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Breakfast patterns are associated with metabolic syndrome in Korean adults

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Abstract

The Korean diet, including breakfast, is becoming more Western, which could increase the risk of metabolic syndrome. Our aim was to assess whether breakfast patterns are associated with risk for metabolic syndrome in Korean adults. The study subjects (n = 371; 103 men, 268 women) were employees of Jaesang Hospital in Korea and their acquaintances, and all subjects were between 30 and 50 years old. The data collected from each subject included anthropometric measurements, three-day food intake, blood pressure (BP) and blood analyses. The three breakfast patterns identified by factor analysis were "Rice, Kimchi and Vegetables", "Potatoes, Fruits and Nuts" and "Eggs, Breads and Processed meat". The "Rice, Kimchi and Vegetables" pattern scores were positively correlated with systolic (SBP) and diastolic blood pressure (DBP) measurements in men ($P < 0.05$) and with serum triglyceride (TG) levels in women ($P < 0.05$). The "Eggs, Breads and Processed meat" pattern scores correlated positively with weight, body mass index ($P < 0.05$) and serum TGs ($P < 0.01$) in men. The "Potatoes, Fruits and Nuts" pattern was associated with lower risk of elevated BP (OR 0.49, 95% CI 0.28-0.88) and fasting glucose levels (OR 0.51, 95% CI 0.26-1.00). In contrast, the "Eggs, Breads and Processed meat" pattern was associated with increased risk of elevated TGs (OR 2.06, 95% CI 1.06-3.98). Our results indicate that reducing the consumption of eggs, western grains and processed meat while increasing fruit, nut and vegetable intake for breakfast could have beneficial effects on decreasing metabolic syndrome risk in Korean adults.

Key Words: Breakfast pattern, metabolic syndrome risk, Korean adults

Introduction

Breakfast is an important meal for maintaining adequate nutrient intake and health [1-7]. The type of food consumed at breakfast is also important because different breakfast patterns lead to different nutrient intakes. Juang *et al.* [8] reported that a vegetarian breakfast increased the risk of metabolic syndrome in the elderly. Shim *et al.* [9] studied breakfast consumption patterns based on staple foods in Korea and reported that individuals who ate bread for breakfast tended to have elevated serum total cholesterol and an overall high-fat diet. Several studies indicated that convenient foods, such as ready-to-eat cereal (RTEC) and cooked cereal, were desirable for diet quality [10] and lowered body mass index (BMI) compared with other breakfast foods [11].

In nutritional epidemiology, dietary complexity and the long-term influence of dietary practices on the risk of chronic diseases have led to dietary pattern studies [12] because they are based on the overall quality of diets. di Giuseppe *et al.* [13] used a typical dietary pattern to derive a breakfast score for Italian adults *a priori* and showed that typical Italian breakfast foods were associated with a decreased risk of cardiovascular disease. However, before analyzing the typical foods consumed, it was necessary to determine the typical patterns *a posteriori* using a principal component analysis based on factor or cluster analysis [12].

Data on the association between dietary pattern and the risk of metabolic syndrome among Koreans have been published. Because a typical Korean diet is composed mostly of rice and vegetables, it has been considered healthier than a Western diet

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[14]. However, the traditional rice-based Korean dietary pattern was associated with an increased risk of low levels of high-density lipoprotein (HDL) cholesterol [15], and vegetable-rich dietary patterns positively correlate with hypertension in Korean men [16].

Recently, the Korean diet has transitioned toward the Western style of diet, which includes bread, meat and high-fat or manufactured foods. According to a report from the Korea National Health and Nutrition Examination Survey (KNHANES) [17], between 1990 and 2008, daily fat intake increased from 28.9 grams to 39.2 grams, and daily meat intake increased from 47.3 grams to 85.5 grams. The Westernization of breakfast may be associated with an increased risk of metabolic syndrome among Koreans, but few studies have been conducted that associate breakfast patterns with metabolic syndrome. The purpose of this study was to investigate the breakfast patterns of Korean adults using factor analysis and to study the possible associations between the breakfast patterns and the risk of metabolic syndrome.

Subjects and Methods

Study subjects

Between June and September 2009, we recruited a total of 425 subjects who provided written informed consent after receiving a detailed explanation of the study protocols. The subjects were employees of Jaesang Hospital and their acquaintances who were between 30 and 50 years old and were not taking any medications regularly. Among those recruited, 10 subjects were excluded due to inadequate dietary record, and 44 subjects were excluded from analysis due to skipping breakfast on 2 or more of the 3 days. The data from 371 subjects (103 men and 268 women) were included in the final analysis. This study was approved by the Institutional Review Board of Jaesang Hospital in Korea (IRB NO. IMG 09-01).

Breakfast pattern analysis

Three-day dietary intake data over one weekend day and two weekdays were collected from each subject using a 24-hour diet recall (24HR) and a 2-day diet record (DR). To increase the accuracy of the diet record and 24HR, the subjects were instructed and interviewed in three stages according to the methods used in a previous study [18]. The daily intake of energy, nutrients, food and food groups for each subject were calculated using CAN-Pro 3.0 (Korean Nutrition Society, Korea).

A total of 1,114 individual food items consumed by the subjects at breakfast were classified into 20 food groups using the food classification table from the CAN-Pro 3.0 appendix with modifications based on a previous study [19]. The food groups were rice, Eastern grains, Western grains, cookies and cakes, potatoes, vegetables, kimchi, fruits, fruit juice, seaweed, meat, processed meat, fish and shellfish, eggs, legumes, milk and dairy products, sweets, seasoning, nuts and seeds, and coffee and tea.

Breakfast patterns were identified by factor analysis. We used the intake amount of each food group as the input variable for factor analysis because we considered it to be more interpretable than the energy contribution ratio. The number of factors was determined based on the eigen value (greater than one), the scree plot and the interpretability of the factors. The derived factors were labeled based on the food groups with the highest factor loadings. A factor score for the identified patterns was determined for each subject and was used for the association analysis between breakfast pattern and metabolic syndrome.

Diagnosis of metabolic syndrome

Anthropometric measurements, blood pressure measurements and blood collection were conducted at the Biomedical Research Center as described in a previous report [20]. Blood was collected after an 8-hour fast and kept until analysis. Blood samples were analyzed by the Department of Laboratory Medicine at Jaesang Hospital, Bundang, Korea. Enzyme-linked immunosorbant assay (ELISA) kits (Quantikine; R & D Systems, Minneapolis, MN, USA) were used to analyze TGs, low-density lipoprotein cholesterol (LDL-C), HDL-C and serum fasting glucose levels. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a sphygmomanometer (Diagnostec, Panasonic, Japan). Weight and height were measured using an automatic extensometer (GL-150, G-Tech International, Uijeongbu-si. Korea), and body mass index (BMI) was calculated as weight (kg)/height (m^2). The subjects were classified according to their BMI as 'underweight' (< 18.5 kg/m^2), 'normal weight' (> 18.5 kg/m^2), 'overweight' (< 25 kg/m^2) and obese (≥ 25 kg/m^2). Waist circumference was measured using a tape measure. Metabolic syndrome was defined by the International Diabetes Federation (IDF) [21] with the exception of the abdominal obesity cut-off point, which was defined by the Korean Society for the Study of Obesity (KOSSO) [22].

According to the IDF definition, a person must have central obesity and two of the following four factors to be defined as having metabolic syndrome: elevated TGs (≥ 150 mg/dL), reduced HDL-C (< 40 mg/dL for men, < 50 mg/dL for women), high blood pressure (SBP ≥ 130 or DBP ≥ 85 mmHg) or high fasting plasma glucose (≥ 100 mg/dL) [21]. The KOSSO definition of abdominal obesity is a waist circumference greater than 90 cm for men or 85 cm for women.

Statistical analysis

All statistical analyses were performed using SAS (Statistical Analysis System version 9.1; SAS Institute, Cary, NC, USA). Dietary patterns were derived by factor analysis with varimax rotation. Pearson correlation coefficients were used to evaluate the association between factor scores and the intake of energy and nutrients, the percentage of energy derived from macronutrients and anthropometric, biochemical and BP measurements. ORs and 95% CIs of the risk of metabolic syndrome for the tertiles of each breakfast pattern were calculated by logistic regression. A *P*-value under 0.05 was considered to be statistically significant.

Results

General characteristics of study subjects

The general characteristics of the subjects and the prevalence of metabolic syndrome risk factors by gender are shown in Table 1. The women were older than the men ($P < 0.01$), so we adjusted for age in the subsequent statistical analyses. Compared with women, men had significantly higher heights, weights, BMIs, BPs, TGs, and LDL-C levels ($P < 0.05$) and lower HDL-C levels ($P < 0.0001$).

The prevalences of elevated BP, serum fasting glucose and serum TGs were significantly higher in men ($P < 0.0001$), and the prevalence of reduced serum HDL-C was significantly higher in women ($P < 0.05$). The risk factor with the highest prevalence was elevated BP in both men and women. Among the risk factors for metabolic syndrome, the prevalences of reduced HDL-C in men and elevated fasting glucose levels in women were the lowest. Less than one out of five of the men and women in this study had central obesity above the risk cut-off point for metabolic syndrome. Only 28 subjects (11 men, 17 women) were classified as having metabolic syndrome.

Table 1. General characteristicsand prevalence of metabolic syndrome risk factors[1] of study subjects by gender

	Total (n = 371)	Gender		*P*-value[3]
		Men (n = 103)	Women (n = 268)	
Age (yrs)	42.4 ± 7.8[2]	40.4 ± 7.4	43.1 ± 7.8	0.0026
Height (cm)	161.7 ± 6.3	170.7 ± 6.3	158.3 ± 5.2	< 0.0001
Weight (kg)	61.0 ± 10.4	71.2 ± 8.8	57.1 ± 8.1	< 0.0001
Waist (cm)	78.7 ± 8.2	83.7 ± 6.5	76.8 ± 8.0	< 0.0001
BMI (kg/m^2)	23.3 ± 3.0	24.4 ± 2.5	22.8 ± 3.1	< 0.0001
SBP (mmHg)	118.3 ± 13.6	126.3 ± 11.4	115.3 ± 13.1	< 0.0001
DBP (mmHg)	75.5 ± 9.4	79.4 ± 8.0	74.0 ± 9.4	< 0.0001
Fasting glucose (mg/dL)	89.2 ± 21.2	97.3 ± 24.7	86.1 ± 18.8	< 0.0001
Serum TG (mg/dL)	113.9 ± 74.9	153.7 ± 106.8	98.7 ± 51.0	< 0.0001
HDL-C (mg/dL)	58.7 ± 13.6	53.8 ± 12.6	60.6 ± 13.6	< 0.0001
LDL-C (mg/dL)	118.5 ± 30.1	121.4 ± 31.3	117.4 ± 29.6	0.0280
Prevalence (n(%))				
Central obesity (%)	60 (16.17)	18 (17.48)	42 (15.67)	0.6726
Elevated BP (%)	113 (30.46)	48 (46.60)	65 (24.25)	< 0.0001
Elevated fasting glucose (%)	72 (19.41)	36 (34.95)	36 (13.43)	< 0.0001
Elevated TG (%)	80 (21.56)	40 (38.83)	40 (14.93)	< 0.0001
Reduced HDL-C (%)	72 (19.41)	13 (12.62)	59 (22.01)	0.0405
Metabolic syndrome (%)	28 (7.55)	11 (10.68)	17 (6.34)	0.1568

BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, TG: triglyceride, HDL-C:HDL cholesterol, LDL-C: LDL cholesterol

1) The criteria for Metabolic syndrome risk factors based on the International Diabetes Federation (IDF) and abdominal obesity cut points suggested by the Korean Society for the Study of Obesity (KOSSO):
Waist circumference ≥ 90 cm for men, ≥ 85 cm for women; Systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg; Serum fasting glucose ≥ 100mg/dL; Serum TG ≥ 150 mg/dL; Serum HDL-cholesterol < 40 mg/dL for men, < 50 mg/dL for women.

2) Mean ± SD

3) Statistical difference of age, anthropometric, biochemical and blood pressure measurements between genders calculated by General linear model (GLM) and anthropometric, biochemical and blood pressure measurement were adjusted by age. Statistical difference of prevalence of metabolic syndrome risk factors between genders calculated by χ^2 test.

Classification of breakfast patterns

Three breakfast patterns were identified by factor analyses (Table 2). Pattern 1, “Rice, Kimchi and Vegetables”, was characterized by a high consumption of rice, vegetables, kimchi, meat, fish and shellfish and seasonings. Pattern 2, “Potatoes, Fruits and Nuts”, was characterized by a high consumption of potatoes, vegetables, fruits, sweets, and nuts and seeds. Pattern

Table 2. Factor loading matrix for three breakfast patterns according to intake amount of food or food groups for breakfast[1]

	Rice, Kimchi and Vegetables (Factor1)	Potatoes, Fruits and Nuts (Factor2)	Eggs, Breads and Processed meat (Factor3)	% Variance Explained
Rice	0.70	-0.26		55.66
Eastern grains[2]	-0.29			9.43
Western grains[3]	-0.37	0.22	0.49	43.01
Cookies and cakes				7.62
Potatoes		0.61		38.97
Vegetables	0.66	0.33		55.42
Kimchi	0.68			49.07
Fruits	-0.21	0.53		32.81
Fruit juice			0.51	31.38
Seaweed	0.29			8.63
Meat	0.49			26.85
Processed meat		-0.22	0.48	29.94
Fish and shellfish	0.49			26.62
Eggs			0.62	40.86
Legumes	0.22		-0.22	10.20
Milk and dairy product	-0.35			14.45
Sweets[4]		0.51		27.80
Seasonings	0.76	0.27		68.04
Nuts and seeds		0.42	-0.22	22.84
Coffee and tea				5.22
Eigenvalues	3.09	1.56	1.39	
% of Variance Explained	15.47%	7.81%	6.96%	Σ 30.24

1) Listed are those with factor loading values, > | 0.2 |

2) Eastern grains included Ramyon, Rice cakes, Noodle, Chinese noodle, Udong, Black-bean-sauce noodle, Sweet steamed rice;

3) Western grains included Breads, Flour, Cereals, Sweet corn, Doughnut, Sandwiches, Baguette, Bagel, Macaroni;

4) Sweets included Sugar, Starch syrup, Jam, Honey, Gum, Candy, Chocolate;

Table 3. Pearson's correlation coefficients between dietary factor scores[1)] of breakfast pattern and daily nutrient intakes in study subjects

	Rice, Kimchi and Vegetables (Factor1)		Potatoes, Fruits and Nuts (Factor2)		Eggs, Breads and Processed meat (Factor3)	
	Absolute	Adjusted[2)]	Absolute	Adjusted[2)]	Absolute	Adjusted[2)]
Energy (kcal)	0.252****	0.287****	0.039	0.050	0.160**	0.155**
Carbohydrate (g)	0.277****	0.113*	-0.017	-0.094	0.060	-0.115*
Protein (g)	0.304****	0.138**	0.131*	0.155**	0.161**	0.065
Fat (g)	0.053	-0.138**	0.149**	0.193***	0.147**	0.042
Cholesterol (mg)	0.041	-0.083	0.186***	0.209****	0.279****	0.228****
Fiber (g)	0.446****	0.296****	0.305****	0.297****	0.042	-0.017
Calcium (mg)	0.227****	0.057	0.338****	0.345****	0.104*	0.048
Phosphorus (mg)	0.313****	0.124*	0.224****	0.269****	0.136**	0.045
Iron (mg)	0.354****	0.236****	0.147**	0.149**	0.050	-0.071
Sodium (mg)	0.402****	0.281****	0.154**	0.139**	0.117*	0.040
Potassium (mg)	0.395****	0.237****	0.297****	0.303****	0.082	0.017
Zink (mg)	0.259****	0.132*	0.016	-0.016	0.066	-0.036
Vitamin A (μgRE)	0.240****	0.139**	0.195***	0.178***	0.010	-0.037
Vitamin B_1 (mg)	0.250****	0.090	0.158**	0.154**	0.019	-0.091
Vitamin B_2 (mg)	0.049	-0.079	0.131*	0.117*	0.076	0.024
Vitamin B_6 (mg)	0.371****	0.222****	0.224****	0.242****	0.098	0.005
Niacin (mg)	0.207****	0.035	0.038	0.003	0.037	-0.078
Vitamin C (mg)	0.300****	0.201***	0.303****	0.289****	0.194***	0.168**
Vitamin E (mg)	0.294****	0.192***	0.191***	0.198***	0.153**	0.084
Folate (μg)	0.391****	0.261****	0.289****	0.287****	0.126*	0.074
Calories from macronutrients						
Carbohydrate (% energy)	0.083	0.054	-0.175***	-0.193***	-0.060	-0.057
Protein (% energy)	0.109*	0.110*	0.154**	0.145**	0.030	0.056
Fat (% energy)	-0.147**	-0.113*	0.150**	0.178***	0.061	0.047

[1)] Factor score of each subject for a given factor was obtained by the sum of products of factor loading and standardized score of each variable.
[2)] Energy intake was adjusted for age, and all other nutrient intakes were adjusted for age and energy intake by partial Pearson's correlation coefficients analysis
* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, **** $P < 0.0001$

3, "Eggs, Breads and Processed meat", was characterized by a high consumption of Western grains, fruit juice, processed meat and eggs. These three patterns accounted for 30.24% of the total variance.

Relationship between Nutrient Intake and Breakfast Pattern

The correlations between the factor scores of the breakfast pattern and the daily intake of energy and nutrients are shown in Table 3. The daily intake of macro- and micronutrients was positively associated with the factor scores of the breakfast patterns. However, the results of a partial correlation analysis differed from those using absolute nutrient intake for the breakfast patterns. Energy intake was adjusted for age, and the intake of other nutrients was adjusted for energy intake and age. Energy intake was positively correlated with the factor scores of the "Rice, Kimchi and Vegetables" and the "Eggs, Breads and Processed meat" patterns ($P < 0.01$). The "Rice, Kimchi and Vegetables" pattern scores were positively correlated with the intake of carbohydrates, protein, fiber, phosphorus, iron, sodium, potassium, zinc, vitamin A, vitamin B_6, vitamin C, vitamin E and folate ($P < 0.05$) and negatively correlated with fat intake ($P < 0.01$). The "Potatoes, Fruits and Nuts" pattern scores were positively correlated with the intake of all nutrients except for carbohydrates, zinc and niacin. The "Eggs, Breads and Processed meat" pattern scores were positively correlated with the intake of cholesterol and vitamin C ($P < 0.01$) and negatively correlated with the daily intake of carbohydrates ($P < 0.05$).

The correlations between the factor scores and the proportion of energy intake from macronutrients are shown in Table 3. The "Rice, Kimchi and Vegetables" pattern scores exhibited a positive correlation with the percent of energy derived from protein ($P < 0.05$) and a negative correlation with the percent of energy derived from fat ($P < 0.05$). The "Potatoes, Fruits and Nuts" pattern scores exhibited a positive correlation with the percent of energy derived from protein and fat ($P < 0.01$) and a negative correlation with the percent of energy derived from carbohydrates ($P < 0.001$). The percentage of energy derived from different sources had no association with the factor scores of the "Eggs, Breads and Processed meats" pattern scores.

Association of breakfast patterns with the risk of metabolic syndrome

The Pearson correlation coefficients between the breakfast pattern scores and the anthropometric, BP and biochemical

Table 4. Correlation coefficients between dietary factor scores of breakfast pattern and biomarkers in study subjects

	Rice, Kimchi and Vegetables (Factor1)		Potatoes, Fruits and Nuts (Factor2)		Eggs, Breads and Processed meat (Factor3)	
	Men[1)]	Women[1)]	Men	Women	Men	Women
Weight (kg)	0.027	0.092	-0.055	-0.033	0.229*	-0.009
Waist (cm)	-0.037	0.056	-0.103	-0.137	0.096	-0.029
BMI (kg/m^2)	0.017	0.132	0.055	-0.135	0.239*	-0.017
SBP (mmHg)	0.238*	0.133	-0.095	-0.045	0.065	-0.064
DBP (mmHg)	0.244*	0.124	0.004	0.078	0.092	-0.043
Fasting glucose (mg/dL)	-0.031	0.057	0.159	0.013	0.054	-0.065
Serum TG (mg/dL)	-0.008	0.148*	0.002	0.105	0.332**	-0.005
HDL-C (mg/dL)	-0.079	0.021	0.210	-0.003	-0.133	0.004
LDL-C (mg/dL)	0.084	-0.033	0.144	0.124	0.014	-0.053

1) Adjusted for age by Partial Pearson's correlation coefficients analysis
* $P < 0.05$, ** $P < 0.01$

Table 5. Odds ratios of metabolic syndrome risk factors according to tertiles of breakfast pattern scores of study subjects[1)]

Tertiles (T)	Odds ratio (95% CI)[2)]			P for trend
	T1 (Reference)	T2	T3	
Factor 1: Rice, Kimchi and Vegetables pattern				
Central obesity	1	0.97 (0.47-2.02)	1.22 (0.60-2.49)	0.5586
Elevated BP	1	0.94 (0.52-1.71)	1.51 (0.85-2.69)	0.1439
Elevated fasting glucose	1	1.33 (0.68-2.62)	0.87 (0.43-1.75)	0.6505
Elevated serum TG	1	1.32 (0.67-2.60)	1.87 (0.97-3.60)	0.0601
Low HDL-C	1	1.07 (0.55-2.10)	1.41 (0.71-2.77)	0.3103
Metabolic syndrome	1	1.20 (0.44-3.25)	1.09 (0.40-2.98)	0.8890
Factor 2: Potatoes, Fruits and Nuts pattern				
Central obesity	1	1.16 (0.60-2.25)	0.74 (0.37-1.52)	0.4267
Elevated BP	1	0.79 (0.46-1.36)	0.49 (0.28-0.88)	0.0170
Elevated fasting glucose	1	0.59 (0.31-1.12)	0.51 (0.26-1.00)	0.0418
Elevated serum TG	1	1.12 (0.59-2.14)	1.39 (0.74-2.62)	0.3071
Reduced HDL-C	1	0.92 (0.49-1.71)	0.72 (0.38-1.38)	0.3295
Metabolic syndrome	1	0.99 (0.41-2.38)	0.48 (0.17-1.36)	0.1809
Factor 3: Eggs, Breads, and Processed meat pattern				
Central obesity	1	0.80 (0.41-1.56)	0.72 (0.36-1.43)	0.3379
Elevated BP	1	0.98 (0.56-1.71)	0.92 (0.52-1.61)	0.7668
Elevated fasting glucose	1	0.69 (0.35-1.35)	0.97 (0.51-1.84)	0.9120
Elevated serum TG	1	1.90 (0.96-3.73)	2.06 (1.06-3.98)	0.0357
Reduced HDL-C	1	1.60 (0.85-3.00)	1.13 (0.58-2.24)	0.7006
Metabolic syndrome	1	0.80 (0.32-2.01)	0.69 (0.26-1.79)	0.4352

1) Metabolic syndrome risk factors cut point suggested by the International Diabetes Federation (IDF) and abdominal obesity cut points suggested by the Korean Society for the Study of Obesity (KOSSO): Waist circumference ≥ 90 cm for men, ≥ 85 cm for women; Systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg; Serum fasting glucose ≥ 100mg/dL; Serum TG ≥ 150 mg/dL; Serum HDL-cholesterol < 40 mg/dL for men, < 50 mg/dL for women.
2) Odds ratios were adjusted by age and gender using logistic regression

measurements are summarized in Table 4. The "Rice, Kimchi and Vegetables" pattern scores were positively correlated with SBP and DBP in men ($P < 0.05$) and with serum TG levels in women ($P < 0.05$). The "Eggs, Breads and Processed meat" pattern scores were positively correlated with weight, BMI ($P < 0.05$) and serum TG levels ($P < 0.01$) in men.

The odds ratios for risk of metabolic syndrome across tertiles are presented in Table 5. The tertile with the highest factor score for "Potatoes, Fruits and Nuts" pattern had a significantly lower risk of elevated BP (OR 0.49, 95% CI 0.28-0.88) and fasting glucose levels (OR 0.51, 95% CI 0.26-1.00). The risk of elevated serum TG levels was increased in the highest tertile of the "Eggs, Breads and Processed meat" pattern (OR 2.06, 95% CI 1.06-3.98). The risk of metabolic syndrome was not significant for any breakfast pattern.

Discussion

We identified three breakfast patterns for Korean adults by factor analysis, and found associations between breakfast pattern and risk of metabolic syndrome. The three patterns were labeled as "Rice, Kimchi and Vegetables", "Potatoes, Fruits and Nuts" and "Eggs, Breads and Processed meat". The most frequently consumed food groups in the highest tertile of all three patterns were the same: vegetables, seasoning and rice (data not shown). These data indicate that most of the subjects consumed rice as the staple food as well as side dishes with vegetables at breakfast.

We found that the "Rice, Kimchi and Vegetables" pattern was positively correlated with BP among men and with serum TG levels among women. Reedy [23] reported that fruit and vegetable intake was beneficial in reducing the risk of hypertension, but Lee *et al.* [24] showed that the "rice-vegetable" pattern, which is similar to the "Rice, Kimchi and Vegetables" breakfast pattern of our study, was associated with a high risk of hypertension. Turley *et al.* [25] reported that the intake of low-fat, high-carbohydrate and high-fiber foods was associated with low total and LDL cholesterol and had minor adverse effects on HDL-C and serum TG levels. The reason why the "Rice, Kimchi and Vegetables" pattern was associated with elevated serum TG levels could be explained by a positive correlation with the intake of carbohydrates and fiber as well as a negative correlation with fat intake.

The "Potatoes, Fruits and Nuts" breakfast pattern did not correlate with any of the metabolic abnormalities. The "Eggs, Breads and Processed meat" pattern scores were positively correlated with BMI, waist circumference and serum TG levels in men; this finding is consistent with previous studies. Cho *et al.* [11] reported that a breakfast of meat and eggs was associated with the highest energy intake and the highest BMI compared with other breakfast types. Siega-Riz *et al.* [10] also reported that a breakfast pattern of "Eggs" was positively associated with fat and negatively with fiber, iron and calcium density. Therefore, it appears that a Western breakfast could have negative effects on diet quality and health.

We examined the association between breakfast patterns and the risk of metabolic syndrome. Although breakfast patterns were not significantly associated with metabolic syndrome risk, they were associated with some metabolic syndrome components. The "Potatoes, Fruits and Nuts" pattern was associated with a lower risk of elevated BP (OR 0.49, 95% CI 0.28-0.88). The subjects in the highest tertile of this pattern score had more consumption of fruits, milk and dairy products compared with the other patterns. A previous study [26] concluded that the Dietary Approach to Stop Hypertension (DASH) diet, which is rich in fruits, vegetables and low-fat dairy foods with reduced levels of saturated and total fat, could lower BP. In addition, The "Potatoes, Fruits and Nuts" pattern was associated with a reduced risk of elevated fasting glucose levels (OR 0.51, 95% CI 0.26-1.00), but potatoes, which are considered to be refined grains, were consumed in large amounts in this pattern. We could not postulate the underlying mechanism, but the inverse relationship between this pattern score and daily percent energy intake from carbohydrates could be a possible explanation.

It should be noted that all three breakfast patterns identified in our study were based on rice (including whole grains) as a staple food. Nettleton *et al.* [27] reported that a lower risk of diabetes was associated with a food pattern composed of whole grains, vegetables, nuts/seeds, low-fat dairy and coffee, which partially matches the "Potatoes, Fruits and Nuts" breakfast pattern in our study. Several studies [28-30] have reported that a high-carbohydrate diet leads to high serum TG levels. The "Eggs, Breads and Processed meat" pattern scores were negatively correlated with carbohydrate intake, and therefore, this pattern was expected to be inversely associated with serum TG levels. In contrast, the subjects in the highest tertile of the "Eggs, Breads and Processed meat" pattern score had an increased risk of elevated serum TG levels (OR 2.06, 95% CI 1.06-3.98). Although the "Rice, Kimchi and Vegetables" pattern was positively correlated with carbohydrate intake, there was no significant association with elevated serum TG. The reason for this phenomenon could be the differences in dietary fiber between breakfast patterns. Bread, a representative food in the Western grain category, is generally made of refined grain, while rice often includes whole grain rice or a mixture of other whole grains. Whole grain intake was inversely associated with the risk of metabolic syndrome, especially regarding serum TG levels and the risk of hypertension [31]. Both the carbohydrate source and the breakfast pattern appeared to affect the daily intake of fiber. The "Rice, Kimchi and Vegetables" pattern and the "Potatoes, Fruits and Nuts" pattern had high loading of vegetables or fruits and positively correlated with fiber intake. In contrast, the "Eggs, Breads and Processed meat" factor scores did not correlate with fiber intake.

Our study has several limitations. First, we used a cross-sectional study design; therefore, a causal relationship between the breakfast pattern and the risk of metabolic syndrome could not be confirmed. Second, the subjects were self-selected and were recruited within a limited region of the metropolitan area. Finally, we did not collect lifestyle information, such as physical activity, alcohol consumption and smoking habit, which can influence dietary intake and the risk of metabolic syndrome.

In summary, the "Potatoes, Fruits and Nuts" pattern was associated with a decreased risk of elevated BP and elevated fasting glucose levels, and the "Eggs, Breads and Processed meat" pattern was associated with an increased risk of elevated serum TGs. Our study suggests that reducing the intake of eggs, refined grains and other salty foods and increasing the intake of fruit, nuts and vegetables in a breakfast based on rice (including whole grains) as the staple food could have preventive effects against metabolic syndrome in Korean adults.

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