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ORIGINAL ARTICLE

Intake Trends of Red Meat, Alcohol, and Fruits and Vegetables as Cancer-Related Dietary Factors from 1998 to 2009

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Abstract
Objectives: Cancer is the leading cause of death worldwide, and cancer incidence and mortality have been increasing steadily in South Korea. This study aimed to examine the change in consumption of three cancer-related dietary factors—red meat, alcohol, and fruits/vegetables, and to evaluate consumption of these dietary factors among Koreans according to the criteria from the recommendations of the World Cancer Research Fund/American Institute of Cancer Research.
Methods: Consumption of red meat, alcoholic beverages, and fruits and vegetables was calculated from the 24-hour recall data of 36,486 individuals older than 20 years who were selected from the Korea National Health and Nutrition Examination Survey 1998—2009. The intake adequacy of these three factors was evaluated by the recommended criteria of the World Cancer Research Fund/American Institute of Cancer Research report.
Results: The mean red meat intake in the men in their 20s increased sharply (from 91.6 g to 111.3 g, $p < 0.05$). The mean alcohol intake increased continuously in men (from 10.3 g to 20.0 g, $p < 0.05$) and women (from 1.5 g to 3.5 g, $p < 0.05$). The mean fruit/vegetable intake decreased in the 21—29—year age group (from 349.4 g to 306.7 g in men; from 393.3 g to 292.5 g in women; $p < 0.05$). The percentage of individuals who did not meet the intake criteria for the three cancer-related dietary factors was especially high, and the percentage increased over 10 years in those in their 20s ($p < 0.05$).
Conclusion: We confirmed that intakes of red meat, alcoholic drink, and fruits and vegetables have moved toward a negative direction in both men and women in their 20s.

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1. Introduction

Prevention of cancer is one of the most pressing challenges faced by researchers and public health policy makers. Cancer is, however, preventable through modification of lifestyle and diet and by increasing physical activity. The World Cancer Research Fund (WCRF) and the American Institute for Cancer Research (AICR) published the report "Food, Nutrition and the Prevention of Cancer: a Global Perspective" in 2007 [1]. The purpose of this report was to review all the relevant research to suggest comprehensive recommendations for food, nutrition, and physical activity to prevent cancer. In this report, 10 dietary and physical activity recommendations for cancer prevention were established, and six out of these 10 recommendations are concerned with dietary factors: (1) limit consumption of energy-dense foods and avoid sugary drinks; (2) eat mostly foods of plant origin; (3) limit intake of red meat and avoid processed meat; (4) limit intake of alcoholic drinks; (5) limit consumption of salt and avoid moldy cereals (grains) or pulses (legumes); and (6) aim to meet nutritional needs through diet alone.

Cancer is the leading cause of death worldwide, and cancer incidence and mortality have been increasing steadily in South Korea [2]. According to Globocan 2012, the incidence of all cancers is expected to increase up to 25% in South Korea by 2020 [3]. Meanwhile, the dietary habits of Koreans may contribute to both protective factors against cancer and risk factors for cancer. In general, Koreans consume a great deal of vegetable dishes, such as salads and seasoned vegetables, which are known through case–control and cohort studies to be protective factors for colorectal cancer [4–7]. Meta-analyses have reported that beans and soybean products such as soybean paste, tofu, and soy milk reduce breast cancer risk [8–10]; these foods are frequently consumed in Korea. By contrast, barbecued meats, especially those barbecued with charcoal, are very popular in Korea and significantly increase gastric cancer risk [11]. Traditional Korean salted foods such as salted fish and salted vegetables have been reported as risk factors for gastric cancer [12,13]. Koreans usually consume a large amount of salted vegetables such as kimchi.

In many studies, it has been found that food consumption patterns are different by age groups and sex. Bezerra et al [14] recently found differences in food intake by sex and age groups in a study comparing food intakes in Brazil and the United States. Differences in food consumption pattern by age groups and sex were found in Canada and Lebanon as well [15,16]. In Taiwan and Spain, food consumption was different by age groups [17,18]. In a cohort of young Brazilian adults, Arruda et al [19] found that sex is associated with the dietary pattern. Considering these differences, consumption patterns of cancer-related dietary factors would also be different by age groups and sex. Therefore, it seems meaningful to evaluate the consumption of cancer-related dietary factors for Koreans in order to monitor risk groups for cancer prevention.

In this study, we examined the change in consumption of cancer-related dietary factors—red meat, alcohol, and fruits and vegetables—and evaluated the consumption of these dietary factors according to the criteria from the recommendations of WCRF/AICR in Koreans, by comparing data from the first to the fourth Korea National Health and Nutrition Examination Survey (KNHANES).

2. Materials and methods

2.1. Dataset for analysis

The intake levels of the selected factors were analyzed in the 1998, 2001, 2005, and 2007–2009 KNHANES, which is the national monitoring survey of South Korea (a cross-sectional study). The KNHANES has been conducted with individuals selected by representative sampling of the household registries in the National Census Registry since 1998. The KNHANES data have three components: a health interview, a health examination, and a nutrition component. In this study, we used 1-day 24-hour recall data from the nutrition survey in the KNHANES to calculate and evaluate the consumption of the selected cancer-related dietary factors. We selected participants who were over 21 years of age in the KNHANES, since the intake criteria from the recommendations of the WCRF/AICR report were applicable to adults older than 21 years.

2.2. Selection of cancer-related dietary factors and calculation of intake of cancer-related dietary factors

Three cancer-related dietary factors—red meat, alcohol, and fruits and vegetables—which could be analyzed quantitatively using the KNHANES data were selected to evaluate the consumption of cancer-related dietary factors. This is because only these three dietary factors have recommended intake criteria, although the associations between $>$ 40 dietary factors and cancer were reviewed by panels in the WCRF/AICR report. This is due to the difficulty in determining the intake criteria for all cancer-related dietary factors because of an insufficient number of reliable studies. Sodium intake, one of the cancer-related dietary factors in the WCRF/AICR report, was excluded from this study because the average of the sodium intake of Koreans has exceeded the recommended limit of 2,400 mg/d; therefore, the evaluation of sodium intake in Koreans seemed meaningless. Ultimately, only three cancer-related dietary factors with the intake criteria—red meat, alcohol,

and fruits and vegetables—were selected for the present study.

The intakes of red meat, alcohol, and fruits and vegetables were calculated for each age or sex group. All individuals were divided into five age groups according to the age classification of Dietary Reference Intakes for Koreans [20].

Food items belonging to red meat, alcohol, and fruits and vegetables, according to the definitions in the WCRF/AICR report [21], were identified and combined to obtain the intake of each factor of each participant: (1) Red meat refers to beef, pork, lamb, and goat meat obtained from domesticated animals including that contained in processed foods, and flesh from animals that have more red than white muscle fibers. Meat includes skeletal muscles and the internal organs (offal, such as the brain, liver, heart, intestines, and tongue). (2) Alcoholic beverages include beer, wine, and spirits. Other alcoholic beverages that may be locally important include fermented milk, fermented honey water (mead), and fermented apples (cider). Since alcoholic beverages vary in their ethanol content, ethanol intake was calculated taking into consideration alcoholicity and specific gravity of the alcoholic drinks, and not their intake. The intake criterion for ethanol was determined by assuming 10 g of ethanol per "drink" because one glass of soju or beer, the most frequently consumed alcoholic beverage in Korea [22], contains about 10 g of ethanol. Calculated ethanol contents were converted into number of "drinks," with one drink being equivalent to 10 g of ethanol, to evaluate the intake of alcoholic beverages. (3) Vegetables (nonstarch) are the edible parts of plants, usually including fungi. Nonstarch vegetables can be divided into green, leafy vegetables, and cruciferous vegetables. Fruits are the seed-containing part of a plant, but only those that are eaten as fruits are included in the culinary definition, for example, apples, bananas, berries, figs, grapes, mangoes, and melons. These also include citrus fruits such as oranges, grapefruits, lemons, and limes, and dried fruits such as apricots, figs, and raisins. Judgments on vegetables and fruits do not include those preserved by salting and/or pickling (e.g., kimchi in Korea).

The consumption criteria for each factor were chosen from the 10 recommendations by WCRF/AICR [21]. Personal recommendations for each factor were as follows: (1) consumption of red meat should be limited to < 500 g/wk; (2) consumption of alcoholic beverages should be limited to two drinks per day for men and one drink per day for women; and (3) consumption of fruits and vegetables should be at least 400 g/d.

We converted the intake criterion per week for red meat (500 g) to one per day (g) divided by 7 days because the KNHANES includes only 1-day 24-hour recall data. Individuals who consumed ≥ 71.4 g red meat per day and/or < 400 g fruits and vegetables per day were classified as risk groups for cancer. For alcoholic beverages, men who consumed over two drinks per day and women who consumed over one drink per day were also classified as risk groups for cancer. The evaluation results were used to determine whether the participants have risk factors, and the percentage of individuals with risk factors was calculated.

2.3. Statistical analysis

The mean and median intakes of the three cancer-related dietary factors of each year were calculated with the nutrition survey weight using the survey procedure. The mean intakes of the three cancer-related dietary factors for subgroups such as sex, age groups, and number of risk factors were calculated with the nutrition survey weight using the domain statement of survey procedure. The trends for mean intake of each cancer-related dietary factor were tested by regression analysis using a generalized linear model. The trends for sex ratio, percentages of individuals in each age group, and percentages of individuals who have three risk factors were also tested by the two-sided Cochran−Armitage trend test. All statistical analyses were performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA); the level of significance was $p < 0.05$.

3. Results

Table 1 summarizes the general characteristics of the participants. More female than male individuals older than 21 years were in the four sets of KNHANES data from 1998 to 2009. The number of individuals in the fourth KNHANES (2007−2009) was more than twice that who participated in any other previous KNHANES. The number of individuals aged 30−49 years was the highest and that of individuals older than 65 years was the lowest in all KNHANES data. The percentage of individuals in their 20s decreased, but the percentage of those older than 65 years increased. The mean intake of red meat slightly decreased from 63.0 g to 60.6 g ($p < 0.05$). The mean alcohol intake consistently increased ($p < 0.05$), and the mean intake of fruits and vegetables decreased since 2001 ($p < 0.05$).

Table 2 shows the changes in red meat, alcohol, and fruit and vegetable intake by sex and age groups in the KNHANES from 1998 to 2009. The mean intake of red meat for both sexes in their 20s was highest in 1998 and 2007−2009, while that for both sexes aged 30−49 years was highest in 2001. The mean intake of red meat in men in their 20s increased sharply from 63.6 g in 2001 to 111.3 g in 2007−2009. The mean intake of red meat in women in their 20s also increased sharply from 2001 to 2005. The mean alcohol intake increased from 9.2 g to 20.3 g, especially in men in their 20s, since 1998, although it was not statistically significant. Since 1998, the mean alcohol intake of men rapidly increased from 10.6 g in 2001 to 20.3 g in 2007−2009 ($p < 0.05$). The mean alcohol intake of men aged 30−49 years was the

Table 1. Distribution of selected individuals according to sex/age groups and the mean intake of red meat, alcohol, and fruits/vegetables among selected individuals in the KNHANES.

	1998	2001	2005	2007−2009
Total participants	7,292	6,880	6,384	15,930
Men (%)*	3,401 (46.6)	3,159 (45.9)	2,863 (44.9)	6,497 (40.8)
Age groups (y)				
21−29*	1,341 (18.4)	1,158 (16.8)	903 (14.1)	1,783 (11.2)
30−49*	3,327 (45.6)	3,406 (49.5)	3,025 (47.4)	6,386 (40.1)
50−64*	1,650 (22.6)	1,400 (20.4)	1,452 (22.7)	3,970 (24.9)
≥65 *	974 (13.4)	916 (13.3)	1,004 (15.7)	3,791 (23.8)
Red meat intake*,†,‡				
Mean ± SE	63.0 ± 1.3	53.6 ± 1.4	64.8 ± 1.5	60.6 ± 1.1
Median (95% CL)	26.5 (25.1−27.9)	4.9 (1.3−8.6)	25.8 (23.5−28.2)	24.4 (22.8−26.0)
Alcohol intake*,†,§				
Mean ± SE	5.7 ± 0.3	6.4 ± 0.3	9.1 ± 0.5	11.7 ± 0.4
Median (95% CL)	1.7 (−3.4 to 3.4)	0.0 (−3.4 to 3.4)	0.0 (−3.8 to 3.8)	0.0 (−3.5 to 3.5)
Fruit/vegetable intake*,†,‖				
Mean ± SE	367.4 ± 4.5	391.5 ± 4.7	283.0 ± 3.7	350.5 ± 3.5
Median (95% CL)	277.5 (268.5−286.5)	307.8 (298.8−316.8)	219.2 (211.7−226.6)	254.7 (248.7−260.7)

*p for trend ($p < 0.05$). The p values are determined by the two-sided Cochran−Armitage trend test for binominal variables and by a generalized linear model for continuous variables; †Weighted with the nutrition survey weight; ‡Organ meats, residual products, and processed meats were included; meat broth was excluded; §Alcoholic drinks used for flavoring in the cooking process were excluded; ‖Fruit juices, fruit jams, and salted and picked foods were excluded. CL = confidence limits; KNHANES = Korea National Health and Nutrition Examination Survey; SE = standard error.

highest among all age groups from 1998 to 2009. In women, alcohol intake increased continuously from 1.5 g in 1998 to 3.5 g in 2007−2009 ($p < 0.05$). The mean intake of fruits and vegetables for people of both sexes, aged 21−29 years, decreased from 1998 to 2007−2009 (from 349.4 g to 306.7 g in men; from 393.3 g to 292.5 g in women; $p < 0.05$). By contrast, the mean intake of fruits and vegetables for individuals of both sexes, > 50 years of age, increased since 1998. For both sexes, the mean intake of fruits and vegetables decreased, but notably in women (from 375.4 g in 1998 to 346.5 g in 2007−2009, $p < 0.05$). Distribution of individuals who did not meet each intake criterion for red meat, alcohol, and fruits and vegetables is presented in Table 3. The percentage of people in their 20s who consumed red meat over 71.4 g/d showed an increasing tendency for both sexes and became the highest at 47.2% for men in 2007−2009. The percentage of men who drank more than two cups and that of women who drank more than one cup of alcoholic beverages increased significantly with time, except for people over 65 years of age. The percentage of men and women in their 20s who did not meet the intake criteria for alcohol increased notably (from 13.4% in 1998 to 21.0% in 2007−2009 in men; from 4.9% in 1998 to 12.9% in 2007−2009 in women; $p < 0.05$). The percentages of individuals who consumed fruits and vegetables under 400 g/d in age groups 21−29 years and 30−49 years showed a tendency to increase significantly in both sexes from 1998 to 2009.

Distribution of individuals with risk factors and the mean intake of red meat, alcohol, and fruits and vegetables by the number of risk factors are presented in Table 4. Individuals with one risk factor comprised 57% of all participants, the highest percentage among groups with risk factors. Eighty-five percent of individuals with one risk factor had a low intake of fruits and vegetables as their risk factor. In the group with two risk factors, 89% of individuals had a risk factor for fruits and vegetables, 67% for red meat, and 44% for alcohol. The mean intake of red meat and alcohol increased as the number of risk factors increased ($p < 0.05$). By contrast, the mean intake of fruits and vegetables decreased as the number of risk factors increased ($p < 0.05$).

4. Discussion

This study is an important attempt to investigate the changes in consumption of three cancer-related dietary factors—red meat, alcohol, and fruits and vegetables—in the KNHANES data from 1998 to 2009. We found that the mean red meat intake in men in their 20s increased sharply. The mean alcohol intake increased continuously in men and women. The mean fruit/vegetable intake decreased notably in the 21−29-year age group. The percentage of individuals who did not meet the intake criteria for the three cancer-related dietary factors was especially high, and the percentage increased over 10 years in those in their 20s.

The three risk factors came from the WCRF/AICR recommendations for cancer prevention that were based on the reviews of numerous research findings from a variety of countries and ethnic backgrounds. Since these

Table 2. Changes in red meat, alcohol, and fruit/vegetable intake by gender and age groups in the KNHANES.

CRDF (g/d)	Sex	Age group (y)	1998	2001	2005	2007−2009
Red meat*	Men	21−29†	91.6 ± 5.9	63.6 ± 5.1	92.9 ± 6.4	111.3 ± 6.2
		30−49	88.7 ± 3.4	81.8 ± 4.0	94.0 ± 3.6	88.6 ± 2.8
		50−64	61.9 ± 4.0	50.8 ± 3.9	56.5 ± 3.9	61.2 ± 3.0
		≥65	35.3 ± 3.2	40.5 ± 4.8	35.4 ± 4.3	33.4 ± 2.1
		Total†	79.3 ± 2.3	67.7 ± 2.4	80.5 ± 2.4	80.8 ± 1.9
	Women	21−29†	64.2 ± 4.0	48.8 ± 3.6	72.1 ± 5.1	62.9 ± 3.0
		30−49†	54.5 ± 2.3	51.5 ± 2.6	55.2 ± 2.4	45.7 ± 1.4
		50−64	32.5 ± 2.2	29.5 ± 2.4	34.8 ± 2.9	29.8 ± 1.4
		≥65	23.9 ± 2.2	20.4 ± 2.2	20.9 ± 2.4	18.0 ± 1.1
		Total†	48.2 ± 1.4	41.8 ± 1.5	49.3 ± 1.7	40.7 ± 0.9
Alcohol‡	Men	21−29	9.2 ± 1.4	10.6 ± 1.3	15.9 ± 2.3	20.3 ± 2.2
		30−49†	11.2 ± 0.8	12.3 ± 0.8	17.0 ± 1.2	22.5 ± 1.1
		50−64†	11.1 ± 1.2	11.2 ± 1.2	15.5 ± 2.0	19.9 ± 1.9
		≥65	5.7 ± 0.9	6.5 ± 0.9	8.2 ± 1.3	9.2 ± 0.7
		Total†	10.3 ± 0.5	11.2 ± 0.6	15.6 ± 0.9	20.0 ± 0.8
	Women	21−29	1.9 ± 0.4	2.8 ± 0.8	5.1 ± 1.2	6.7 ± 0.8
		30−49†	1.8 ± 0.3	2.9 ± 0.3	2.8 ± 0.3	4.1 ± 0.3
		50−64	0.9 ± 0.2	2.2 ± 0.6	2.1 ± 0.4	2.0 ± 0.2
		≥65	1.0 ± 0.3	1.3 ± 0.5	0.5 ± 0.1	0.7 ± 0.1
		Total†	1.5 ± 0.2	2.5 ± 0.3	2.7 ± 0.3	3.5 ± 0.2
Fruit/vegetables§	Men	21−29†	349.4 ± 15.8	336.5 ± 14.5	260.1 ± 12.3	306.7 ± 12.4
		30−49†	382.6 ± 8.8	392.5 ± 10.0	315.8 ± 7.8	379.9 ± 8.1
		50−64†	346.5 ± 13.6	382.0 ± 12.5	296.8 ± 12.3	378.0 ± 9.8
		≥65†	264.5 ± 16.6	341.6 ± 18.9	235.2 ± 11.5	286.8 ± 8.8
		Total†	358.6 ± 6.3	375.1 ± 6.6	291.9 ± 5.4	354.6 ± 5.2
	Women	21−29†	393.3 ± 15.4	383.9 ± 16.3	272.8 ± 12.6	292.5 ± 11.8
		30−49†	414.5 ± 9.8	435.9 ± 9.3	297.7 ± 7.8	374.7 ± 7.2
		50−64†	349.7 ± 13.0	430.4 ± 15.5	281.2 ± 10.7	405.2 ± 12.0
		≥65†	244.5 ± 11.5	294.4 ± 11.9	192.7 ± 8.9	247.1 ± 7.6
		Total†	375.4 ± 6.4	405.2 ± 6.5	274.3 ± 5.0	346.5 ± 4.8

*Organ meats, residual products, and processed meats were included, meat broth was excluded; †p for trend ($p < 0.05$). The p values are determined by a generalized linear model; ‡Alcoholic drinks used for flavoring in the cooking process were excluded; §Fruit juices, fruit jams, and salted and picked foods were excluded. Values are given as mean (g) ± SE. All values were weighted with the nutrition survey weight. CRDF = cancer-related dietary factors; KNHANES = Korea National Health and Nutrition Examination Survey; SE = standard error.

recommendations were drawn from evidences that each risk factor increases the risk for all cancers, we assumed that the cancer risk for a person who has one risk factor is higher than that for a person with no risk factors. It is also projected that the cancer risk for a person with three risk factors is higher than that for one with fewer risk factors. With the data from European Prospective Investigation into Cancer and Nutrition Project (EPIC) study, Romaguera et al [23] found that concordance with WCRF/AICR recommendations may lower the risk for most types of cancer. Concordance with WCRF/AICR recommendations was also associated with lower all-cause mortality among women cancer survivors, as evident from the Iowa Women's Health Study [24]. Several studies assessed the associations between WCRF/AICR recommendations and specific cancer risks. Hastert et al [25] examined the association of six recommendations, including three cancer-related dietary factors that were selected in this study from the WCRF/AICR report, with breast cancer risk and found that breast cancer risk was reduced by 60% in women who met at least five recommendations compared with those who met none (the Vitamins and Lifestyle study cohort). They recently found that cancer-specific mortality was 61% lower in individuals who met at least five recommendations compared with those who met none, and adherence to the recommendation of plant foods was strongly associated with lower cancer-specific mortality [26]. Consumption of < 500 g red meat per week was a statistically significant protective factor for prostate cancer [27]. Catsburg et al [28] found that adherence to six or seven of the WCRF/AICR recommendations was associated with 31% reduction in breast cancer risk.

The consumption of red meat was similar to that in other countries but attention needs to be paid to red meat consumption of men in their 20s. The mean intake of red meat increased from 79.3 g/d in 1998 to 80.8 g/d 2007−2009 in men and from 48.2 g/d to 40.7 g/d in women (Table 2), which slightly exceeded other countries' red meat intake. Linseisen et al [29] reported that

Table 3. Distribution of participants who did not meet the intake criteria for red meat, alcohol, and fruits/vegetables from recommendations of WCRF/AICR.

CRDF	Sex	Age group (y)	1998	2001	2005	2007–2009
Red meat*	Men	21–29†	36.2	28.8	40.9	47.2
		30–49†	36.9	31.1	41.8	39.2
		50–64	27.9	23.5	27.6	28.0
		≥65	16.9	17.8	16.7	15.7
		Total	32.5	27.7	34.8	31.6
	Women	21–29†	28.2	20.7	34.3	30.9
		30–49	24.6	21.6	26.8	22.5
		50–64	14.4	13.7	16.5	13.6
		≥65	10.6	8.5	9.6	8.1
		Total	20.8	17.9	22.7	17.8
Alcohol‡	Men	21–29†	13.4	16.3	18.9	21.0
		30–49†	18.2	18.3	22.5	26.4
		50–64†	20.7	19.0	21.0	25.7
		≥65	12.2	13.6	14.6	16.3
		Total†	17.2	17.6	20.4	23.3
	Women	21–29†	4.9	6.1	8.7	12.9
		30–49†	4.4	7.5	8.6	10.8
		50–64†	3.5	4.5	6.1	5.6
		≥65	3.5	2.1	3.2	2.4
		Total†	4.1	5.8	7.0	7.8
Fruits/vegetables§	Men	21–29†	70.1	71.0	80.8	75.2
		30–49†	65.3	63.1	72.1	67.0
		50–64	70.3	60.7	74.8	64.6
		≥65†	81.2	69.2	84.3	74.9
		Total†	69.0	64.6	75.7	69.2
	Women	21–29†	66.2	64.5	79.9	75.2
		30–49†	60.0	57.1	75.5	64.7
		50–64	69.0	58.3	74.8	62.9
		≥65	81.0	74.4	89.0	80.5
		Total†	66.4	61.2	78.3	69.3

*Percentages of participants who consumed red meat over 71.4 g/d; †p for trend ($p < 0.05$). The p values are determined by the two-sided Cochran–Armitage trend test; ‡Percentages of male participants who consumed more than two alcoholic drinks/d and female participants who consumed more than one alcoholic drink/d; one drink = 10 g of alcohol; §Percentages of participants who consumed fruits and vegetables < 400 g/d. Values are given as percentages. CRDF = cancer-related dietary factors; WCRF/AICR = World Cancer Research Fund/American Institute of Cancer Research.

Table 4. Distribution of participants with risk factors and mean intake of red meat, alcohol, and fruits/vegetables by the number of risk factors in the KNHANES 2007–2009.

	Number of risk factors*			
	0	1	2	3
	n (%)			
Total	3,174 (19.9)†	9,107 (57.2)	3,049 (19.1)	600 (3.8)
Participants with risk factors				
Red meat	0 (0.0)‡	1,093 (12.0)	2,044 (67.0)	600 (100.0)
Alcohol	0 (0.0)	288 (3.2)	1,355 (44.4)	600 (100.0)
Fruits and vegetables	0 (0.0)	7,726 (84.8)	2,699 (88.5)	600 (100.0)
Mean intake	Mean ± SE (g)			
Red meat§	16.6 ± 0.5	37.5 ± 1.1	122.7 ± 2.9	200.0 ± 6.6
Alcohol§,‖	0.4 ± 0.0	2.4 ± 0.2	30.0 ± 1.3	74.0 ± 2.8
Fruits/vegetables§,¶	754.0 ± 9.3	266.4 ± 4.0	250.8 ± 4.8	217.0 ± 5.2

*Whether participants have risk factors was determined with the criteria in the WCRF/AICR report. Participants who consumed ≥ 71.4 g red meat per day and/or < 400 g fruits and vegetables per day were classified as risk groups for cancer. For alcoholic drinks, men who consumed over two drinks and women who consumed over one drink per day were also classified as risk groups for cancer; †Proportions of total participants; ‡Proportions of groups according to the number of risk factors; §*p* for trend ($p < 0.05$). The p values are determined by a generalized linear model; ‖The intake of alcoholic drinks was converted into alcohol content; ¶Salted vegetables were excluded. Mean intakes were weighted with the nutrition survey weight. KNHANES = Korea National Health and Nutrition Examination Survey; SE = standard error; WCRF/AICR = World Cancer Research Fund/American Institute of Cancer Research.

the intakes of red meat ranged from 40 g/d (UK) to 74 g/d (Spain) in men and from 24.6 g/d (UK) to 44.1 g/d (Denmark) in women. The intake of red meat in the USA [30] ranged from 70.3 g/d (1994) to 76.0 g/d (2004). For the Fukuoka Colorectal Cancer Study in Japan, the red meat intake ranged from 29 g/d to 61 g/d [31]. Although the mean intake of red meat for all individuals decreased since 1998, that of men aged 21−29 years increased sharply from 88.4 g in 1998 to 109.5 g in 2009 ($p < 0.05$). In addition, the mean intake of red meat for men in their 20s has been the highest since 1998 except for in 2001. By contrast, in the United States and Brazil, meat intake was highest in the age group of 40−59 years [14]. In Spain, meat intake was significantly decreased in the age group of 25−44 years from 1992 to 2003 [18].

Alcohol intake for men in this study was similar to that in other countries, while alcohol intake for women was lower than that in other countries. However, alcohol consumption should be monitored with special interest because alcohol consumption for total population (in both sexes) has shown a tendency to increase since 1998. In this study, alcohol intake for men 30−64 years of age has increased significantly since 1998 and for women 30−49 years of age has been increasing since 1998 ($p < 0.05$; Table 2). Genkinger et al [32] reported that alcohol intake ranged from 7.9 g/d to 17.3 g/d in men and from 1.6 g/d to 8.6 g/d in women, by the assessment of alcohol intake from 13 cohort studies in the USA. Weikert et al [33] reported alcohol intakes in European countries surveyed in the EPIC study. The alcohol intake ranged from 10.1 g/d (UK) to 40.6 g/d (Spain) in men and from 4.2 g/d (Italy) to 7.2 g/d (Denmark) in women. The mean alcohol intake observed in the Women's Health Initiative was 5.6 g/d (range, 0−244.5 g/d) [34]. Compared with these studies, alcohol intake for women in their 20s was similar to those in other countries, which was 6.7 g in 2007−2009, and the alcohol intake for this age group increased rapidly since 1998. A J- or U-shaped relationship between alcohol consumption and chronic diseases has been demonstrated in many studies [35−38]. By contrast, Maraldi et al [39] found that the protective effect of moderate alcohol intake was strongly attenuated after adjustment for lifestyle indicators such as education, income, body mass index, and physical activity. In this respect, although alcohol intake in women was not high enough to be classified as moderate intake, it should be noted that their alcohol intake increased continuously from 1998 to 2007−2009. Furthermore, many studies have reported that alcohol intake is associated with colorectal cancer incidence [21]. In Korea, colorectal cancer incidence has increased in both sexes since 1999 [40]. While we calculated alcohol intake using the 1998 KNHANES data, which are the oldest available data, there is a possibility that alcohol intake had been increasing continuously before 1998.

The results from this study implied that intake of fruits and vegetables in most of Korean adults was not sufficient for cancer prevention, even though it is not lower than the fruit and vegetable intake of other studies. The mean intake of fruits and vegetables in France was 424.4 g/d in men and 492.4 g/d in women [41]. The median intakes of fruits and vegetables were 346 g/d in The Netherlands [42] and 198 g/d in Sweden [43]. The median intakes obtained from the EPIC cohort were 150.9 g/d for vegetables and 163.9 g/d for fruits in men, and 185.2 g/d for vegetables and 217.0 g/d for fruits in women [44]. In this cohort, the median intake of fruits and vegetables in Greece was over 800 g/d, which was more than twice that of the other participating countries. Kurahashi et al [45] reported the median fruit and vegetable intake to be 120.3 g/d in Japan. In the Shanghai women's and men's health studies, the median intakes for fruits were 238.3 g/d in women and 128.3 g/d in men, and for vegetable were 261.3 g/d in women and 307.2 g/d in men [46]. These results seem to show that the intake of fruits and vegetables in the KNHANES was similar to that in other Western countries and China, but higher than that in Japan and Sweden. However, since our calculations for fruit and vegetable intake excluded pickled vegetables (e.g., kimchi), which were important sources of vegetables among Koreans, and fruit juices, the fruit and vegetable intake of this study would seem to be low compared with the results from other studies. The Korea Health Statistics 2014 reported that kimchi was the third most frequently consumed food in Korea, and its mean intake was 62.5 g/d [47]. Since the total vegetable intake was 304.9 g/d in the report, the kimchi intake was $> 20\%$ of total vegetable intake. For Koreans, kimchi, a form of salted and fermented vegetables, is known as one of the healthy foods because it is an important source of vitamins, minerals, and dietary fiber [48]. Kimchi has been studied for its health-related effects, and many studies have reported that kimchi has various lactic acid bacteria produced in the fermentation process [49]. In addition, some studies reported that kimchi reduced body weight in obese patients [50] and it had antioxidant functions [51]. However, little evidence supports the cancer-preventive effects of kimchi. More research on kimchi and its effect on cancer is needed in order to recommend kimchi consumption for cancer prevention. The most notable results were that the intake of fruits and vegetables for men and women aged 21−29 years showed a tendency of decreasing significantly over 10 years. In the study of Bezerra et al [14] with the sample population of the United States and Brazil, fruit and vegetable consumption was lowest in the age group of 21−39 years for both sexes, as individuals aged 21−29 years showed the lowest intake of fruits and vegetables in 2007−2009, except for those over 65 years, in this study.

In addition, low intake of fruits and vegetables seems to be the major risk factor among the participants of the

KNHANES from 1998 to 2009. As the number of risk factors increased, distribution of risk factors and intakes of selected cancer-related dietary factors were changed. For the participants who had only one risk, it seems that their risk came from low fruits and vegetables intake since intake of fruits and vegetables was sharply dropped down being compared to the participants who had no risk. It is also supported by that 85% of the risk factors for individuals who had only one risk factor can be attributed to the intake of fruits and vegetables. For individuals who had two risk factors, intake of red meat massively increased compared with those who had one risk factor. This shows that risks of individuals with two risk factors were mostly from high red meat intake and low fruit and vegetable intake. Alcohol intake was multiplied in individuals who had three risk factors compared with those with two risk factors. As the number of risk factors increased, another type of risk factor was added one by one. Since individuals with one risk factor are the majority, it seems that low intake of fruits and vegetables that is the major source of the risk factor for individuals with one risk factor is the major risk factor for all individuals from 1998 to 2009.

The differences between fruit and vegetable intakes in 2005 and those at other times can partly be explained by seasonal variation. The fruit and vegetable intake in 2005 was lower than that in other years. The KNHANES in 2005 was conducted in the spring (April and May), whereas the surveys in 1998 and 2001 were conducted in the early winter (November and December). Since 2007, the KNHANES has been a year-round survey. Locke et al [52] found that consumption of fruits and vegetables was highest in the fall harvest season.

As we assessed the consumption of three cancer-related dietary factors in this study, the risk of cancer might be underestimated. The percentages of individuals with three risk factors have increased significantly since 1998 in all age groups except for in the age group of $>$ 65 years (data not shown). For both sexes in the age group 21−29 years, notably, this percentage has increased sharply since 1998 (data not shown). However, the actual cancer risk in Koreans could be higher than shown by the results of this study, since sodium intake was not counted as a cancer-related dietary factor in this study although the mean intake of sodium in most Koreans was much higher than the intake criteria in the WCRF/AICR report.

The strength of this study is that we used nationally representative data with a large sample size, KNHANES data from 1998 to 2007−2009, spanning a period of 10 years, for analysis. We examined the intake trends for cancer-related dietary factors reported in the most recent WCRF/AICR report by chronological order. It should be noted that this study has been primarily concerned with cancer-related dietary factors that were included in goals and recommendations suggested by the WCRF/AICR. If the WCRF/AICR report is updated with more reliable research findings in the future, then consumption of other cancer-related dietary factors could be evaluated in further studies. The limitation of this study is that the KNHANES data are 1-day recall data, which do not reflect usual intakes. To overcome this limitation, new statistical methods such as the multiple source method [53] and the National Cancer Institute method [54] have recently been suggested as alternatives. However, these methods require at least 2 days' 24-hour recall data to convert 24-hour recall data into the usual intake. Thus, if the KNHANES could provide 2 days' data, cancer-related dietary factor intake might be evaluated more precisely using statistical methods. In addition, dietary factors such as selenium and quercetin could not be analyzed in this study because no food composition tables were available for these factors in Korea. Dietary supplements were also excluded because no supplement database is open to the public in Korea.

We confirmed that intakes of red meat, alcohol, and fruits and vegetables have changed toward a negative direction over 10 years, especially in the age group of 21−29 years. Overall, the percentage of individuals who did not meet the intake criteria for the three cancer-related dietary factors has increased over 10 years and was especially high in those in their 20s. Therefore, it seems necessary to monitor and educate individuals in the age group of 21−29 years, based on the consumption pattern of three cancer-related dietary factors, to reduce the risk of cancer and the increase of cancer incidence in this age group in the future.

Conflicts of interest

All authors have no conflicts of interest to declare.

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