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Dietary Patterns and Nutrient Intakes of Individuals with Circulatory Diseases: Ansan-Ansung Cohort Data from the Korean Genome and Epidemiology Study

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Abstract

Recently, there is growing interest in studying the dietary patterns that affect the risk of circulatory system diseases (CSDs). We investigated the relationship between CSDs and dietary patterns through a follow-up study in Korea (2001-2016). The participants of this study were obtained from the Korean Genome and Epidemiology Study (KoGES). This study was a large community-based cohort study (the Ansan-Ansung areas) conducted to assess the effects of various factors, especially diet, on the onset of chronic diseases among the Korean population aged 40-69 yrs. Baseline data were collected from 2001 to 2002, and follow-up studies were performed every 2 yrs, with over 7 follow-up studies performed (2015-2016). Three dietary patterns were identified using factor analysis: "vegetable and seafood (men)/soup and stew (women)" pattern, "sweet foods and breads-rice cake" pattern, and "multigrain rice and cooked white rice" pattern. None of the dietary patterns were significantly associated with the risk of CSDs in either men or women. Our follow-up study is meaningful as it investigated whether the dietary patterns of individuals according to sex affects the development of CSDs.

Key Words : Korean genome and epidemiology study, circulatory system diseases, dietary pattern, factor analysis, cohort study

I. Introduction

The analysis of dietary patterns has a certain advantage: it examines the complex interactions between the nutrients and the foods ingested to explain the effect of the foods being incorporated in the actual diet (Milte & McNaughton 2016). Two approaches have been used to analyze dietary patterns: the empirical dietary pattern approach using data and the a priori approach using guidelines and recommendations. Principal component analysis (PCA), the most commonly used method, involves extracting patterns through a linear combination of foods that are frequently consumed using correlations between different food groups (Hu 2002).

Circulatory system diseases (CSDs) such as hypertension, stroke, myocardial infarction, and coronary artery disease constitute a significant part of the global burden of disease and are known to cause premature death (Benjamin et al. 2017). Among the causes of death among Koreans in 2018, the death rate from chronic diseases was reported to be approximately 70%, and among them, the rate of death from cardiovascular disease and hypertension was 20.4% (Statistic Korea 2018).

A healthy diet is considered, along with a healthy lifestyle, to be an efficient modifiable risk factor for preventing non-communicable diseases NCDs (such as CSDs) (Atkins et al. 2016). The Dietary Approaches to Stop Hypertension (DASH) diet, Mediterranean diet, and dietary patterns rich in vegetables, fruits, fish, legumes, and whole grains were favorable dietary patterns for reducing cardiovascular risk (Yokoyama et al. 2014; Muga et al. 2016). On the contrary, dietary patterns characterized by consumption of high fat meat, sweets, refined grains, and high-fat dairy products have a deleterious effect on cardiovascular risk (Rodríguez-Monforte et al. 2015).

A recent study reported a significant correlation between CVD risk factors and dietary patterns after adjusting subjects' general and health characteristics (BMI, age, physical activity, blood pressure, waist circumference, etc.) (Muga et al. 2016)

Recently, studies have investigated the relationship between the Korean traditional diet and metabolic disease (Lee & Cho 2014; Jun et al. 2016; Park et al. 2017). Although dietary pattern studies have been widely attempted, it is difficult to reach a definite conclusion due to the

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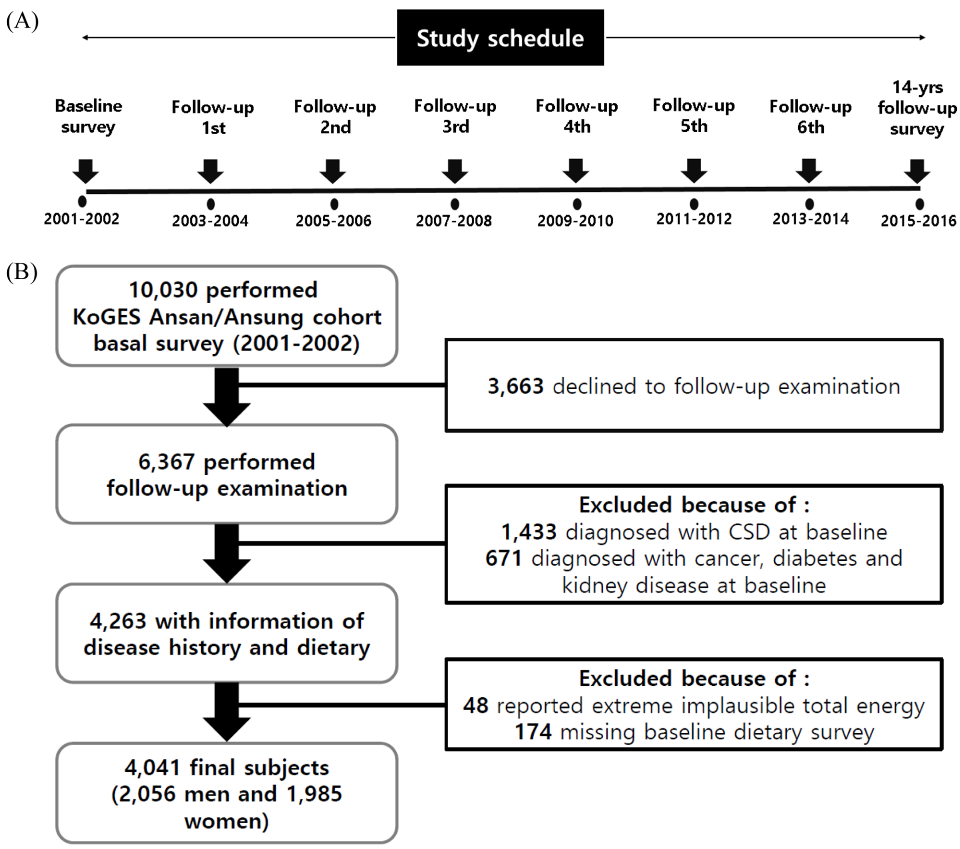
inconsistent results (Lee & Cho 2014; Jun et al. 2016; Park et al. 2017). In short, dietary habits are influenced by lifestyle, socioeconomic, and environmental factors (e.g., income, individual preferences, cultural beliefs, and traditional food culture), and Korean individuals have a unique food culture and different dietary patterns compared with Western individuals (Kim et al. 2016). Hence, the findings of previous studies are inconsistent. In this follow-up study, we examined the sex-specific association between dietary pattern and CSDs incidence risk among 4,041 Korean individuals aged 40-69 yrs using the data from the Korean Genome and Epidemiology Study (KoGES) adjusted for potential confounding factors.

Ⅱ. Materials and Methods

1. Participants and study design

In order to investigate the effects of lifestyle, diet, and environmental factors on the development of chronic diseases, KoGES was conducted by Korea Centers for Disease Control and Prevention from 2001 to 2016 with men and women aged 40-69 in Ansan-Ansung areas and it performed follow-up survey every two yrs. The total of participants for the base survey was 10,030 (Ansan: 5,012, Ansung: 5,018), and the 7th follow-up survey was completed until 2016. The study was approved by Chonnam National University (1040198-190214-HR-007-02). Data were provided by the Institutional Review Boards of the Korea Centers for Disease Control and Prevention and written informed consent was obtained from all participants.

The cohort used in KoGES conducted in the Ansan-Ansung areas were selected as the study participants. Baseline data from 2001 to 2002 were collected, and follow-up examinations were performed every 2 yrs over a 14 yrs period. To calculate follow-up period of the participants, data was collected for the year, month, and day of the follow-up examination. This study aimed to analyze the effect of dietary factors on disease incidence. The participants responded to questionnaires administered by trained staff and underwent physical examination. Moreover, data on past medical history, lifestyle factors including dietary habits, and sociodemographic characteristics were obtained. Of the baseline 10,030 study participants, 3,663 (no follow-up until 2015-2016), 1,433 (with CSDs such as myocardial infarction, coronary artery



<Figure 1> Flow chart of the study schedule (A) and subjects (B) for our study according to KoGES.

disease, hypertension, and stroke in the baseline investigation), and 671 (with diseases affected by dietary factors such as cancer, diabetes, or kidney disease or those with a medical history in the baseline investigation) were excluded. In addition, 48 patients with extremely implausible total energy intake (<500 or >5,000 kcal/day) and 174 with missing data (no response to food frequency questionnaire) were excluded from the study. Finally, 4,041 participants (2,056 men and 1,985 women) were included <Figure 1>.

2. Baseline general characteristics and anthropometric and biochemical measurements

At baseline, the participants' general characteristics were obtained using a questionnaire survey administered by trained investigators biennially. Smoking and drinking status were classified as never, former, and current. Participants also reported the types of physical activity, categorized by intensity, performed during the day. The total metabolic equivalents (METs) was calculated by summing the activity type which indicated the level of physical activity (Kim et al. 2017). The anthropometric measurement methods used were described in study of Kim et al. (2017) and the variables are shown in <Table 3>. Blood samples were collected after fasting for at least 8 hrs, and plasma was separated for biochemical measurements. Fasting plasma glucose (mg/dL), triglycerides (TG; mg/dL), total cholesterol (TC; mg/dL), high-density lipoprotein cholesterol (HDL-C; mg/dL), and aspartate aminotransferase (AST) were measured by an automatic analyzer (Advia 1650, Bayer HealthCare, Tarrytown, NY, USA). Low-density lipoprotein cholesterol (LDL-C; mg/dL) concentration was calculated using the Friedewald equation (Friedewald et al. 1972).

3. Follow-up and incidence of CSDs

Participants were followed up every 2 yrs using questionnaires and biochemical tests. Follow-up began when the subjects entered the study and ended when the subjects were diagnosed with CSD by the doctor. During the follow-up period after base investigation, new-onset CSDs were defined as patients being diagnosed by a physician or prescribed CSDs medication. CSDs included hypertension, stroke, myocardial infarction, and coronary artery disease.

4. Dietary assessment

Dietary assessments of KoGES conducted by Korea Centers for Disease Control and Prevention were collected using a valid semi-quantitative food frequency questionnaire (SQ-FFQ) at baseline. SQ-FFQ was used to assess the average intake frequency and portion size of 103 food items consumed in the previous year. The frequency of each food consumed was divided into nine categories and the portion size of each food consumed was divided into three categories (Lee et al. 2020). To calculate the food intake, the investigated intake values were converted to frequency per day and then multiplied by the portion size. Nutrient intake was measured using the Korean Food Composition Table (The Korean Nutrition Society 2015).

5. Dietary patterns

To identify the dietary patterns, food items obtained from the SQ-FFQ were categorized into 21 food groups based on the common food groups reported in the previous studies (Ahn et al. 2003; Kim & Jo 2011; Khosravi et al. 2015). The frequency of rice intake was divided into multigrain rice group and cooked white rice group. Vegetables were divided into the salty vegetable group (5 items) and the vegetable group (22 items) on the basis of sodium content. Based on the analysis of intake frequency, oyster mushrooms were combined with other mushrooms into one mushroom group. Coffee and tea, which are the most preferred beverages of Korean adults, were classified into different food groups (Ahn et al. 2003), while carbonated and other drinks were classified as soft drinks and beverages <Table 1>. A factor analysis was performed to determine the dietary patterns of men and women.

6. Statistical analysis

All data analyses were performed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA). Dietary patterns were derived using factor analysis of factor loadings that were extracted by PCA and Varimax rotation using 21 food groups <Table 1>. The frequency of intake of the 21 food groups was converted to daily equivalent food intake frequencies, and these were entered into the factor analysis. Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests were applied for sample adequacy evaluation. Since the KMO value of the extracted dietary pattern was 0.799 for men and 0.835 for women, and the Bartlett test was significant ($p<0.001$) as a result, the input components were suitable for factor analysis. To clarify the number of factors, we used an eigenvalue of >1.0. Three dietary patterns were identified from the study participants with post-rotated factor loadings (>|0.3|) <Table 2>. The factor scores for each dietary pattern were categorized as tertiles for further analysis. Statistical differences were determined using chi-square test and one-way analysis of variance with Tukey's test. Cox regression analysis was performed to determine the association between dietary pattern and new-onset CSDs. In Cox proportional hazard model, model 1 was not adjusted. Total energy (kcal/day), metabolic equivalent (hr/day), abdominal fat (%), HDL cholesterol (mg/dL), triglyceride (mg/dL), LDL cholesterol (mg/dL), total cholesterol (mg/dL) and AST (IU/L) were adjusted in model 2. All p values less than 0.05 were considered significant.

Ⅲ. Results and Discussion

1. Three dietary patterns for adult men and women

<Table 2> displays the three dietary patterns identified for men and women. The dietary patterns were determined on the basis of the participants' intake frequency of the following food or food groups: vegetable and seafood (men)/soup and stew (women) pattern (high intake of vegetables, mushrooms, seaweeds, legumes/soy products, seafood, and fruits), sweet foods and breads and rice cake pattern (high intake of sweet foods, breads, rice cake, soft drinks, beverages, coffee, red meat, processed meat, poultry, milk and dairy products, noodles and dumplings, tea (only in women), and nuts (only in women), and multigrain rice and cooked white rice pattern. Since the factor loading is a correlation coefficient between variables and factors, the negative value (–) of the multigrain rice and cooked white rice pattern does not indicate a causal relationship, but rather a positive or negative correlation. Factor analysis is a statistical technique that bind similar variables in consideration of correlation. Table 2 presents the explanatory power of each pattern.

2. Baseline characteristics and nutrient intakes of participants by tertile categories of dietary pattern scores

<Table 3> shows the baseline characteristics of participants according to the tertile categories of dietary pattern scores by sex. During a 16-yr follow-up period, 378 participants (199 men and 179 women) developed CSDs. In the sweets and breads and rice cake patterns, level of METs, LDL-C, TC, and AST in men were significant according to tertile and level of HDL-C and TG in women were significant according to tertile.

The METs of men with the highest score (T3) in the sweet foods and breads and rice cake pattern were significantly the lowest. In a population-based prospective cohort study in China, the mean total physical activity of 487,334 participants aged 30-79 yrs (mean: 51 yrs) who were recruited in 2004-2008 was 21.5±12.8 MET-h/d, participants with the highest quintiles were inversely associated with major vascular events than those with the lowest quintiles (Bennett et al. 2017). In addition, baseline total physical activity was found to significantly lower the HRs of CVD subtypes. Therefore, participants at higher risk for CVD and similar diseases should pay attention to their dietary intake.

As shown in <Table 3>, compared with other tertiles, women with T2 of the sweet foods, breads, and rice cake pattern had lower HDL-C and/or higher TG concentrations. Since the types and intake levels of food items and food groups constituting the dietary pattern are study-dependent, the results on health are also inconsistent. In the future, it is necessary to conduct relevant studies. The food components of the sweet foods, breads, and rice cake pattern in this study are similar to those of the Western dietary pattern (unhealthy dietary pattern) reported in previous studies (Fung et al. 2001; Heidemann et al. 2008). In the follow-up studies of Fung et al. (2001) and Heidemann et al. (2008), the Western dietary pattern proved to be a potent risk factor for CVD and obesity. A study by Heidemann et al. (2008) reported that this pattern could increase an individual's total mortality by 22%, cancer by 16%, and all causes by 21%.

The nutrient intakes of participants according to the tertile categories of dietary pattern scores are presented in <Table 4>. In both men and women, those with high scores in the vegetable and seafood/soup and stew patterns had higher intakes of total energy and other nutrients, except energy from carbohydrates. Men with high scores in the sweet foods and breads and rice cake pattern had higher intake of energy from protein and fat, vitamin A, vitamin E, vitamin B_2, potassium, phosphorus, calcium, and cholesterol (T3 vs. T1). Women with high scores in the sweet foods and breads and rice- cake patterns had higher intake of total energy, energy from protein, energy from fat, vitamin A, vitamin E, vitamin B, vitamin B_6, potassium, phosphorus, calcium, iron, and cholesterol (T3 vs. T1). Men with low scores in the multigrain rice and cooked white rice pattern had higher intake of other nutrients except total energy and energy from carbohydrates. Women with low scores in the multigrain rice and cooked white rice pattern had higher intake of energy from protein, energy from fat, vitamin E, phosphorus, calcium, iron, and cholesterol.

In a meta-analysis of prospective cohort studies reported in 2015, unhealthy dietary pattern was associated with a high risk of coronary heart disease due to insufficient intake of

<Table 1> Daily intake frequency of food groups included in different dietary patterns based on the semi-quantitative food frequency questionnaire

Food or food groups	Food items	Men (n=2,056)	Women (n=1,985)
Multigrain rice	Cooked rice with other cereals and cooked rice with soybean	0.6±0.51[1)]	0.6±0.5
Cooked white rice	Cooked white rice	0.6±0.5	0.6±0.5
Vegetables	Cucumber, potatoes, pumpkin, immature, perilla leaf, bean sprouts, carrot/carrot juice, radish/salted radish, seasoned spinach, vegetable wrap/vegetable salad, other green vegetables, crown daisy/leek/water dropwort, sweet potatoes, pepper leaves/chamnamul/asterscaber, deoduck/doraji (kinds of white root), starch jelly, pumpkin, mature/pumpkin juice, bracken/sweet potato stalk/stem of taro, onion, lettuce, starch vermicelli, green pepper, and Korean cabbages/Korean cabbage soup	3.4±2.2	3.3±2.1
Salty vegetables	Korean cabbage kimchi, kkakduki/small radish kimchi, other kimchi, kimchi, radish with water, and Korean style pickles	1.7±1.0	1.7±1.0
Mushrooms	Other types of mushroom and oyster mushroom	0.3±0.3	0.3±0.4
Soup and stew	Soup and stew with soybean paste/soybean paste and soup	0.5±0.3	0.5±0.4
Seaweeds	Laver, dried, and kelp/sea mustard	0.6±0.5	0.6±0.5
Legumes/soy products	Tofu, legumes, and soybean	0.7±0.5	0.6±0.5
Seafood	Dried anchovy, mackerel/Pacific saury/Spanish mackerel, salt-fermented fish, Alaska pollock, hair tail, yellow croaker/sea bream/flat fish, cuttlefish/octopus, dried, sushi, clam/whelk, fish paste/crab flavored, shrimp, oyster, tuna, canned, eel, and crab	1.2±1.0	1.2±1.0
Coffee	Coffee, coffee sugar, and coffee cream	1.6±1.3	1.6±1.3
Milk and dairy products	Milk, yogurt, and cheese	0.6±0.6	0.6±0.6
Fruits	Tangerine, watermelon, grape/grape juice, melon, tomato/cherry tomato/tomato juice, apple/apple juice, peach/plum, pear/pear juice, persimmon, hard/persimmon, dried, strawberry, orange/orange juice, and banana	1.7±1.8	1.8±2.0
Eggs	Eggs	0.2±0.3	0.2±0.3
Red meat and processed meat	Pork, belly, pork, roasted, pork, braised, steak/beef, roasted, edible viscera, and ham/sausage	0.4±0.5	0.4±0.4
Poultry	Fried chicken/chicken stew	0.1±0.1	0.1±0.1
Noodles and dumpling	Wheat noodles with soup, ramyun, chajangmyun/jjambbong, buckwheat vermicelli/buckwheat noodle, and dumpling/dumpling with soup	0.3±0.4	0.4±0.4
Sweet foods	Candy/chocolate, ice cream, cookie/ cracker/snack, and cakes/choco pie	0.3±0.4	0.3±0.4
Soft drinks and beverages	Carbonated drink and other drinks	0.2±0.3	0.2±0.3
Tea	Green tea	0.3±0.4	0.2±0.4
Nuts	Nuts	0.1±0.1	0.1±0.1
Breads and rice cake	Rice cake, rice cake (plain rod shape)/rice cake with soup, cereals, corn flakes, other breads, parched cereal powder, loaf bread/sandwich/toast, jam/honey/butter/margarine, and bread with small red beans, pizza/hamburger	0.3±0.4	0.3±0.5

The 103 food items were categorized into 21 food groups based on similarities in food and nutrient composition as well as the results of previous studies. The intake (times per day) of each food group was calculated by summing up the intakes of food items (Khosravi et al. 2015; Kim & Jo. 2011).
[1)] Values are expressed as mean ± standard deviation.

nutrients such as vitamins, minerals, antioxidants, fibers, monounsaturated fatty acids, and n-3 fatty acids to maintain cardiac health (Hou et al. 2015). In our study, the vitamin E, vitamin B, and mineral (phosphorus, calcium, and iron) intake levels in women with T3 of vegetables, seafood/soup-stew and sweet foods and bread-rice cake patterns were higher than those of participants with T1. By contrast, vitamin E, vitamin B, and mineral intake levels in women with T1 of the multigrain-cooked white rice pattern were higher than those in participants with T3. Based on the results shown in <Table 4>, we learned that participants with vegetables and seafood/soup-stew and sweet foods and bread-rice cake patterns can obtain more diverse nutrients, and that those with multigrain rice/cooked white rice pattern

<Table 2> Factor loading ascertained from the dietary patterns of Korean adults (40–69 yrs)

Food or food groups	Vegetables and seafood/soup and stew pattern (Men/women)	Sweet foods and breads and rice cake pattern (Men/women)	Multigrain rice and cooked white rice pattern (Men/women)
Multigrain rice	0.12/0.12	0.05/0.02	0.83/0.79
Cooked white rice	0.02/0.03	0.03/0.07	0.86/0.83
Vegetables	0.74/0.72	0.21/0.29	0.07/0.00
Salty vegetables	0.54/0.53	0.03/0.01	0.14/0.19
Mushrooms	0.48/0.43	0.26/**0.34**	0.11/0.07
Soup and stew	0.56/0.63	0.08/0.08	0.04/0.10
Seaweeds	0.57/0.50	0.19/**0.31**	0.12/0.12
Legumes/soy products	0.53/0.58	0.04/0.10	0.33/0.31
Seafood	0.63/0.56	0.39/0.48	0.04/0.01
Coffee	0.10/0.09	0.49/0.37	0.10/0.20
Milk and dairy products	0.17/0.06	0.40/0.52	0.18/0.19
Fruits	0.48/0.53	0.05/0.02	0.04/0.05
Eggs	0.29/0.28	0.25/**0.31**	0.07/0.03
Red meats and processed meat	0.29/**0.39**	0.49/0.43	0.27/0.26
Poultry	0.17/0.24	0.43/0.40	0.27/0.23
Noodles and dumpling	0.28/0.22	0.38/0.35	0.11/0.22
Sweet foods	0.01/0.00	0.65/0.59	0.13/0.04
Soft drinks and beverages	0.17/0.10	0.49/0.52	0.15/0.22
Tea	0.21/0.11	0.26/**0.33**	0.21/0.11
Nuts	0.11/0.16	0.25/**0.34**	0.16/0.03
Breads and rice cake	0.11/0.06	0.63/0.60	0.15/0.11
% of cumulative variance explained	16.731/14.104	28.992/26.988	39.347/35.486

Food groups with an absolute value of factor loading >|0.3| for each dietary pattern are in bold.

must try to consume a variety of foods to obtain different nutrients.

3. Association of dietary pattern with CSDs incident risk

The hazard ratios (HR) and 95% confidence intervals (CI) for the risk of CSDs incidence according to dietary pattern score by sex are shown in <Table 5>. None of the dietary patterns were significantly associated with the risk of CSDs in both men and women. Although the results of the analysis have not been presented in a table, participants with T2 of sweet foods and breads and rice cake pattern scores had higher risk of hypertension compared with T1 after adjusting for confounding factors (p=0.037).

Unlike the diets in Western countries, the Korean diet is not only prepared using a single ingredient, but is often prepared using a combination of ingredients (Kim et al. 2016). The composition of a traditional Korean diet makes it difficult to identify its dietary patterns. In addition, the results of the identification of dietary patterns affecting the risk of disease were different depending on the method of nutritional epidemiology used (Reedy et al. 2010). Song et al (2009) conducted cluster and factor analyses using the data from the 2005 Korea National Health and Nutrition Examination Survey. The dietary patterns obtained from cluster analysis and factor analysis may differ even if the participants are the same, which means that the epidemiological method introduced may lead to the differences in the interpretation of results. The factor analysis for identifying dietary patterns includes the following processes: screening tests, computation of eigenvalues, and determining whether a meaningful interpretation is possible for factor extraction. However, an arbitrary decision made the researcher may still act as a limitation that will result in low reproducibility of results. Therefore, the study of dietary patterns for disease prevention needs to be quantified to reflect various conditions. However, we failed to identify the dietary pattern of Korean adults associated with CSDs, although three dietary patterns were extracted using factor analysis.

<Table 3> Baseline characteristic of the participants by sex, according to the tertile (T) of dietary pattern scores (n=4,041)

Dietary patterns	Vegetables and Seafood/Soup and stew			Sweet foods and Breads-rice cake			Multigrain rice and Cooked white rice		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Men (n=2,056)									
No. of participants (No. of cases)	689 (60)	693 (66)	674 (73)	669 (54)	696 (82)	691 (63)	140 (11)	1,230 (122)	686 (66)
Age (yrs)	50.5±8.4[1)]	50.6±8.3	50.8±8.4	50.9±8.5	50.7±8.5	50.2±8.1	49.3±8.2	50.7±8.5	50.6±8.2
Resident area, %									
Rural area (Ansung)	44.2[1)]	43.6	42.8	44.5	43.5	42.4	44.0	43.4	43.5
Urban area (Ansan)	55.8	56.4	57.2	55.5	56.5	57.6	56.0	56.6	56.5
Drinking status, %[2)]									
Never	19.5	18.8	19.7	20.9	19.0	18.0	17.9	20.2	18.0
Former	7.4	9.6	8.6	7.7	9.7	8.8	6.4	8.1	9.6
Current	73.0	71.6	71.7	71.4	71.9	73.2	75.7	71.6	72.4
Smoking status, %[2)]									
Never	22.0	20.6	19.9	22.0	22.0	18.4	18.3	20.4	22.0
Former	29.6	31.2	31.9	28.7	30.6	33.3	29.1	31.4	30.4
Current	48.5	48.2	48.2	49.3	47.3	48.3	52.6	48.2	47.6
Metabolic equivalent (hr/day)	28.1±17.8	28.4±17.9	27.5±18.2	29.0±18.1[a]	28.1±18.0[b]	26.8±17.7[c,*]	28.4±17.9	27.8±18.0	28.3±17.8
Body mass index (kg/m^2)	24.3±2.8	24.2±2.8	24.2±3.0	24.6±3.2	24.5±3.3	24.4±3.1	24.5±2.8	24.2±2.8	24.3±2.9
Abdominal fat, %	0.9±0.0	0.9±0.0	0.9±0.0	0.9±0.1	0.9±0.1	0.9±0.1	0.9±0.0	0.9±0.0	0.9±0.0
HDL cholesterol (mg/dL)	44.6±10.2[a]	43.5±9.8[b]	43.5±9.7[c,*]	43.9±10.0	43.7±10.1	43.9±9.6	43.1±9.2	43.7±9.7	44.3±10.4
Triglyceride (mg/dL)	173.6±118.2	173.8±111.9	175.0±115.9	174.0±108.1	170.2±115.1	178.2±122.2	188.4±119.8	172.9±115.7	173.4±113.5
LDL cholesterol (mg/dL)	112.9±33.1	113.5±33.7	113.7±36.1	111.4±33.7	113.2±34.8	115.5±34.3*	110.2±31.6	114.2±34.7	112.6±34.2
Total cholesterol (mg/dL)	190.1±33.6	190.9±36.6	195.0±35.3	190.1±33.6[a]	195.0±35.3[b]	195.0±35.3[b,**]	191.0±31.2	192.3±35.9	191.6±34.8
AST(IU/L)	31.6±15.4	32.3±17.0	33.7±33.3	34.2±35.2	31.3±11.9	32.1±15.9*	31.2±11.9	32.3±20.8	33.3±28.8
Women (n=1,985)									
No. of participants (No. of cases)	667 (58)	664 (62)	654 (59)	662 (57)	661 (73)	662 (49)	1,303 (116)	54 (5)	628 (58)
Age (yrs)	50.8±8.8	51.0±8.5	51.4±8.8	50.8±8.6	51.2±8.7	51.3±8.8	51.2±8.9	51.0±8.8	50.8±8.3
Resident area, %									
Rural area (Ansung)	51.3	52.1	50.8	51.4	49.8	53.0	51.7	54.2	50.5
Urban area (Ansan)	48.7	47.9	49.2	48.6	50.2	47.0	48.3	45.8	49.5
Drinking status, %[2)]									
Never	69.8	67.9	69.9	68.4	69.2	70.0	68.6	84.7	69.0
Former	3.2	2.1	2.0	2.4	2.9	2.0	2.5	1.4	2.4
Current	27.1	30.0	28.1	29.3	27.8	28.0	28.9	13.9	28.7
Smoking status, %[2)]									
Never	95.5	95.7	84.1	95.3	95.2	95.5	95.6	68.8	94.7
Former	1.7	1.1	1.4	1.5	0.6	1.3	1.4	1.4	0.6
Current	2.8	3.2	4.5	3.2	4.2	3.2	3.0	2.8	4.7
Metabolic equivalent (hr/day)	26.8±17.7	26.3±17.8	25.7±17.9	26.4±17.8	25.9±17.6	26.6±17.9	26.6±17.9	27.3±18.4	25.5±17.5
Body mass index (kg/m^2)	24.4±3.0	24.6±3.2	24.6±3.3	24.6±3.2	24.5±3.3	24.4±3.1	24.5±3.2	25.2±4.0	24.4±3.1
Abdominal fat, %	0.8±0.1[a]	0.9±0.1[b]	0.9±0.1[b,*]	0.9±0.1	0.9±0.1	0.9±0.1	0.9±0.1	0.9±0.1	0.9±0.1
HDL cholesterol (mg/dL)	46.4±9.8	46.4±10.0	45.9±9.9	46.8±10.2[a]	45.6±9.4[b]	46.3±10.1[c,*]	46.4±10.2	44.7±8.7	46.1±9.2
Triglyceride (mg/dL)	135.3±74.7	139.6±76.2	137.1±78.3	130.5±65.1[a]	141.6±90.5[b]	139.9±70.9[c]**	136.3±74.6	146.7±75.8	138.7±80.0
LDL cholesterol (mg/dL)	114.2±30.3	115.0±31.4	113.1±30.9	114.4±31.5	112.4±30.4	115.4±30.6	113.8±30.1	112.1±31.0	114.8±32.3
Total cholesterol (mg/dL)	187.6±34.0	189.3±34.2	186.4±34.2	187.3±34.7	186.3±33.7	189.7±33.9	187.4±33.5	186.2±33.6	188.6±35.6
AST (IU/L)	27.1±21.1	27.2±13.8	25.9±7.3	27.4±21.3	26.3±11.1	26.5±10.6	26.8±15.0	26.4±8.2	26.6±16.1

[1)]Values are expressed as mean±standard deviation for continuous variables and percentages for categorical variables. Statistical differences were determined using chi-square test for categorical variables and one-way analysis of variance for continuous variables with Tukey's test for multiple comparisons.

[a,b,c]Differences in variables among tertile groups were tested by post-hoc test (Tukey's test for multiple comparisons).

[2)]The response base differs as some cases had either irrelevant responses or no response at all.

*p for trend <0.05, **p for trend <0.01

<Table 4> Energy and nutrient intakes by sex, according to the tertile (T) of dietary pattern scores

Dietary patterns	Vegetables and seafood/soup and stew			Sweet foods and breads and rice cake			Multigrain rice and cooked white rice		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Men (n=2,056)									
No. of participants	689 (60)	693 (66)	674 (73)	669 (54)	696 (82)	691 (63)	140 (11)	1,230 (122)	686 (66)
Total energy (kcal/day)	1,633.8±510.3[a]	1,897.0±528.0[b]	2,302.3±658.9[c],**	1,698.8±550.9[a]	1,850.8±517.4[b]	2,282.6±666.7[c],**	1,323.9±540.6[a]	1,863.2±492.4[b]	2,218.3±734.3[c],**
Percentage from energy									
Carbohydrate (%)	74.1±6.3[a]	70.7±6.4[b]	67.8±7.2[c],**	73.5±7.0[a]	71.3±6.6[b]	67.9±6.6[c],**	66.5±9.4[a]	70.7±6.4[b]	72.1±7.4[c],**
Protein (%)	12.1±2.0[a]	13.5±1.9[b]	15.0±2.3[c],**	13.2±2.5[a]	13.4±2.4[b]	14.0±2.1[c],**	15.2±3.0[a]	13.6±2.1[b]	13.1±2.5[c],**
Fat (%)	12.1±5.1[a]	15.0±5.1[b]	16.7±5.5[c],**	12.0±5.3[a]	14.2±4.9[b]	17.4±5.1[c],**	18.3±7.4[a]	14.6±5.0[b]	13.6±5.7[c],**
Fiber (g/1,000 kcal)	3.1±1.2[a]	3.6±1.1[b]	4.2±1.3[c],**	3.9±1.4[a]	3.6±1.2[b]	3.4±1.1[c],**	4.5±1.9	3.6±1.2	3.5±1.2[c],**
Vitamin A (RE/1,000 kcal)	189.3±106.2[a]	263.0±133.5[b]	372.6±195.2[c],**	269.4±176.5	265.5±161.8	289.7±162.8[c],**	359.2±213.3[a]	268.9±161.0[b]	268.1±163.4[c],**
Vitamin E (mg/1,000 kcal)	3.9±1.3[a]	4.6±1.1[b]	4.6±1.1[c],**	4.4±1.6[a]	4.6±1.4[b]	5.0±1.3[c],**	5.7±1.9[a]	4.6±1.3[b]	4.6±1.5[b],**
Vitamin B_1 (mg/1,000 kcal)	0.6±0.1[a]	0.6±0.1[b]	0.7±0.1[c],**	0.6±0.2[a]	0.6±0.1[a]	0.7±0.1[c],**	0.7±1.2[a]	0.6±0.1[b]	0.6±0.1[b],**
Vitamin B_2 (mg/1,000 kcal)	0.4±0.1[a]	0.5±0.1[b]	0.6±0.1[c],**	0.4±0.2[a]	0.5±0.1[b]	0.6±0.1[c],**	0.6±0.2 [a]	0.5±0.1[b]	0.5±0.1[b],**
Vitamin B_6 (mg/1,000 kcal)	0.8±0.2[a]	09±0.2[b]	1.1±0.2[c],**	0.9±0.2	0.9±0.2	0.9±0.2	1.1±0.3 [a]	0.9±0.2[b]	0.9±0.2[b],**
Folate (g/1,000 kcal)	102.7±36.3[a]	125.5±35.4[b]	153.4±50.1[c],**	130.5±52.3[a]	123.8±43.4[b]	127.2±41.5[c],*	159.4±68.9 [a]	125.7±42.1[b]	123.1±44.4[c],**
Vitamin C (mg/1,000 kcal)	50.5±31.1[a]	63.1±33.0[b]	79.2±37.6[c],**	67.3±41.4[a]	62.6±32.4[b]	62.9±33.1[c],*	91.3±54.7 [a]	60.5±31.6	65.4±35.9**
Sodium (mg/1,000 kcal)	1,423.2±671.7[a]	1,696.5±682.6[b]	1,946.6±805.5[c],**	1,767.1±894.7[a]	1,674.5±725.7[b]	1,624.2±602.7[c],**	2,104.3±1089.4 [a]	1,682.2±695.0[b]	1,613.9±741.4[c],**
Potassium (mg/1,000 kcal)	1,096.4±330.6	1,296.2±296.0	1,519.5±350.3	1,275.6±430.5	1,298.4±351.5	1,337.4±313.0[c],**	1,665.6±532.4 [a]	1,289.3±325.9[b]	1,254.6±361.1[c],**
Phosphorus (mg/1,000 kcal)	475.5±82.6[a]	525.6±75.7[b]	579.2±85.7[c],**	519.2±102.9	522.4±90.2	538.5±79.6[c],**	599.3±124.3 [a]	529.5±85.3[b]	506.5±86.8[c],**
Calcium (mg/1,000 kcal)	196.1±91.5[a]	243.2±81.9[b]	302.7±102.4[c],**	229.7±112.7[a]	241.0±95.8[b]	271.2±91.9[c],**	328.1±138.1 [a]	246.5±95.1[b]	231.7±97.5[c],**
Iron (mg/1,000 kcal)	4.6±1.3[a]	5.5±1.0[b]	6.6±1.4[c],**	5.5±1.7	5.5±1.4	5.7±1.3	6.7±2.2 [a]	5.6±1.3[b]	5.3±1.4[c],**
Cholesterol (mg/1,000 kcal)	60.8±42.3[a]	86.7±46.3[b]	110.1±52.4[c],**	73.8±52.4[a]	84.6±49.4[b]	99.5±48.6[c],**	108.2±61.1 [a]	87.6±50.5[b]	77.9±48.7[c],**

<Table 4> Energy and nutrient intakes by sex, according to the tertile (T) of dietary pattern scores (continued)

Dietary patterns	Vegetables and seafood/soup and stew			Sweet foods and breads and rice cake			Multigrain rice and cooked white rice		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Women (n=1,985)									
No. of participants	667 (58)	664 (62)	654 (59)	662 (57)	661 (73)	662 (49)	1,303 (116)	54(5)	628(58)
Total energy (kcal/day)	1,616.9±452.9^{a}	1,897.8±523.7^{b}	2,359.2±703.6^{c,**}	1,693.2±590.5^{a}	1,865.7±521.7^{b}	2,313.2±655.6^{c,**}	1,834.1±531.2	1,815.0±538.6	2,228.2±780.0^{c,**}
Percentage from energy									
Carbohydrate (%)	74.0±5.9^{a}	70.6±6.2^{b}	69.3±7.3^{c,**}	74.8±5.9^{a}	71.8±6.0^{b}	67.3±6.3^{c,**}	70.4±6.8	73.9±7.1	72.9±6.5^{c,**}
Protein (%)	12.1±1.8^{a}	13.6±2.0^{b}	14.5±2.4^{c,**}	12.6±2.2^{a}	13.3±2.2^{b}	14.3±2.2^{c,**}	13.7±2.3^{a}	12.7±2.1	12.9±2.2**
Fat (%)	12.1±4.9^{a}	14.7±4.9^{b}	15.9±5.3^{c,**}	11.2±4.4^{a}	13.9±4.5^{b}	17.7±4.7^{c,**}	14.9±5.2^{a}	12.5±5.5	13.0±5.1**
Fiber (g/1,000 kcal)	3.0±1.1^{a}	3.6±1.1^{b}	4.3±1.2^{c,**}	3.8±1.4	3.7±1.3	3.4±1.1^{c,**}	3.7±1.3	3.9±1.6^{b}	3.5±1.2**
Vitamin A (RE/1,000 kcal)	189.0±132.9^{a}	270.3±168.3^{b}	353.9±171.7^{c,**}	249.0±187.9^{a}	268.7±170.9^{b}	295.0±153.3^{c,**}	276.1±175.8	278.6±182.2	259.3±163.3
Vitamin E (mg/1000 kcal)	3.8±1.2^{a}	4.7±1.4^{b}	5.7±1.4^{c,**}	4.2±1.6^{a}	4.7±1.4^{b}	5.2±1.4^{c,**}	4.8±1.6	4.7±1.8	4.5±1.5
Vitamin B_1 (mg/1,000 kcal)	0.5±0.1^{a}	0.6±0.1^{b}	0.7±0.1^{c,**}	0.6±0.1^{a}	0.6±0.1^{a}	0.7±0.1^{b,**}	0.6±0.1	0.7±0.2^{b}	0.6±0.1**
Vitamin B_2 (mg/1,000 kcal)	0.4±0.1^{a}	0.5±0.1^{b}	0.6±0.1^{c,**}	0.5±0.1^{a}	0.5±0.1^{a}	0.6±0.1^{b,**}	0.5±0.1^{a}	0.4±0.1	0.4±0.1**
Vitamin B_6 (mg/1,000 kcal)	0.8±0.2^{a}	0.9±0.2^{b}	1.1±0.2^{c,**}	0.9±0.2^{a}	0.9±0.2^{a}	1.0±0.2^{b,**}	0.9±0.2	0.9±0.2	0.8±0.2
Folate (g/1,000 kcal)	100.7±39.3^{a}	127.5±46.3^{b}	152.9±45.0^{c,**}	125.1±55.8	127.6±48.0	128.4±40.9	130.1±50.0	131.9±55.4^{b}	120.1±44.8**
Vitamin C (mg/1,000 kcal)	46.2±29.2^{a}	62.1±29.5^{b}	88.0±41.3^{c,**}	64.6±41.3	66.5±38.2	65.1±34.0	65.5±37.8	77.7±52.2^{b}	64.2±36.6**
Sodium (mg/1,000 kcal)	1,421.1±708.4^{a}	1,658.3±725.7^{b}	1,836.3±674.8^{c,**}	1,653.5±851.9	1,654.7±707.0	1,606.5±586.4	1,671.1±731.4	1,722.7±807.0	1,562.0±692.8
Potassium (mg/1,000 kcal)	1,063.1±324.9^{a}	1,298.5±332.6^{b}	1,524.2±330.9^{c,**}	1,219.7±430.1	1,314.0±360.8	1,350.9±328.7^{c,**}	1,324.0±380.6	1,350.6±425.2	1,228.9±361.6^{c,**}
Phosphorus (mg/1,000 kcal)	472.4±76.6^{a}	527.5±78.5^{b}	563.1±80.4^{c,**}	500.8±91.1^{a}	520.2±86.1^{b}	541.7±78.3^{c,**}	531.6±87.4^{a}	499.9±70.5	500.5±83.3**
Calcium (mg/1,000 kcal)	191.1±87.8^{a}	242.0±88.8^{b}	287.4±90.1^{c,**}	212.8±97.4^{a}	239.1±97.6^{b}	268.4±88.3^{c,**}	248.4±97.9^{a,}	225.6±76.7	224.1±95.3**
Iron (mg/1,000 kcal)	4.5±1.2^{a}	5.6±1.3^{b}	6.5±1.3^{c,**}	5.3±1.7^{a}	5.5±1.5^{b}	5.8±1.3^{c,**}	5.7±1.5^{a,}	5.4±1.6	5.3±1.4**
Cholesterol (mg/1,000 kcal)	64.3±48.5^{a}	87.7±47.7^{b}	106.9±54.5^{c,**}	65.6±49.1^{a}	83.6±49.6^{b}	109.6±51.6^{c,**}	90.8±53.1^{a}	67.2±48.2	78.7±52.7**

[1)]Values are expressed as mean±standard deviation for continuous variables. Statistical differences were determined using one-way analysis of variance for continuous variables with Tukey's test for multiple comparisons.

[a,b,c]Differences in variables among tertile groups were tested by post-hoc test (Tukey's test for multiple comparisons).

*p for trend <0.05, **p for trend <0.01

<Table 5> Hazard ratio (95% confidence intervals) for the risk of incident circulatory system diseases according to tertile of dietary pattern scores[1)]

	T1	T2	T3	p for trend
Vegetables and Seafood/Soup and stew pattern				
Men				
No. of participants (No. of cases)	689 (60)	693 (66)	674(73)	
Model 1	1 (reference)	1.037 (0.727–1.478)	1.190 (0.837–1.693)	0.577
Model 2	1 (reference)	1.090 (0.761–1.562)	1.304 (0.890–1.913)	0.371
Women				
No. of participants (No. of cases)	667 (58)	664 (62)	654 (59)	
Model 1	1 (reference)	1.072 (0.745–1.542)	1.105 (0.756–1.615)	0.870
Model 2	1 (reference)	0.978 (0.676–1.417)	1.040 (0.690–1.568)	0.951
Sweet foods and breads and rice cake pattern				
Men				
No. of participants (No. of cases)	669 (54)	696 (82)	691 (63)	
Model 1	1 (reference)	1.398 (0.988–1.978)	1.051 (0.722–1.530)	0.098
Model 2	1 (reference)	1.403 (0.988–1.993)	1.111 (0.745–1.656)	0.127
Women				
No. of participants (No. of cases)	662 (57)	661 (73)	662 (49)	
Model 1	1 (reference)	1.294 (0.911–1.838)	0.819 (0.549–1.222)	0.046
Model 2	1 (reference)	1.261 (0.885–1.797)	0.812 (0.531–1.243)	0.072
Multigrain rice and Cooked white rice pattern				
Men				
No. of participants (No. of cases)	140(11)	1,230 (122)	686 (66)	
Model 1	1 (reference)	1.263 (0.681–2.343)	1.231 (0.649–2.332)	0.760
Model 2	1 (reference)	1.354 (0.716–2.558)	1.378 (0.689–2.724)	0.634
Women				
No. of participants (No. of cases)	1,303 (116)	54 (5)	628 (58)	
Model 1	1 (reference)	0.905 (0.368–2.225)	1.028 (0.748–1.412)	0.958
Model 2	1 (reference)	0.786 (0.319–1.941)	1.034 (0.741–1.444)	0.844

Calculated using the Cox proportional hazard model. Model 1: crude, Model 2: adjusted for total energy (kcal/day), metabolic equivalent (hr/day), abdominal fat (%), high-density lipoprotein cholesterol (mg/dL), triglyceride (mg/dL), low-density lipoprotein cholesterol (mg/dL), total cholesterol (mg/dL), and aspartate aminotransferase (IU/L).

Ⅳ. Summary and Conclusion

In this follow-up study, KoGES data (2001-2016) was used to investigate the relationship between dietary pattern and CSDs in 4,041 Korean adults aged 40-69 yrs. Dietary patterns were derived using factor analysis of factor loadings that were extracted by PCA and Varimax rotation using 21 food groups. To clarify the number of factors, we used an eigenvalue of >1.0.

Three dietary patterns were identified as follows: “vegetable and seafood (men)/soup and stew (women)” pattern, “sweet foods and breads-rice cake” pattern, “multigrain rice and cooked white rice” pattern. However, none of the dietary patterns were significantly associated with the risk of CSDs in either men or women.

In analyzing dietary patterns, the gold standard for determining the number of factors has not yet been established, and the subjectivity of the researcher affects how the number of factors and classification of food groups are determined. Nevertheless, our study is meaningful because the results of this study were obtained through descriptive statistical analysis of accumulated data (2001-2016). In addition, it is shown that this study can be used to determine dietary recommendations according to sex by analyzing the effects of disease on participants by sex.

As mentioned before, the combination of food and food groups determines an individual’s dietary pattern. To analyze exact dietary patterns, an extensive investigation of the eating environment reflecting how the diets of individuals are changing (such as increased consumption of home meal replacement) should be conducted.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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