## ORIGINAL ARTICLE

# Identification of major dietary patterns in Korean adults and their association with cancer risk in the Cancer Screening Examination Cohort

G-A Wie[1], Y-A Cho[1], H-h Kang[1], KA Ryu[1], M-K Yoo[1], J Kim[2], S Shin[3], OK Chun[4,5] and H Joung[5]

**BACKGROUND/OBJECTIVES:** Cancer is the primary cause of disease-related death in Korea. The purposes of this study were to confirm the major dietary patterns and to evaluate whether there were associations between these identified dietary patterns and the risk of cancer based on data from the Cancer Screening Examination Cohort (CSEC) 2004–2008 of the National Cancer Center (NCC) of Korea.

**SUBJECTS/METHODS:** This study included 8 024 subjects who completed a written survey on demographics and lifestyles, as well as a 3-day dietary record. Dietary patterns were identified by factor analysis using the principal component analysis method. The associations between the identified dietary patterns and cancer risk were examined using Cox proportional hazards regression models.

**RESULTS:** During a median follow-up period of 9.0 years, 425 cancer cases were newly diagnosed. We identified 4 major dietary patterns ('rice and kimchi', 'vegetables and fish', 'fruits and dairy', and 'meats and sweets'). There was a negative relation between 'rice and kimchi' pattern and the risk of non-gastrointestinal cancers only (highest vs. lowest tertile; multivariate-adjusted hazard ratio = 0.60, 95% confidence interval = 0.41, 0.88). The 'fruits and dairy' pattern tended to decrease the risk of cancer, and the preventive effect was noted only for gastrointestinal cancer risk. However, there was no association after adjusting for covariates.

**CONCLUSIONS:** The traditional dietary pattern with high consumption of rice, kimchi, soybean paste and vegetables may decrease the cancer risk among Koreans, and strategies based on the dietary pattern may effectively reduce the cancer risk.

## INTRODUCTION

Since 1983, cancer has been the primary cause of death in Korea, and the age-standardized incidence and mortality rates were 299.0 and 90.2 per 100 000 persons, respectively, in 2012.[1] Gastrointestinal (GI) cancers, including gastric, colorectal and liver cancers, are the most common cancers, and the age-standardized incidence rates of these cancers were 39.9, 37.3 and 21.1 per 100 000 persons, respectively, in 2012.[1]

Diet is thought to play a major cause in the incidence and prognosis of cancer.[2–4] Diet-related cancer risk factors, such as high sodium intake, red meat intake, low intake of vegetables and fruit and obesity, may be responsible for around 30% of cancers in Western countries.[4–7]

In our previous study, the intake of sodium and red meat was positively related with an increased cancer risk among Koreans.[8] In addition, a previous meta-analysis reported that the consumption of soy-based foods, vegetables and fruits might reduce the cancer incidence, whereas the consumption of high salty foods might be a risk factor for gastric cancer and the high intake of meat might increase the risk of colorectal cancer among Koreans.[9] However, because of the complexity of diets, these studies did not examine

in-depth the intricate relationships and synergistic effects of nutrients and foods on cancer risk.

The dietary pattern approach has been presented as a new nutritional epidemiology for examining associations between the overall diet and chronic diseases.[10–12]

Many clinical, experimental and epidemiological studies have identified distinctive dietary patterns and have examined whether certain patterns are related with the cancer incidence.[12–18] A healthy dietary pattern, characterized by high intake of whole grains, vegetables, lean meat, poultry, fruits and low-fat dairy products, is related with a reduced cancer incidence. On the contrary, a Western dietary pattern that involves high consumption of simple carbohydrates, fatty meat and animal fat and alcohol increases the cancer risk.

However, the application of the results of these studies to Koreans may be limited, as their dietary patterns differ from those of Western populations owing to differences in geography, socioeconomic status, food environments and behaviors.[10]

Korea has experienced a unique nutritional transition during the past several decades because of fast economic growth and the increased exposure to Western culture.[19–22] Accordingly, the dietary pattern has gradually changed from a traditional rice-based Korean diet to a Western style diet, characterized by

[1]Department of Clinical Nutrition, Research Institute & Hospital, National Cancer Center, Goyang-si, Republic of Korea; [2]Division of Cancer Epidemiology & Management, National Cancer Center, Goyang-si, Republic of Korea; [3]Department of Preventive Medicine & Institute of Environmental Medicine, Seoul National University College of Medicine, Seoul, Republic of Korea; [4]Department of Nutritional Sciences, University of Connecticut, Storrs, CT, USA and [5]Graduate School of Public Health and Institute of Health and Environment, Seoul National University, Seoul, Republic of Korea. Correspondence: Dr H Joung, Graduate School of Public Health & Institute of Health and Environment, Seoul National University, 599 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea or G-A Wie, Department of Clinical Nutrition, Research Institute & Hospital, National Cancer Center, 323 Ilsan-ro, Ilsandong-gu, Goyang-si 10408, Republic of Korea.
E-mail: hjjoung@snu.ac.kr or gawie@ncc.re.kr

**Table 1.** Factor loading matrix for four dietary patterns identified in the Korean population using factor analysis

| Food items | Dietary patterns | | | |
|---|---|---|---|---|
| | Vegetables and fish | Rice and kimchi | Fruits and dairy | Meats and sweets |
| Soy sauce and red peppers | 0.68 | | | 0.21 |
| Oils | 0.63 | −0.26 | | |
| Vegetables | 0.63 | 0.30 | | |
| Fish and shellfish | 0.54 | | | |
| Eggs | 0.39 | −0.29 | | |
| Seaweed | 0.21 | | | |
| Mushrooms | 0.20 | | | |
| Rice | | 0.62 | −0.33 | |
| Soybean paste | | 0.47 | | |
| Kimchi | | 0.45 | | |
| Tofu and soymilks | | 0.24 | 0.21 | |
| Noodles and dumplings | 0.22 | −0.45 | | |
| Breads and snacks | | −0.47 | | |
| Fruits | | | 0.61 | |
| Milk and dairy products | | | 0.49 | |
| Grains | | | 0.44 | |
| Potatoes | | | 0.39 | |
| Nuts | | | 0.26 | |
| Alcohols | | | −0.27 | 0.22 |
| Red meats and its products | | | −0.21 | 0.69 |
| White meats and its products | | | | 0.68 |
| Sweets | 0.21 | | | 0.38 |
| Hamburgers and beverages | | | −0.24 | 0.35 |
| Variance of intake explained (%) | 9.1 | 7.9 | 6.7 | 5.3 |

For simplicity, factor loading scores of −0.20 and +0.20 are not shown.

high consumption of meat and animal products.[19–21,23,24] Although the vegetable and fruit intake of Koreans has increased, the intake of salted vegetables, including kimchi which is a traditional Korean food, remains high.[25] Such dietary changes are believed to influence the cancer risks among Koreans; however, evidence for the association is limited. Most previous nutritional epidemiological studies on cancer risk performed in Korea focused on individual nutrients or foods and were case–control or cross-sectional studies or were limited to specific cancers or certain regional areas.[8,26–29]

Therefore, this study aimed to determine the distinct dietary patterns in Korean adults and to examine the associations between these dietary patterns and the risk of cancer based on data from the Cancer Screening Examination Cohort (CSEC) of the National Cancer Center (NCC) in Korea. In addition, the study aimed to examine whether the impact of diets on the risk of cancer differed between GI cancers and non-GI cancers.

## PATIENTS AND METHODS

### Study population
The CSEC of the NCC is a prospective cohort study among Koreans. Of the 26 815 subjects aged 20 years and older (mean age, 48.6 years) who participated in the CSEC between September 2004 and December 2008, 8 179 subjects who completed a questionnaire, health examination and nutrition survey at the baseline interview were included in this study. We excluded subjects who had previous cancer history (n = 79) or who had

very low or high daily energy intake (< 700 kcal or > 5000 kcal, n = 29). Thus, 8024 subjects (3622 women and 4402 men) were finally eligible for analysis. Details regarding the rationale and methods of the CSEC have been published elsewhere.[8]

The cancer incidence among all study subjects after the baseline survey was confirmed using the Korean Central Cancer Registry or the electronic medical record (EMR) of the NCC. According to the International Classification of Diseases (ICD)-10 Codes C00-C99, 425 new cancer cases were identified during the follow-up until 3 February 2016.[30]

All subjects provided written informed consent, and this study was approved by the Institutional Review Board of the NCC of Korea (NCCNCS-09-274).

### Data collection
All subjects completed a questionnaire about their sociodemographic (sex, age, income, occupation, education, marital status, physical activity, alcohol consumption habits and smoking habits) and medical history at the baseline interview. Data on body mass index (BMI), cancer site and cancer diagnosis time were obtained using the EMR of the NCC in Korea.

Dietary information was obtained from a 3-day food record. Specially, the study subjects were asked to record all foods and drinks consumed over a 3-day period (1 weekend day and 2 weekdays) within a week. To increase the accuracy of the records, registered dietitians (RD) confirmed all food records written by study subjects during face-to-face interviews using food models and supplemental instruments. For each subject, the daily consumption of energy, macronutrients, micronutrients and foods and food groups was assessed using CAN-Pro 3.0 (Korean Nutrition Society, Seoul, Korea).

### Dietary patterns
Principal component analysis was used to examine dietary patterns. All food items consumed by study subjects were divided into 23 food groups, based on nutrient profiles, culinary uses of foods or food groups categorized in the Nutrient Database of Korea.[31] Grains and grain products were further classified into four subgroups (rice, grains, noodles and dumplings, and bread and snacks) as the consumption of these foods is considerably high in Korean adults.[32] Kimchi, traditional Korean fermented cabbage, was also categorized as a group because it is usually consumed. Dietary patterns were derived using the PROC FACTOR procedure. The orthogonal transformation by the 'Varimax' rotation function of SAS (version 9.3; SAS Institute, Inc., Cary, NC, USA) was applied to rotate the factor correlation matrix. The number of factors was decided by a scree plot, eigenvalues (> 1.2) and the interpretability. The factor score for each dietary pattern was calculated by summing the intake of each food group, weighted by the factor loading. Dietary patterns were named as food groups with high positive loading on the factor.

### Statistical analysis
The general characteristics of the subjects are showed as the percentage or number of study subjects in each tertile of the four dietary patterns, and the distributions and mean differences of the subjects among the tertiles of each dietary pattern group were compared using the chi-square test and generalized linear regression analysis, respectively.

The hazards ratios (HRs) and 95% confidence intervals (CIs) for cancer risk by the tertiles of dietary pattern scores were calculated using the Cox proportional hazards regression model with adjustments for covariates. A trend test was conducted to examine the association between each dietary pattern score and cancer risk. Information on the potential confounding variables was identified using a self-reported questionnaire. Continuous variables considered as confounders included age (years), sex (women, men), energy intake (kcal) and BMI (kg/m²), whereas categorical variables considered as confounders included physical activity (yes/ no), alcohol consumption (yes/no), smoking (yes/no), income (< 4 million won (₩)/month, 4–7 million won (₩)/month, > 7 million won (₩)/month), education (middle school or less, high school and college or more) and marital status (unmarried, married and divorced or widowed). If subjects answered that they regularly engaged in physical activity, physical activity was classified as 'yes'; otherwise, it was classified as 'no'. Similarly, if subjects answered that they drank alcohol in the past or currently drink alcohol, alcohol consumption was classified as 'yes', and if they answered that they smoked in the past or currently smoke, smoking was classified as 'yes'.

**Table 2.** General characteristics of the study participants according to dietary pattern scores

| | Vegetables and fish | | | | Rice and kimchi | | | | Fruits and dairy | | | | Meats and sweets | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | P-value | T1 | T2 | T3 | P-value | T1 | T2 | T3 | P-value | T1 | T2 | T3 | P-value |
| *Demographic factors* | | | | | | | | | | | | | | | | |
| Female (%)[a] | 56.2 | 45.4 | 33.9 | < 0.0001 | 62.1 | 47.0 | 26.3 | < 0.0001 | 28.0 | 49.3 | 58.0 | < 0.0001 | 54.8 | 39.0 | 34.1 | < 0.0001 |
| Age (%)[a] | | | | | | | | | | | | | | | | |
| < 50 years | 52.3 | 57.2 | 59.0 | < 0.0001 | 65.3 | 56.1 | 47.1 | < 0.0001 | 62.6 | 57.6 | 48.3 | < 0.0001 | 46.0 | 57.0 | 65.4 | < 0.0001 |
| ⩾ 50 years | 47.7 | 42.8 | 41.0 | | 34.7 | 43.9 | 52.9 | | 37.4 | 42.4 | 51.7 | | 54.0 | 43.0 | 34.6 | |
| BMI (%) [b] | | | | | | | | | | | | | | | | |
| < 25.0 kg/m² | 63.4 | 61.3 | 55.2 | < 0.0001 | 65.9 | 59.5 | 54.4 | < 0.0001 | 53.3 | 61.7 | 64.8 | < 0.0001 | 61.4 | 62.2 | 56.2 | < 0.0001 |
| ⩾ 25.0 kg/m² | 36.6 | 38.7 | 44.8 | | 34.1 | 40.5 | 45.6 | | 46.7 | 38.3 | 35.2 | | 38.6 | 37.8 | 43.8 | |
| Income (%)[b] | | | | | | | | | | | | | | | | |
| < 4 million[c] | 38.2 | 35.6 | 33.4 | < 0.0001 | 30.2 | 36.3 | 40.5 | < 0.0001 | 36.4 | 35.3 | 35.4 | 0.0552 | 40.2 | 34.7 | 32.3 | < 0.0001 |
| 4–7 million[c] | 35.1 | 37.6 | 39.6 | | 39.3 | 38.1 | 34.9 | | 38.0 | 37.3 | 36.9 | | 33.3 | 38.7 | 40.2 | |
| >7 million[c] | 14.8 | 18.3 | 20.4 | | 21.4 | 16.8 | 15.4 | | 17.3 | 19.0 | 17.3 | | 16.4 | 17.4 | 19.7 | |
| Missing | 11.9 | 8.5 | 6.6 | | 9.1 | 8.8 | 9.2 | | 8.3 | 8.4 | 10.4 | | 10.1 | 9.2 | 7.8 | |
| Education (%)[b] | | | | | | | | | | | | | | | | |
| ⩽ Middle school | 17.9 | 11.1 | 9.1 | < 0.0001 | 7.2 | 13.5 | 17.5 | < 0.0001 | 13.1 | 12.1 | 12.9 | 0.5919 | 17.5 | 11.1 | 9.5 | < 0.0001 |
| High school | 35.6 | 34.1 | 30.9 | | 32.1 | 34.8 | 33.8 | | 33.2 | 34.3 | 33.1 | | 37.8 | 34.2 | 30.8 | |
| ⩾ College | 43.0 | 52.4 | 57.8 | | 58.0 | 49.2 | 45.9 | | 50.8 | 51.3 | 51.1 | | 43.6 | 52.5 | 57.0 | |
| Missing | 3.5 | 2.4 | 2.2 | | 2.7 | 2.5 | 2.8 | | 2.9 | 2.3 | 2.9 | | 3.1 | 2.2 | 2.7 | |
| Marital status (%)[b] | | | | | | | | | | | | | | | | |
| Unmarried | 2.7 | 2.8 | 2.4 | 0.0012 | 4.3 | 2.4 | 1.3 | < 0.0001 | 3.1 | 2.3 | 2.6 | < 0.0001 | 1.8 | 2.8 | 3.3 | < 0.0001 |
| Married | 88.1 | 90.2 | 91.6 | | 87.8 | 90.0 | 92.1 | | 90.7 | 91.3 | 87.9 | | 88.5 | 91.2 | 90.2 | |
| Divorced/ widowed | 6.3 | 4.8 | 4.2 | | 5.6 | 5.4 | 4.2 | | 3.5 | 4.7 | 7.0 | | 7.2 | 4.2 | 3.9 | |
| Missing | 2.9 | 2.2 | 1.8 | | 2.3 | 2.2 | 2.4 | | 2.7 | 1.7 | 2.5 | | 2.5 | 1.8 | 2.6 | |
| *Behavioral factors*[b] | | | | | | | | | | | | | | | | |
| Smoking (%) | | | | | | | | | | | | | | | | |
| No | 52.7 | 47.0 | 39.9 | < 0.0001 | 56.7 | 46.7 | 36.1 | < 0.0001 | 31.7 | 51.1 | 56.7 | < 0.0001 | 53.6 | 47.6 | 38.3 | < 0.0001 |
| Current or former | 36.1 | 45.9 | 54.1 | | 34.5 | 44.7 | 57.0 | | 62.4 | 41.1 | 32.7 | | 36.1 | 44.1 | 55.9 | |
| Missing | 11.2 | 7.1 | 6.0 | | 8.8 | 8.6 | 6.9 | | 5.9 | 7.8 | 10.6 | | 10.3 | 8.3 | 5.8 | |
| Alcohol use (%) | | | | | | | | | | | | | | | | |
| No | 29.8 | 26.6 | 20.1 | < 0.0001 | 31.1 | 25.9 | 19.5 | < 0.0001 | 15.9 | 27.3 | 33.3 | < 0.0001 | 31.7 | 25.4 | 19.4 | < 0.0001 |
| Current or former | 63.1 | 68.3 | 75.2 | | 62.9 | 69.0 | 74.8 | | 79.1 | 68.2 | 59.3 | | 61.3 | 69.0 | 76.3 | |
| Missing | 7.1 | 5.1 | 4.7 | | 6.0 | 5.1 | 5.7 | | 5.0 | 4.5 | 7.4 | | 7.0 | 5.6 | 4.3 | |
| Regular physical activity (%) | | | | | | | | | | | | | | | | |
| Yes | 37.0 | 42.1 | 46.1 | < 0.0001 | 39.9 | 41.7 | 43.5 | 0.0018 | 40.8 | 39.5 | 44.8 | < 0.0001 | 37.2 | 42.0 | 45.9 | < 0.0001 |
| No | 53.7 | 52.2 | 48.7 | | 54.1 | 51.7 | 48.8 | | 53.8 | 54.1 | 46.7 | | 54.4 | 51.5 | 48.8 | |
| Missing | 9.3 | 5.7 | 5.2 | | 6.0 | 6.5 | 7.7 | | 5.4 | 6.4 | 8.5 | | 8.4 | 6.5 | 5.3 | |

%; $P$-value from $\chi^2$-test. Missing included no response or unwilling to respond. [a]Generalized linear model. [b]Generalized linear model adjusted by sex and age. [c]Unit is won (₩)/month.

All statistical analyses were conducted using the SAS program version 9.3 (SAS Institute, Inc.).

## RESULTS

The median follow-up was 9.0 years (total 72 009 person-years), and 425 incident cancer cases occurred (246 men and 179 women), including 145 (34.1%) cases of GI cancer during this period.

We identified 4 distinct dietary patterns in factor analysis and named according to food groups that had high positive loading. Table 1 shows the factor-loading matrix. The first pattern was characterized by a high intake of oils, vegetables, fish and shellfish, eggs, seaweed and mushrooms and was named the 'vegetables and fish' pattern. The second pattern loaded positively for rice, soybean paste, and kimchi, but negatively for noodles, dumplings, bread and snacks, and was named the 'rice and kimchi' pattern. The third dietary pattern reflected high positive loading for fruits, milk, and dairy products, other grains, potatoes and nuts, but showed negative loading for rice, alcohol and red meat and was named the 'fruits and dairy' pattern. The fourth pattern was characterized by a high consumption of alcohol, red and white meat and animal products and sweets, and was named the 'meats and sweets' pattern. These 4 dietary patterns accounted for 29.0%

of total variation in the consumption of 23 food groups (9.1% by the 'vegetables and fish' pattern, 7.9% by the 'rice and kimchi' pattern, 6.7% by the 'fruits and milk' pattern and 5.3% by the 'meats and sweets' pattern).

Detailed characteristics of the subjects are presented in Table 2. The distributions of the study subjects by sex, age and the tertile of each dietary pattern score were significantly different ($P < 0.0001$); therefore, sex and age were adjusted in the later analyses as potential confounding variables. Subjects with higher score in the 'vegetables and fish' pattern had higher BMI, were younger, had higher levels of education, were more physically active and were more likely to be smokers and alcohol drinkers ($P < 0.0001$). Subjects with higher score in the 'rice and kimchi' pattern had higher BMI, had lower level of education, were more likely to be smokers and alcohol drinkers ($P < 0.0001$), and were more physically active ($P = 0.0018$). Subjects with higher score in the 'fruits and dairy' pattern were less likely to be smoker and alcohol drinker, had lower BMI, were older and were more physically active ($P < 0.0001$). Individuals with higher score in the 'meats and sweets' pattern were younger, had increased physical activity and were more likely to be smokers and alcohol drinkers ($P < 0.0001$).

Table 3 presents the relations between nutrient consumption and dietary factor scores. The 'vegetables and fish' pattern was

**Table 3.** Correlation coefficients[a] between the scores of the four dietary pattern and the intake of various nutrients

|  | Vegetables and fish | Rice and kimchi | Fruits and dairy | Meats and sweets |
|---|---|---|---|---|
| Energy (kcal) | 0.48* | 0.16* | 0.14* | 0.37* |
| Carbohydrate (g) | − 0.23* | 0.21* | 0.17* | − 0.25* |
| Protein (g) | 0.36* | 0.08* | 0.05* | 0.08* |
| Fat (g) | 0.24* | − 0.33* | 0.08* | 0.27* |
| Calcium (mg) | 0.24* | 0.14* | 0.38* | − 0.14* |
| Iron (mg) | 0.19* | 0.18* | 0.16* | − 0.06* |
| Fiber (mg) | 0.23* | 0.28* | 0.46* | − 0.17* |
| Phosphorus (mg) | 0.39* | 0.15* | 0.37* | − 0.01 |
| Sodium (mg) | 0.37* | 0.25* | − 0.09* | − 0.04** |
| Zinc (mg) | 0.09* | 0.08* | 0.04** | 0.03*** |
| Vitamin A (μgRE) | 0.34* | 0.12* | 0.19* | − 0.03** |
| Thiamin (mg) | − 0.02 | − 0.00 | 0.03*** | 0.02 |
| Riboflavin (mg) | 0.18* | − 0.05* | 0.21* | 0.04** |
| Vitamin $B_6$ (mg) | 0.12* | 0.02 | 0.09* | 0.02 |
| Niacin (mg) | 0.15* | 0.15* | 0.07* | 0.22* |
| Vitamin C (mg) | 0.13* | 0.11* | 0.41* | − 0.05* |
| Folic acid (mg) | 0.32* | 0.16* | 0.35* | −0.12* |

*$P < 0.0001$, **$P < 0.001$, ***$P < 0.05$. [a]Partial Pearson's correlation, including age, sex and energy as covariates.

significantly positively related with consumption of the majority of the nutrients, including energy, protein and minerals or vitamins, but excluding carbohydrates. The 'rice and kimchi' pattern was positively related with consumption of the majority of nutrients, except fat and riboflavin. The 'fruits and dairy' pattern was positively associated with consumption of the majority of the nutrients, except sodium. The 'meats and sweets' pattern was positively related with consumption of energy, fat, protein, niacin and riboflavin, whereas it was negatively related with carbohydrate, calcium, iron, fiber, sodium, vitamin A, vitamin C and folic acid.

Table 4 presents the crude and multivariate-adjusted HRs for the cancer risk across the 4 dietary patterns. The 'fruits and dairy' pattern tended to decrease the cancer risk (highest vs. lowest tertile; crude HR = 0.81, 95% CI = 0.64, 1.03, P for trend = 0.0589); however, this relation was not statistically significant (multivariate-adjusted HR = 0.95, 95% CI = 0.72, 1.25, P for trend = 0.0626). When new cancer cases were divided into GI and non-GI cancers, the 'fruits and dairy' pattern showed a significant inverse relation with the incidence of GI cancers (highest vs. lowest tertile; crude HR = 0.61, 95% CI = 0.41, 0.91, P for trend = 0.0109). However, there was no relation after adjusting for covariates. Additionally, no association was found for non-GI cancers. The 'rice and kimchi' pattern did not show any significant relation with the risk of cancer. However, when cancer cases were further divided according to cancer site, the 'rice and kimchi' pattern showed a significant inverse relation with the incidence of non-GI cancers after adjusting for confounding variables (highest vs. lowest tertile; HR = 0.60, 95% CI = 0.41, 0.88, P for trend = 0.0027). There was no relation between 'rice and kimchi' pattern and GI cancers. The other dietary patterns ('vegetables and fish' and 'meats and sweets') were not significantly related with cancer risk.

## DISCUSSION

This study identified four distinct dietary patterns ('rice and kimchi', 'vegetables and fish', 'fruits and dairy' and 'meats and sweets') among Koreans, and found that the 'fruits and dairy' pattern showed a marginally inverse relation with the cancer risk and that the 'rice and kimchi' pattern showed a significantly inverse relation with non-GI cancer risk. To our knowledge, this is the first large prospective cohort study using a 3-day food records

to examine the relations between the cancer incidence and dietary patterns in the Korean populations.

In our study, the four dietary patterns explained 29.0% of the total variation in food consumption. Several previous studies used an eigenvalue of 1.5 to identify 3–4 dietary patterns representing 16.7–31.1% of the total variation.[16,17,32–36] Although the results of our study are not directly comparable with those of previous studies owing to differences in the study protocol, dietary patterns identified in our study are similar to those presented in previous studies.[32,33,35,36]

The 'fruits and dairy' pattern in our study is similar to the 'high dairy, high fruit and vegetable, low alcohol' pattern in the Ohsaki Cohort Study[37] and the 'Healthy' dietary patterns in a previous study,[38] which was characterized by high consumption of other grains, fruits, milk and nuts, and showed a negative relation to cancer risk at several sites.[3,16,17,37–40] The 'fruits and dairy' pattern in this study showed a positive association with calcium, zinc, riboflavin, vitamin C and folic acid, which has received significant attention for cancer prevention.[3] Previous studies found that calcium and several nutrients found in fruit and dairy products were negatively correlated with the incidence of colorectal and prostate cancers.[41,42] Furthermore, a meta-analysis indicated that folate consumption was inversely related with the incidence of esophageal, gastric and pancreatic cancers.[43] We identified a positive relation between the 'fruits and dairy' pattern and absence of smoking or alcohol consumption, high level of physical activity and lower BMI, which are factors indicative of a healthy lifestyle and are consistent with those identified in previous studies.[44–46] Thus, our results indicate that 'fruits and dairy' pattern may reduce the cancer risk through synergistic effects or interactions of the nutrients of foods within the dietary pattern and a healthy lifestyle. In addition, the 'fruits and dairy' dietary pattern showed an inverse association with GI cancers only; however, there was no relation after adjusting for covariates. The reason for this cannot be explained by our study, and further studies on the effects of covariates on the cancer incidence, especially in a multivariate-adjusted model, are warranted.

The 'rice and kimchi' pattern in our study was similar to 'traditional' Korean dietary pattern in previous Korean studies[33,34] and was characterized by low energy density and fat consumption. Additionally, this pattern involved intake of a large amount of soybean paste and vegetables, which was known to be significantly inversely related to the cancer incidence.[2,3,39,40,47] Therefore, a significant relationship between the 'rice and kimchi' pattern and a reduced overall cancer risk was expected in our study. However, we found that only the non-GI cancers showed a significant inverse relation with the 'rice and kimchi' pattern (highest vs. lowest tertile; multivariate-adjusted HR = 0.60, 95% CI = 0.41, 0.88). The 'rice and kimchi' pattern in this study and 'traditional Korean' dietary pattern in several previous studies were characterized by high consumption of kimchi that is associated with high sodium intake. High sodium consumption has been showed to be a risk factor for gastric cancer,[3,8,25] so no significant association between the 'rice and kimchi' pattern and the GI cancer incidence might be expected in this study. Accordingly, additional studies are needed to explain the relation between a traditional dietary pattern and cancer risk among Koreans.

The 'meats and sweets' pattern in our study is similar to the 'meat and alcohol' or 'Western' dietary patterns presented in previous studies,[33–35,13,17] which is characterized by high intake of meat, sweets and alcohol. Most previous studies have reported that consumption of meat, sweets and alcohol is related with an increased cancer incidence.[3,4,5,11,38,39] However, the 'meats and sweets' dietary pattern in the present study showed no association with cancer risk. This result was most likely obtained because the highest tertile of the 'meats and sweets' pattern showed high intake of vegetables and fruits, similar to the

**Table 4.** Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for cancer risks by tertile of dietary pattern scores in the study participants

| | Total | | | | | Gastrointestinal cancer | | | | | Non-gastrointestinal cancer | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of cases | Crude[a] HR | 95% CI | Multivariate[b] HR | 95% CI | Number of cases | Crude[a] HR | 95% CI | Multivariate[b] HR | 95% CI | Number of cases | Crude[a] HR | 95% CI | Multivariate[b] HR | 95% CI |
| *Vegetables and fish* | | | | | | | | | | | | | | | |
| T1 | 149 | 1.00 | | 1.00 | | 55 | 1.00 | | 1.00 | | 94 | 1.00 | | 1.00 | |
| T2 | 152 | 1.06 | 0.85 1.33 | 1.15 | 0.88 1.51 | 52 | 0.97 | 0.66 1.42 | 1.10 | 0.70 1.74 | 101 | 1.13 | 0.85 1.50 | 1.10 | 0.86 1.67 |
| T3 | 124 | 0.87 | 0.68 1.11 | 0.90 | 0.66 1.23 | 38 | 0.69 | 0.46 1.06 | 0.83 | 0.48 1.42 | 85 | 0.98 | 0.73 1.32 | 0.94 | 0.64 1.38 |
| P trend | | 0.2597 | | 0.2062 | | | 0.1847 | | 0.5221 | | | 0.5538 | | 0.3023 | |
| *Rice and kimchi* | | | | | | | | | | | | | | | |
| T1 | 128 | 1.00 | | 1.00 | | 39 | 1.00 | | 1.00 | | 89 | 1.00 | | 1.00 | |
| T2 | 159 | 1.11 | 0.88 1.41 | 1.03 | 0.78 1.35 | 40 | 0.83 | 0.53 1.30 | 0.86 | 0.51 1.47 | 119 | 1.25 | 0.95 1.65 | 1.10 | 0.80 1.50 |
| T3 | 138 | 0.86 | 0.67 1.11 | 0.79 | 0.59 1.07 | 66 | 1.12 | 0.74 1.69 | 1.20 | 0.73 1.99 | 72 | 0.71 | 0.51 0.99 | 0.60 | 0.41 0.88 |
| P trend | | 0.1032 | | 0.1495 | | | 0.3435 | | 0.3649 | | | 0.0010 | | 0.0027 | |
| *Fruits and dairy* | | | | | | | | | | | | | | | |
| T1 | 154 | 1.00 | | 1.00 | | 63 | 1.00 | | 1.00 | | 91 | 1.00 | | 1.00 | |
| T2 | 125 | **0.76** | **0.60 0.92** | **0.73** | **0.55 0.96** | 38 | **0.58** | **0.39 0.87** | **0.59** | **0.36 0.96** | 88 | 0.89 | 0.66 1.20 | 0.83 | 0.59 1.17 |
| T3 | 146 | 0.81 | 0.64 1.03 | 0.95 | 0.72 1.25 | 44 | 0.61 | 0.41 0.91 | 0.80 | 0.50 1.28 | 101 | 0.95 | 0.72 1.27 | 1.03 | 0.73 1.45 |
| P trend | | **0.0589** | | **0.0626** | | | **0.0109** | | 0.1012 | | | 0.7461 | | 0.4073 | |
| *Meats and sweets* | | | | | | | | | | | | | | | |
| T1 | 148 | 1.00 | | 1.00 | | 53 | 1.00 | | 1.00 | | 95 | 1.00 | | 1.00 | |
| T2 | 146 | 1.09 | 0.87 1.34 | 1.16 | 0.88 1.52 | 53 | 1.12 | 0.76 1.64 | 1.40 | 0.87 2.23 | 93 | 1.08 | 0.81 1.44 | 1.05 | 0.75 1.47 |
| T3 | 131 | 1.04 | 0.82 1.33 | 1.22 | 0.91 1.65 | 39 | 0.87 | 0.57 1.33 | 1.36 | 0.81 2.29 | 92 | 1.15 | 0.85 1.55 | 1.16 | 0.81 1.67 |
| P trend | | 0.7543 | | 0.3796 | | | 0.4882 | | 0.3390 | | | 0.6607 | | 0.6996 | |

Abbreviations: CI, confidence interval; HR, hazards ratio. [a]Estimated using the Cox proportional hazards regression model, adjusted for age and sex. [b]Estimated using the Cox proportional hazards regression model, adjusted for age, sex, energy intake, BMI, physical activity, smoking, alcohol use, income, education and marital status.

individuals in the other tertiles (data not shown), which is relevant to cancer prevention.[2,39,40] In addition, the absence of an association could be attributed to the fact that the consumption of meat is much lower in Koreans than in Western countries and that many Koreans have a rice-based dietary pattern.[23,48] However, this association requires more attention because of the ongoing rapid change in the Western style diet among the younger individuals.[48] Therefore, further studies are required to clarify the role of meat consumption or related dietary patterns in cancer risk.

This is the first prospective cohort study with a large number of subjects, and therefore, we could appropriately explain the association between cancer risk and dietary patterns among Koreans. The evaluation of diet prior to cancer diagnosis could minimize reverse causation and recall bias. The other strength of this study is the use of 3-day food records that could accurately assess the usual dietary intake of the study subjects. Factor analysis of usual intake could provide high-quality separation of the dietary patterns.[49] On the other hand, the study had some limitations. First, the median follow-up period of our study was 9.0 years, which might not be enough to obtain many cancer cases for high statistical power. A small number of cancer cases might result in insufficient statistical power to elucidate the associations and might cause potential problems with regard to multiple comparisons. Second, the dietary pattern approach could be subjective to a certain extent, although it is a powerful tool to measure the overall diet. When performing factor analysis to derive dietary patterns, researchers arbitrarily decide on matters regarding number of factors, number of food groups and statistical method.[50] To minimize subjectivity, we defined the dietary patterns according to the approach used in previous studies[14,15,17,33–35] and confirmed that dietary patterns identified in our study were similar to those noted in many previous studies of Korean, Japanese and Western populations.[14,15,17,27,32–34] Third, this study included individuals who voluntarily participated in a hospital setting and who were financially capable of joining a cancer screening program; therefore, there might have been selection bias. Fourth, we assessed a 3-day food record at a single time point. Despite these limitations, our study is the first to identify the relation between cancer risk and dietary patterns among Koreans.

In conclusion, this study indicates that high consumption of rice and kimchi that characterizes the traditional Korean diet decreases the non-GI cancer risk, and a dietary pattern characterized by high consumption of fruits, milk, dairy products, potatoes and other grains merely suggests a decrease of the cancer risk, specifically GI cancer risk. These results can be used to develop the cancer prevention programs for the Korean populations, although further nutritional epidemiological studies are required to explain the associations between specific cancer types and dietary risk factors among Koreans.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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