.3	132.1 ± 2.4	129.1 ± 2.5	< 0.0001

[1] Adjusted means for age sex, education, income, smoking, physical activity, energy intake.
[2] By general linear regression.

Table 5. Odds ratios for hypertension based on scores for dietary patterns

Dietary pattern	Quartile of dietary pattern scores				*P*-value for trend
	1 (lowest)	2	3	4 (highest)	
		OR (95% CI)[1]	OR (95% CI)	OR (95% CI)	
Pattern 1 : Traditional					
NO. of case	692	715	701	648	
Model 1[2]	1.0 (ref.)	1.00 (0.87-1.14)	0.99 (0.87-1.13)	0.92 (0.81-1.05)	0.6079
Model 2[3]	1.0 (ref.)	1.03 (0.90-1.18)	1.04 (0.91-1.19)	0.99 (0.86-1.13)	0.8436
Model 3[4]	1.0 (ref.)	1.04 (0.90-1.19)	1.05 (0.92-1.21)	0.99 (0.86-1.14)	0.8117
Pattern 2 : Western					
NO. of case	949	765	585	457	
Model 1	1.0 (ref.)	1.01 (0.89-1.15)	1.03 (0.89-1.18)	1.18 (1.01-1.39)	0.1634
Model 2	1.0 (ref.)	1.02 (0.90-1.15)	1.05 (0.91-1.21)	1.20 (1.02-1.41)	0.1416
Model 3	1.0 (ref.)	1.01 (0.89-1.15)	1.07 (0.92-1.23)	1.24 (1.04-1.46)	0.0732
Pattern 3 : Dairy and carbohydrate					
NO. of case	984	791	608	373	
Model 1	1.0 (ref.)	0.89 (0.79-1.01)	0.76 (0.67-0.87)	0.60 (0.52-0.70)	< 0.0001
Model 2	1.0 (ref.)	0.91 (0.80-1.03)	0.78 (0.69-0.90)	0.64 (0.55-0.75)	< 0.0001
Model 3	1.0 (ref.)	0.85 (0.74-0.96)	0.76 (0.66-0.88)	0.64 (0.55-0.75)	< 0.0001

[1] By logistic regression.
[2] Model 1: Adjusted for age, sex.
[3] Model 2: Adjusted for age, sex, education, income.
[4] Model 3: Adjusted for age, sex, education, income, BMI, smoking, physical activity, energy intake.

and either the traditional pattern or the western pattern was not being observed in Models 1, 2, and 3. Although the relationship was not statistically significant, there was a tendency that a higher western pattern score was associated with a higher prevalence of hypertension (*P*-value for trend = 0.07) after adjustments for age, sex, education, income, BMI, smoking, physical activity, and energy intake. The OR comparing the highest western pattern quartile to the lowest was 1.24 (95% CI, 1.04-1.46). There were significant inverse associations between hypertension and the dairy and carbohydrate pattern in Models 1, 2, and 3. A higher dairy and carbohydrate pattern score was associated with a lower prevalence of hypertension after adjusting for age and sex (*P* for trend < 0.0001). The inverse association remained significant after further adjustments for education, income, BMI, smoking, physical activity, and energy intake (*P*-value for trend < 0.0001). The OR for the top quartile was 0.64 (95% CI, 0.55-0.75) compared with the lowest quartile of the dairy and carbohydrate pattern score.

Nutrient intakes across quartile of dietary patterns

To characterize the nutrient intakes of all subjects according to the three dietary patterns, we analyzed the relationship between nutrient intakes and the dietary pattern scores by general linear regression using a 24-hr dietary record in Table 6. A higher traditional pattern score was associated with a higher energy intake. After adjustments on age, sex, education, income, smoking, physical activity, and energy intake, a higher traditional pattern score was associated with higher intakes of protein, fiber, calcium, phosphorus, iron, sodium, potassium, vitamin A, carotene, vitamin B_1, vitamin B_2, niacin, and vitamin C. Higher western pattern scores were associated with higher intakes of fat and lower intakes of carbohydrates, fiber, and calcium. Micronutrient intakes were decreased from the lowest to the highest quartile of the western pattern. A higher dairy and carbohydrate pattern score was associated with a higher intake of carbohydrate, protein, fat and fiber, and most vitamins, including vitamin A, vitamin B_1, vitamin B_2, niacin, and vitamin C. The sodium intake was significantly lower as the dairy and carbohydrate pattern score increased.

Discussion

In the present study, we have identified three major dietary patterns in a Korean adult population using factor analysis, and observed the associations of these dietary patterns with hypertension, and investigated the blood lipid profiles according to dietary patterns.

The traditional pattern was similar to the "prudent" or "Korean traditional" pattern reported in previous studies [11,28,29]. The traditional pattern did not significantly affect blood pressure and the risk of hypertension, which is consistent with a previous study [11]. It has been reported that vegetable and fruit consumptions increased HDL-cholesterol level in blood and also decreased the prevalence of hypertension, cardiovascular disease, and cancer [29-31]. It has been suggested that although the traditional Korean pattern involves a high intake of vegetables, most

Table 6. Nutrient intakes of the subjects by dietary patterns

Dietary pattern	Pattern 1 : Traditional			Pattern 2 : Western			Pattern 3 : Dairy and carbohydrate		
	1 (lowest)	4 (highest)	*P*-value for trend[2]	1 (lowest)	4 (highest)	*P*-value for trend	1 (lowest)	4 (highest)	*P*-value for trend
	Means ± SE[1]	Means ± SE		Means ± SE	Means ± SE		Means ± SE	Means ± SE	
Nutrient intake									
Energy (kcal)	1,901.5 ± 15.4	2,032.4 ± 16.3	< 0.0001	1,876.3 ± 17.1	2,082.4 ± 16.7	< 0.0001	1,954.9 ± 16.2	2,042.2 ± 17.0	< 0.0001
Carbohydrate (g)	314.3 ± 1.5	311.6 ± 1.6	0.1054	323.9 ± 1.6	298.2 ± 1.6	< 0.0001	299.2 ± 1.5	317.8 ± 1.6	< 0.0001
Protein (g)	65.6 ± 0.4	70.4 ± 0.5	< 0.0001	69.0 ± 0.5	67.9 ± 0.5	0.0539	67.0 ± 0.5	68.7 ± 0.5	0.0091
Fat (g)	37.8 ± 0.4	37.3 ± 0.4	0.4599	35.6 ± 0.4	40.9 ± 0.4	< 0.0001	35.3 ± 0.4	40.5 ± 0.4	< 0.0001
Fiber (g)	7.1 ± 0.1	8.0 ± 0.1	< 0.0001	8.6 ± 0.1	6.6 ± 0.1	< 0.0001	7.1 ± 0.1	7.8 ± 0.1	< 0.0001
Ca (mg)	457.0 ± 6.3	538.7 ± 6.6	< 0.0001	531.0 ± 7.0	461.3 ± 6.8	< 0.0001	463.0 ± 6.6	543.6 ± 6 .9	< 0.0001
P (mg)	1,099.3 ± 6.3	1,211.0 ± 6.6	< 0.0001	1,215.8 ± 7.0	1,106.0 ± 6.8	< 0.0001	1,114.2 ± 6.6	1,186.2 ± 6.9	< 0.0001
Fe (mg)	13.6 ± 0.2	15.4 ± 0.2	< 0.0001	15.8 ± 0.2	13.2 ± 0.2	< 0.0001	13.9 ± 0.2	14.4 ± 0.2	0.0014
Na (mg)	4,763.5 ± 58.3	5,286.2 ± 61.7	< 0.0001	5,139.5 ± 64.8	4,906.3 ± 63.7	0.0286	5,315.4 ± 61.2	4,710.6 ± 64.3	< 0.0001
K (mg)	2,845.8 ± 24.9	3,217.0 ± 26.3	< 0.0001	3,287.9 ± 27.6	2,798.3 ± 27.1	< 0.0001	2,857.6 ± 2 6.3	3,130.7 ± 27.6	< 0.0001
Vitamin A (μgRE)	750.2 ± 19.7	839.2 ± 20.9	0.0003	882.2 ± 21.9	695.7 ± 21.5	< 0.0001	751.7 ± 20.7	780.5 ± 21.8	0.0186
Carotene (μg)	3,859.6 ± 109.4	4,425.5 ± 115.7	< 0.0001	4,633.8 ± 121.2	3,535.7 ± 119.1	< 0.0001	3,970.8 ± 114.9	3,968.6 ± 120.7	0.0300
Retinol (μg)	101.3 ± 8.1	91.8 ± 8.6	0.5385	100.8 ± 9.0	94.0 ± 8.8	0.2356	81.9 ± 8.5	112.0 ± 8.9	0.0164
Vitamin B_1 (mg)	1.22 ± 0.01	1.30 ± 0.01	< 0.0001	1.29 ± 0.01	1.24 ± 0.01	0.0062	1.24 ± 0.01	1.26 ± 0.01	0.0010
Vitamin B_2 (mg)	1.11 ± 0.01	1.22 ± 0.01	< 0.0001	1.20 ± 0.01	1.13 ± 0.01	< 0.0001	1.09 ± 0.01	1.24 ± 0.01	< 0.0001
Niacin (mg)	15.4 ± 0.1	16.4 ± 0.1	< 0.0001	16.0 ± 0.1	16.0 ± 0.1	0.6236	16.0 ± 0.1	15.7 ± 0.1	0.0025
Vitamin C (mg)	94.0 ± 2.1	113.5 ± 2.2	< 0.0001	118.5 ± 2.3	89.7 ± 2.3	< 0.0001	91.6 ± 2.2	113.4 ± 2.3	< 0.0001

[1] Adjusted means for age, sex, education, income, smoking, physical activity, and energy intake.
[2] By general linear regression.

Koreans consume salted vegetables such as "kimchi" instead of unprocessed and fresh vegetables, which are being consumed in western countries [11]. This observation may be applied to fish intake as well. Furthermore, a high intake of refined carbohydrates may be another factor contributing to the lack of effect of the traditional pattern on hypertension in spite of the high level of vegetable consumption. Individuals with a high traditional pattern score had a higher sodium intake than those individuals with lower traditional pattern scores. Reports have indicated that high sodium intake elevated blood pressure [29,32] and resulted in cardiovascular diseases and hypertension [33,34]. According to Shimazu *et al*. [20], the Japanese pattern includes a high sodium intake, and a high Japanese pattern score was associated with an increased hypertension risk. Previously, the level of sodium intake in the rice-vegetable pattern was higher than that in other patterns among Koreans, and the rice-vegetable pattern was positively associated with the hypertension risk [35]. Therefore, a high intake of sodium may mask the protective effects of a high consumption of vegetables in the traditional pattern. The older population tends to consume the traditional Korean diet a lot more than the younger population [36], which might be another contributing factor to this finding. As in other developing countries in Asia, the westernized dietary pattern has become more popular among the younger population in Korea [36].

A western dietary pattern with a high intakes of red meat, processed instant food, sweets and desserts, oils, and fats was related to a significantly increased risk of hypertension in western populations [37,38]. Hu [39] reported that the "western diet pattern" score was positively associated with the fat intake percentage and the prevalence of coronary heart disease. Ahn *et al*. [40] reported that a dietary pattern with high meat consumption was associated with an increased percentage of fat intake and hypertension compared to other dietary patterns. In the present study, a higher western pattern score was significantly associated with increases both in SBP and DBP, total cholesterol, and triglyceride levels in blood. A higher western pattern score tended to be associated with a higher prevalence of hypertension, which was consistent with previous results of a Chinese population [9]. A number of previous studies have observed the atherogenic lipid profile, including high triglycerides, low HDL-cholesterol concentration, and insulin resistance, which may associate with hypertension [20,41]. These metabolic changes caused by the western dietary pattern may be associated with the risk of a hypertension and dyslipidmemia, which are risk factors of cardiovascular disease.

In determining the association between dietary patterns and hypertension, we discovered that the dairy and carbohydrate patterns were inversely associated with the risk of hypertension. A high dairy and carbohydrate pattern score was related to a high intake of fiber, calcium, potassium, and several vitamins, including vitamins A, B, and C. Calcium [42,43] and potassium [44,45] play important roles in the prevention of hypertension and the inhibition of blood pressure elevation. Our data may imply that the decreased risk of hypertension in the dairy and carbohydrate pattern may be related to increased calcium and potassium intake. A previous cross-sectional study based on the second KHANES of 1869 Korean men conducted in 2001 reported no significant correlations between dietary pattern and hypertension [46]. However, a recent cross-sectional study of 5308 Korean adults based on the 2007-2008 KHANES data indicated that the drinking dietary pattern was significantly associated with both hypertension and pre-hypertension [47]. We found that dairy and carbohydrate dietary pattern was associated with a reduced risk of hypertension among Korean adults. The various findings among these studies may be related to their different study designs and population.

The intake of sodium was significantly decreased and the intake of antioxidant vitamins was increased in subjects with a higher dairy and carbohydrate pattern score. Intakes of antioxidant vitamins decreases blood pressure by suppressing aldehyde, which is a risk factor for essential hypertension [48]. Previously, it has been reported that a dietary pattern with a high consumption of bread and milk was inversely associated with the prevalence of hypertension [9]. Another study has shown that the "fruit and milk" pattern with a high intake of milk, bread, and fruit was significantly associated with low SBP and DBP [14]. In the present study, we observed that the dairy and carbohydrate pattern had an inverse association with blood pressure.

The positive relation between alcohol consumption and blood pressure has been widely recognized [49-51]. The average annual increase in SBP was greater among drinkers than among non-drinkers in Japan, which suggested that long-term alcohol consumption may increase hypertension [52]. Previously, it has been reported that blood TG levels was elevated due to high alcohol consumptions [36,53], which was consistent with the results of this study. In the present study, alcohol consumption was high in the population with the western diet whereas alcohol consumption was low in subjects with the dairy and carbohydrate pattern. These results indicated that alcohol consumption may be an important contributing factor for identifying the link between dietary patterns and hypertension risk.

One limitation of the study is a cross-sectional study, which makes it difficult to find a causal relationship between dietary patterns and hypertension risk, and may cause reverse causality. This design may not allow a sequence of temporality to be established for hypertension and dietary patterns. Patients may alter their diet after awareness of previously diagnosed hypertension in order to follow their clinician's advices. If the patients consumed a healthy diet, the dietary pattern we identified may not be the cause of hypertension, but the result. Future prospective cohort studies are necessary in order to verify our findings. In addition, there was a lack of detailed information on foods (e.g., types of meats, cooking methods, and seasoning), which made it difficult to characterize dietary patterns in more

specific details. It is complicated to distinguish one dietary pattern from another since many lifestyle factors are related to dietary patterns and different dietary patterns overlap. Furthermore, although we have adjusted for major lifestyle and socio-demographic factors, confounding factors may also be present. Also, a third limitation was that we used a 24-hour recall data on dietary patterns and nutrient comparisons, because nutrient intakes from FFQ were not available. Dietary data from a single day is seldom a representative of an individual's usual nutrient intakes due to day-to-day or intra-individual variations [54,55]. Therefore, multiple 24-hour recalls may provide a better estimate of nutrient intakes.

In conclusion, three major dietary patterns were identified by factor analysis and were associated with the prevalence of hypertension among Korean adults. The dairy and carbohydrate pattern was inversely associated with the risk of hypertension whereas the western pattern was positively associated with such risks. In the future, these results need to be confirmed by interventional or longitudinal cohort studies.

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