RESEARCH ARTICLE

Diet and Cancer Risk in the Korean Population: A Meta-analysis

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Abstract

Many studies have found links between diet and cancer. The summary estimates of the association between dietary factors and cancer risk were investigated using previously reported studies of the Korean population. Gastric cancer risk was inversely associated with the high intake of soy foods [OR (95% CI): 0.32 (0.25-0.40) for soybean, 0.56 (0.45-0.71) for soybean curd, and 0.67 (0.46-0.98) for soymilk], allium vegetables [OR (95% CI): 0.37 (0.26-0.53) for green onion, 0.54 (0.40-0.73) for garlic, and 0.54 (0.35-0.85) for onion], fruits [OR (95% CI): 0.61 (0.42-0.88)], and mushrooms [OR (95% CI): 0.43 (0.21-0.88)]. Salt and Kimchi were associated with an increased gastric cancer risk [OR (95% CI): 1.92 (1.52-2.43) and 2.21 (1.29-3.77), respectively]. Colorectal cancer risk was positively associated with meat intake [OR (95% CI): 1.25 (1.15-1.36)]. Total soy products, soybean curd, and soymilk showed an inverse association with breast cancer risk [OR (95% CI): 0.61 (0.38-0.99), 0.47 (0.34-0.66), and 0.75 (0.57-0.98), respectively]. Green/yellow and light colored vegetables were associated with a reduced risk of breast cancer [OR (95% CI): 0.34 (0.23-0.49) and 0.44 (0.21-0.90), respectively]. Mushroom intake was inversely associated in pre-menopausal women only [OR (95% CI): 0.47 (0.26-0.86)]. In conclusion, soy foods, fruits and vegetables might reduce cancer risk in the Korean population. High salt food might be risk factor for gastric cancer, and intake of high amount of meat might cause colorectal cancer.

Keywords: Korean - diet - cancer - soy foods - fruits and vegetables - meat

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Introduction

Cancer is a leading cause of death in Korea. The age-standardized incidence and mortality rates in 2011 were 299.8 and 91.8 per 1,000,000 persons, respectively (Jung et al, 2014a); estimated incidence and mortality rates predict that the cancer burden will increase as the population ages (Jung et al, 2014b). Various food types and their nutrients are closely linked to human diseases including cancer. According to the World Cancer Research Fund (WCRF), fruits and vegetables protect against various types of cancer, and red and processed meats and salty food are causes of cancer (WCRF, 2007). Non-starchy vegetables are associated with cancers of the mouth, pharynx, and larynx, and esophagus and stomach, while allium vegetables are associated with stomach cancer. Garlic is associated with colorectal cancer, and fruits are associated with cancers of the mouth, pharynx, and larynx, and those of the esophagus, lung, and stomach. Red meats and processed meats are a convincing cause of colorectal cancer, while milk most likely protects against colorectal cancer. Salt and salted foods are a probable cause of gastric cancer, and Cantonese-style salted fish is a probable cause of nasopharyngeal cancer.

The cancer incidence rates differ among countries (Ferlay et al, 2014). High incidence rates of breast cancer have been observed in Europe and North America; in contrast, Eastern Asia has a very low incidence rate of breast cancer, but the incidence rate of colorectal cancer is increasing rapidly and the incidence rate of gastric cancer is very high. Dietary factors as well as other lifestyle and environmental factors might be responsible for these large discrepancies across countries.

We have previously reviewed studies of cancer epidemiology that have focused on dietary factors for Korean populations (Woo and Kim, 2011). Various food types were tested to find the association with cancer risk. In this study, we aim to calculate the summary estimates of each dietary factor on cancer risk using previously reported studies in the Korean population.

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Materials and Methods

Study selection

A systematic search for studies was performed using KMBase, KoreaMed, and PubMed with the keywords '(Korean or Korea) and (food or diet or intake or nutrition) and cancer risk' up to June 20, 2014. We also reviewed the references cited in the articles to identify additional studies for inclusion. The inclusion/exclusion criteria were as follows: (1) original articles with a case-control or cohort design; (2) articles reporting on cancer risk and diet in the Korean population; (3) studies reporting adjusted odds ratios (OR) or relative risks (RR) with 95% confidence intervals (CI) for the risk of cancer in subjects with the highest category of food intake compared with those with the lowest food intake; and (4) in cases of multiple publications drawn from studies of the same population, only the most recent study was included.

Data collection

Data on authors, publication year, study design, types of diet, cancer type, number of cases and controls, and adjusted OR/RR and 95% CI were collected for the meta-analysis. The multivariate-adjusted values for the OR/RR and 95% CI were selected for the meta-analysis to reduce the effects of potential confounding variables. Studies that reported subgroup-only analyses were excluded except for those that categorized by sex, which are totally independent of each other.

Statistical analysis

All statistical analyses were performed using the STATA software package (version 12; Stata Corp, College Station, TX, USA). Log point effect estimates and the corresponding standard errors were calculated using the covariate-adjusted point effect estimates and 95% CI from selected studies and were weighted by the inverse variance to calculate the summary estimates. The heterogeneity across studies was measured using the Q-test based on the $\chi 2$ statistic. Heterogeneity was considered statistically significant when $p < 0.1$ for the Q-test and was quantified using the I2 test. Based on the heterogeneity of the included studies, fixed or random effects models were selected to calculate the pooled effect measures.

Results

Various diets among the Korean population have been studied for the risk of gastric (10 studies) (Kim et al, 2002; Ko et al, 2013; Ko et al, 2009; Lee et al, 1995; Lee et al, 2003a; Nan et al, 2005; Park et al, 1998; Park et al, 2000; Wie et al, 2014; Zhang et al, 2009), colorectal (5 studies) (Ahn et al, 2006; Kim et al, 2011; Kim et al, 2003; Lee et al, 2005; Oh et al, 2005) and breast cancer (10 studies) (Cho et al, 2010; Do et al, 2007; Hong et al, 2008; Kim et al, 2009; Kim et al, 2008; Lee et al, 2007; Lee et al, 2004; Lee et al, 2003b; Shin et al, 2010; Yu et al, 2010) (Tables 1-3); the studied diet types have been mostly soy products, fruits, and vegetables. A limited number of studies were conducted for each diet. The diets that were reported in more than 2 studies were combined to estimate the summary effect.

Table 4 shows the summary estimates of the cancer risk in the group with the highest food intake compared to the group with the lowest food intake. In the summary estimates, the subjects with the highest intake of soybean curd, soybean, and soymilk had a significantly lower gastric cancer risk compared to the subjects with the lowest dietary intake [OR (95% CI): 0.32 (0.25-0.40), 0.56 (0.45-0.71), and 0.67 (0.46-0.98), respectively]. High allium intake was inversely associated with gastric cancer risk [OR (95% CI): 0.37 (0.26-0.53) for green onion, 0.54 (0.40-0.73) for garlic, and 0.54 (0.35-0.85) for onion]. Fruits and mushrooms were associated with a reduced risk of gastric cancer [OR (95% CI): 0.61 (0.42-0.88) and 0.43 (0.21-0.88), respectively]. However, high salt foods were mostly associated with an increased risk of gastric cancer. Salt and Kimchi intake were associated with an increased gastric cancer risk [OR (95% CI): 1.92 (1.52-2.43) and 2.21 (1.29-3.77), respectively]. Soybean paste, a kind of salty condiment, and soybean paste stew showed non-significant positive associations with gastric cancer risk.

Meat, soybean, and vegetables were tested in studies of colorectal cancer risk. Meat intake was associated with an increased colorectal cancer risk [OR (95% CI): 1.25 (1.15-1.36)], while vegetables and soybeans were not associated with colorectal cancer risk.

Soy foods, which are closely related with breast cancer risk, were associated with reduced breast cancer risk. Total soy products, soybean curd, and soymilk were inversely associated with breast cancer risk in the summary estimates [OR (95% CI): 0.61 (0.38-0.99), 0.47 (0.34-0.66), and 0.75 (0.57-0.98), respectively]. However, legumes did not show a significant association with breast cancer. Vegetables were mostly associated with a reduced risk of breast cancer. Green/yellow and light colored vegetables were associated with a reduced risk of breast cancer [OR (95% CI): 0.34 (0.23-0.49) and 0.44 (0.21-0.90), respectively]. Mushroom intake was inversely associated in pre-menopausal women only [OR (95% CI): 0.47 (0.26-0.86)].

Discussion

The effects of dietary factors on cancer risk were estimated by pooling the estimates of the reported observational studies in the Korean population. The most frequently studied food types were soy foods, fruits, and vegetables. The cancer types studied were gastric, colorectal and breast. Soy foods, fruits and vegetables including allium vegetables were associated with a reduced risk of gastric cancer, but high salt and high salt containing food intake was mostly associated with an increased risk of gastric cancer. Colorectal was the least studied cancer type in association with food. Meat intake was positively associated with colorectal cancer risk. Similar to gastric cancer, soy foods, fruits and vegetables showed protective effects against breast cancer, but no food items were positively associated with breast cancer risk.

Gastric cancer was the most commonly developed

Table 1. List of Included Studies for the Meta-Analysis on Gastric Cancer and Diet in Korean

First author (year)	Study Period	Study type	Case No.	Control No.	Food	Category	OR (95% CI)	Confounding variables considered
Lee JK 1995	1990-1991	CC (hospital-based)	213 132 (m) 81 (f)	213 132 (f) 81 (f)	Soybean curd (tofu)	< 4,5/y 1~3/m ≥2,3/wk	1 0.5 (0.1 - 1.5) 0.2 (0.1 - 0.8)	Adjusted for age, sex, education, economic status
					Soybean paste stew	1~3/m ≥ 2,3/wk	1 5.5 (2.5 - 12.1)	
					Fresh vegetables	T1 T2 T3	1 1.1 (0.7 - 1.9) 1.2 (0.8 - 1.9)	
					Pickled vegetables	T1 T2 T3	1 2.9 (1.6 - 5.2) 3.8 (2.3 - 6.5)	
Park HS 1998	1996	CC (hospital-based)	126 87 (m) 39 (f)	234 135 (m) 99 (f)	Soybean curd (tofu)	≤ 2,3/m 1,2/wk ≥ 3/wk	1 0.7 (0.4 - 1.2) 0.3 (0.2 - 0.7)	Adjusted for age, sex, education, economic status, residence
					Soymilk	≤ 4~6/y ≥ 1/m	1 0.8 (0.5 - 1.4)	
					Soybean paste	≤ 1/wk ≥ 2/wk	1 0.8 (0.5 - 1.2)	
					Soybean paste stew	≤ 1/wk ≥ 2/wk	1 0.8 (0.4 - 1.7)	
					Garlic	low/inter high	1 0.6 (0.4 - 0.9)	
					Green onion	low/inter high	1 0.5 (0.3 - 0.7)	
					Onion	low/inter high	1 0.7 (0.4 - 1.1)	
					Kimchi	< 1/day ≥ 1/day	1 1 (0.3 - 3.6)	
					Total fruits	≤ 2,3/m 1,2/w ≥ 3/w	1 0.4 (0.2 - 0.8) 0.4 (0.2 - 0.7)	
					Mushrooms	≤ 4~6/y ≥ 1/m	1 0.3 (0.2 - 0.7)	
					Salt	low/inter high	1 1.3 (0.8 - 2.2)	
					Salted fish	≤ 4~6/y ≥ 1/m	1 0.7 (0.4 - 1.3)	
					Total meat	≤ 2,3/m 1,2/w ≥ 3/w	1 0.4 (0.2 - 0.7) 0.3 (0.1 - 0.5)	
					Seaweed	≤ 4~6/y ≥ 1/m	1 0.8 (0.5 - 1.3)	
Park JW 2000	1997-1999	CC (hospital-based)	204	204	Soybean curd (tofu)	< 1/m 1-3/m ≥ 1/wk	1 0.71 (0.43 - 1.18) 0.51 (0.30 - 0.89)	Matched by age and sex
					Soybean paste stew	< 4/m 1-6/wk ≥ 1/d	1 1.37 (0.76 - 2.48) 2.73 (1.34 - 5.56)	
					Onion	< 1/m 1-3/m ≥ 1/wk	1 0.54 (0.34 - 0.87) 0.34 (0.16 - 0.74)	
					Welsh (green) onion	< 1/m 1-3/m ≥ 1/wk	1 0.24 (0.14 - 0.41) 0.28 (0.17 - 0.46)	
					Garlic	< 1/m 1-3/m ≥ 1/wk	1 0.81 (0.51 - 1.27) 0.43 (0.23 - 0.80)	
					Seaweed	< 1/m 1-3/m ≥ 1/wk	1 0.75 (0.47 - 1.20) 0.52 (0.29 - 0.94)	
Kim HJ 2002	1997-1998	CC (hospital-based)	136	136	Soybean products	Q1 Q2-Q3 Q4	1 0.81 (0.46 - 1.42) 0.35 (0.16 - 0.75)	Adjusted for age, sex, socioeconomic status, family history and refrigerator use
					Soymilk	Q1 Q2-Q3 Q4	1 0.72 (0.26 - 1.98) 0.50 (0.27 - 0.93)	
					Total vegetables	Q1 Q2-Q3 Q4	1 0.43 (0.23 - 0.80) 0.64 (0.31 - 1.32)	
					Raw vegetables	Q1 Q2-Q3 Q4	1 0.61 (0.34 - 1.09) 0.55 (0.28 - 1.09)	
					Garlic	Q1 Q2-Q3 Q4	1 0.50 (0.27 - 0.91) 0.53 (0.27 - 1.02)	
					Salted vegetables	Q1 Q2-Q3 Q4	1 0.91 (0.51 - 1.63) 1.48 (0.76 - 2.88)	
					Fruits	Q1 Q2-Q3 Q4	1 0.86 (0.48 - 1.55) 0.67 (0.33 - 1.39)	
					Mushroom	Q1	1	

						Q2-Q3	0.38 (0.21 - 0.66)	
						Q4	0.30 (0.15 - 0.62)	
					Salted fishes and shellfishes	Q1	1	
						Q2-Q3	0.83 (0.46 - 1.50)	
						Q4	0.78 (0.39 - 1.56)	
					Milk and milk products	Q1	1	
						Q2-Q3	0.75 (0.42 - 1.35)	
						Q4	0.68 (0.34 - 1.36)	
Lee SA 2003a	1999	CC (hospital-based)	69	199	Soybean curd (tofu)	< 1/m	1	Adjusted for age, sex, education, family history of gastric cancer, smoking, drinking, and H. pylori infection
						≥ 1/m	0.30 (0.20 - 0.80)	
					Raw vegetables	< 4/wk	1	
						4-6/wk	0.20 (0.10 - 0.50)	
						> 6/wk	0.20 (0.10 - 0.50)	
					Kimchi	< 2/d	1	
						≥ 2/d	1.90 (1.30 - 2.80)	
					Fruits	< 3/wk	1	
						3-5/wk	0.40 (0.20 - 1.10)	
						> 5/wk	0.30 (0.10 - 0.70)	
					Salt fermented fish	< 1/m	1	
						≥ 1/m	2.40 (1.00 - 5.70)	
Nan HM 2005	1997-2003	CC (hospital-based)	421	632	Fresh vegetables	≤ 50%	1	Adjusted for age and sex
						> 50%	0.92 (0.72 - 1.17)	
Ko KP 2009	1993-2004	CC (community-based)	84	336	Soybean products	≤ 3-4/m	1 (recalculated)	Matched and adjusted for age, sex, residence area, and the year of recruitment
						≥ 3-4/wk	0.56 (0.26 - 1.11)	
Zhang YW 2009	2000-2005	CC (hospital-based)	471	471	Soybean paste	≤ 50%	1	Matched by age, sex
						> 50%	1.63 (1.24 - 2.14)	Adjusted for energy intake
					Nonfermented soybean foods	≤ 50%	1	
						> 50%	0.57 (0.43 - 0.75)	
					Sodium	≤ 50%	1	
						> 50%	2.14 (1.61-2.84)	
					Kimchi	≤ 50%	1	
						> 50%	3.27 (2.44 - 4.37)	
					Nonfermented seaweeds	≤ 50%	1	
						> 50%	0.78 (0.60-1.03)	
Ko KP 2013	1993-2004	Cohort Until Dec 31, 2008 8.5 y follow-up (mean)	166	9724(total)	Soybean/tofu	Almost never	1	Adjusted for age, sex, cigarette smoking, body mass index, alcohol drinking, and area of residence
						1-4/m	0.92 (0.57-1.48)	
						1-4/wk	0.57 (0.34-0.98)	
						≥ 1/d	0.68 (0.38-1.21)	
					Soybean paste	Almost never	1	
						1-4/m	1.93 (0.40-9.31)	
						1-4/wk	1.70 (0.41-7.06)	
						≥ 1/d	2.01 (0.52-8.5)	
					Vegetables	Almost never	1	
						1-4/m	0.80 (0.28-2.29)	
						1-4/wk	0.66 (0.25-1.7)	
						≥ 1/d	0.68 (0.27-1.68)	
					Fruit	Almost never	1	
						1-4/m	1.12 (0.58-2.18)	
						1-4/wk	1.42 (0.75-2.68)	
						≥ 1/d	1.10 (0.55-2.22)	
					Mushrooms	Almost never	1	
						1-4/m	1.10 (0.79-1.54)	
						1-4/wk	0.67 (0.37-1.22)	
						≥ 1/d	1.15 (0.46-2.84)	
					Salted fish	Almost never	1	
						1-4/m	0.89 (0.60-1.32)	
						1-4/wk	0.90 (0.58-1.39)	
						≥ 1/d	1.24 (0.58-2.64)	
					Meat	Almost never	1	
						1-4/m	1.40 (0.85-2.29)	
						1-4/wk	1.05 (0.60-1.84)	
						≥ 1/d	0.88 (0.30-2.6)	
					Seaweed	Almost never	1	
						1-4/m	1.17 (0.75-1.84)	
						1-4/wk	1.27 (0.80-2.03)	
						≥ 1/d	1.50 (0.82-2.76)	
					Dairy products	Almost never	1	
						1-4/m	1.15 (0.78-1.7)	
						1-4/wk	1.25 (0.82-1.92)	
						≥ 1/d	1.30 (0.83-2.06)	
Wie KA 2014	2004-2008	Cohort Until Sept 24, 2013 7 y follow-up (median)	46	8071(total)	Na (g/d)	< 4	1	Adjusted for age, sex, energy intake, BMI, physical activity, smoking, alcohol use, income, education and marital status.
						≥ 4	2.34 (1.05-5.19)	

*CC: case-control, T:tertile, Q:quartile

cancer, followed by colorectal and lung cancer in Korean males in 2011; the leading primary cancers in Korean females were thyroid, breast, and colorectal cancer (Jung et al, 2014a). Among the leading cancer types, gastric, colorectal, and breast, which are more likely to be associated with diet, were frequently reported in the Korean diet-cancer association studies. Diet has been considered to play a major role in disease incidence and prognosis including cancer (Willett, 2000; Zeng et al, 2013). Thus the effects of dietary factors on cancer risk have been extensively studied worldwide. However, food consumption varies across countries due to cultural

Table 2. List of Included Studies for the Meta-Analysis on Colorectal Cancer and Diet in Korean

First author (year)	Study Period	Study type	Case No.	Control No.	Food	Category	OR (95% CI)	Confounding variables considered
Kim JI 2003	Not Specified	CC (community-based)	125	247	Soybean products	< 3/wk	1	Matched by age and sex
						> 3/wk	1.11 (0.70 - 1.75)	
					Vegetables	Low	1	
						High	0.80 (0.49 - 1.31)	
					Meat	< 2 /wk	1	
						> 2 /wk	1.72 (1.12 - 2.76)	
Lee SY 2005	1994-1995	CC (hospital-based)	162	2576	Soybeans (m)	Q1	1	Adjusted for age, smoking, alcohol, education, and total energy intake
			86(m)	899(m)		Q2-Q3	0.75 (0.39 - 1.44)	
			76(f)	1677(f)		Q4	0.54 (0.22 - 1.36)	
					Soybeans (f)	Q1	1	
						Q2-Q3	1.20 (0.58 - 2.48)	
						Q4	1.36 (0.54 - 3.42)	
Oh SY 2005	-	CC (hospital-based)	136	134	Vegetables	< 130	1	Adjusted for age, body mass index, alcohol drinking, and area of residence
						130-221.4	0.45 (0.23-0.88)	
						> 221.4	0.30 (0.15-0.62)	
Ahn EJ 2006	2003-2005	CC (hospital-based)	113	110	Meat	0 /m	1	None
			65(m)	51(m)		< 12 /m	1.2 (0.5 - 2.8)	
			48(f)	59(f)		≥ 12/m	1.7 (0.7 - 4.2)	
Kim J 2011	1996-1997	Cohort 7 y follow-up	6,444	2,241,685	Meat	≤ 1/wk	1	Adjusted for age, sex, BMI, smoking habits, alcohol consumption, physical activity, and family history of cancer
						2–3/wk	1.06 (1.01 - 1.12)	
						≥ 4/wk	1.23 (1.13 - 1.35)	

*CC: case-control, Q: quartile

Table 3. List of Included Studies for the Meta-Analysis on Breast Cancer and Diet in Korean

First author (year)	Study Period	Study type	Case No.	Control No.	Food	Category	OR (95% CI)	Confounding variables considered
Lee SA 2003b	1995-2002	CC (hospital-based)	1063	1002	Fish	<1/wk	1	Adjusted for age, BMI, and family history.
						≥ 1/wk	1.5 (1.2 - 1.9)	
					Seaweed	<1/wk	1	
						≥ 1/wk	0.7 (0.5 - 1.0)	
					Pulse	<1/d	1	
						≥ 1/d	0.8 (0.6 - 1.1)	
					Milk	<1/d	1	
						≥ 1/d	0.9 (0.8 - 1.2)	
Lee SA 2004	1994-1998	CC (hospital-based)	189	189	Green vegetable	< 1/wk	1	Matched by age
						≥1/wk	0.3 (0.2 - 0.6)	
					White vegetable	< 1/wk	1	Adjusted for education, BMI, and family history of breast cancer
						≥1/wk	0.3 (0.1 - 0.7)	
					Fruits	< 1/wk	1	
						≥1/wk	1.0 (0.6 - 1.7)	
					Mushroom	< 1/wk	1	
						≥1/wk	0.4 (0.3 - 0.7)	
Do MH 2007	1999-2003	CC (hospital-based)	359	708	Total soy foods (g/d)	<6.82	1	Matched by age, sex, and menopausal status
						6.82-16.18	0.73 (0.42 - 1.26)	
						16.18-28.81	0.79 (0.47 - 1.36)	
						>28.81	0.70 (0.37 - 1.19)	Adjusted for age, education, income, age at menarche, parity, age at first live birth, history of breastfeeding, use of hormones, family history of breast cancer, first-degree relative frequency of exercise, physical activity, cigarette smoking, and alcohol consumption
					Soybean (g/d)	<0.31	1	
						0.31-1.62	0.79 (0.50 - 1.40)	
						1.62-3.03	0.63 (0.41 - 0.84)	
						>3.03	0.67 (0.45 - 0.91)	
					Soy milk (g/d)	<0.31	1	
						0.31-1.75	0.73 (0.48 - 1.38)	
						1.75-3.12	0.81 (0.52 - 1.4)	
						>3.12	0.76 (0.56 - 1.33)	
					Soybean curd (g/d)	< 5.10	1	
						5.10-9.68	0.75 (0.56 - 1.27)	
						9.68-14.39	0.80 (0.52 - 1.38)	
						>14.39	0.71 (0.41 - 1.15)	
					Soybean paste (g/d)	< 1.82	1	
						1.82-5.38	0.79 (0.49 - 1.39)	
						5.38-9.24	0.69 (0.39 - 1.09)	
						>9.24	0.71 (0.54 - 1.30)	
					Fruits (g/d)	<82.28	1	
						82.28-152.81	0.81 (0.51 - 1.35)	
						152.81-192.01	0.71 (0.41 - 1.15)	
						>192.01	0.79 (0.52 - 1.32)	
					Total vegetables (g/d)	<65.49	1	
						65.49-32.56	0.7 (0.4 - 1.19)	
						132.56-93.24	0.84 (0.44 - 1.39)	
						>193.24	0.76 (0.46 - 1.23)	
Lee EJ 2007	2004-2005	CC (hospital-based)	103(f)	159(f)	Legume	≤ 1/wk	1	Matched by age, menopausal status.
			57(pre)	87(pre)		2-3/wk	0.69 (0.33 - 1.42)	
			46(post)	72(post)		1/d	1.23 (0.60 - 2.51)	
					(pre)		1	Adjusted for BMI, residence, occupation, family history, delivery miscarriage, breast feeding, periods of breast feeding, HRT, energy. intake
							0.61 (0.21 - 1.79)	
							0.96 (0.33 - 2.74)	
					(post)		1	
							0.85 (0.30 - 2.42)	
							0.97 (0.35 - 2.68)	

					Fruits	≤ 1/wk	1	(pre) residence, occupation, income,
						2-3/wk	0.61 (0.26 - 1.46)	delivery, miscarriage, breastfeeding,.
						1/d	0.37 (0.15 - 0.90)	periods of breast feeding, HRT,
					(pre)		1	energy intake.
							0.50 (0.12 - 2.03)	
							0.24 (0.06 - 1.01)	
					(post)		1	
							0.43 (0.12 - 1.56)	(post) BMI, family history, delivery,
							0.32 (0.08 - 1.18)	miscarriage, HRT, energy intake.
					Green-yellow colored	≤ 1/wk	1	
					vegetable	2-3/wk	0.88 (0.28 - 2.78)	
						1/d	0.83 (0.26 - 2.68)	
					(pre)		1	
							0.56 (0.10 - 3.28)	
							0.47 (0.08 - 2.87)	
					(post)		1	
							3.17 (0.41 - 24.19)	
							3.98 (0.5 - 32.07)	
					Light color vegetable	≤ 1/wk	1	
						2-3/wk	1.12 (0.43 - 3.95)	
						1/d	0.58 (0.22 - 1.53)	
					(pre)		1	
							1.19 (0.23 - 6.23)	
							0.62 (0.11 - 3.35)	
					(post)		1	
							1.08 (0.30 - 3.92)	
							0.55 (0.15 - 1.98)	
					Mushroom	≤ 1/wk	1	
						2-3/wk	1.00 (0.55 - 1.81)	
						1/d	1.11 (0.35 - 3.59)	
					(pre)		1	
							1.41 (0.54 - 3.69)	
							1.48 (0.27 - 8.23)	
					(post)		1	
							0.84 (0.35 - 1.99)	
							1.06 (0.15 - 7.67)	
					Seaweed	≤ 1/wk	1	
						2-3/wk	0.95 (0.52 - 1.74)	
						1/d	0.87 (0.33 - 2.34)	
					(pre)		1	
							1.64 (0.62 - 4.30)	
							4.60 (0.90 - 23.63)	
					(post)		1	
							0.85 (0.30 - 2.42)	
							0.97 (0.35 - 2.68)	
					Milk, Yogurt	≤ 1/wk	1	
						2-3/wk	0.69 (0.36 - 1.30)	
						1/day	1.19 (0.52 – 2.70)	
					(pre)		1	
							0.31 (0.12 - 0.83)	
							0.32 (0.08 - 1.24)	
					(post)		1	
							1.20 (0.46 - 3.03)	
							2.50 (0.77 - 8.45)	
					White flesh fish	≤ 1/wk	1	
						2-3/wk	0.99 (0.54 - 1.81)	
						1/day	1.64 (0.52 - 5.16)	
					(pre)		1	
							1.37 (0.53 - 3.57)	
							5.05 (0.43 - 60.07)	
					(post)		1	
							0.54 (0.21 - 1.34)	
							1.24 (0.29 - 5.32)	
					Blue flesh fish	≤ 1/wk	1	
						2-3/wk	1.32 (0.74 - 2.36)	
					(pre)		1	
							1.49 (0.62 - 3.57)	
					(post)		1	
							1.05 (0.45 - 2.46)	
Hong SA	2004-	CC	362	362	Mushroom	0 (0 - 0.53)	1	Matched by age and menopausal
2008	2006	(hospital-based)			(g/d)	2.45 (0.69 - 2.80)	0.48 (0.28 - 0.81)	status
					median (min-max)	4.9 (3.23 - 5.60)	0.53 (0.30 - 0.92)	
						9.8 (6.57 - 13.8)	0.64 (0.34 - 1.18)	Adjusted for education, family
						18.3 (15.1 - 245)	0.55 (0.33 - 0.94)	history of breast cancer, regular
					(pre)	0 (0 - 1.05)	1	exercise, BMI, current smoker,
						2.8 (1.17 - 2.80)	0.38 (0.18 - 0.80)	current drinker, current multivitamin
						4.9 (3.23 - 5.60)	0.51 (0.24 - 1.10)	supplement, number of children,
						15.1 (7.53 - 15.1)	0.60 (0.30 -1.23)	energy
						30.1 (17.5 - 210)	0.44 (0.19 - 1.00)	
					(post)	0 (0 - 0)	1	
						1.85 (0.69 - 2.45)	0.88 (0.24 - 3.21)	
						3.23 (2.80 - 5.02)	0.20 (0.05 - 0.71)	
						7.96 (5.60 - 13.8)	0.44 (0.14 - 1.38)	
						15.1 (15.1 - 245)	0.16 (0.04 - 0.54)	
Kim MK	2004-	CC	362	362	Tofu	<7.73	1	Matched by age and menopausal
2008	2006	(hospital-based)			(g/d)	7.74-14.39	0.68 (0.39 - 1.18)	status
						14.40-23.59	0.54 (0.31 - 0.93)	

						23.6-49.49	0.46 (0.27 - 0.79)	Adjusted for drinking, multivitamin use, number of children, breast feeding, and quintile of carbohydrate intake, dietary factors (quintiles of energy, vitamin E, and folate)
						≥ 49.5	0.31 (0.17 - 0.57)	
					(pre)		1	
							0.58 (0.28 - 2.21)	
							0.33 (0.16 - 0.68)	
							0.31 (0.15 - 0.66)	
							0.23 (0.11 - 0.48)	
					(post)		1	
							0.88 (0.32 - 2.43)	
							1.29 (0.43 - 3.86)	
							0.66 (0.25 - 1.77)	
							0.39 (0.11 - 1.90)	
Kim J 2009	2007-2008	CC (hospital-based)	358 210(pre) 148(post)	360 196(pre) 164(post)	Total fish (g/d)	<0.99	1	Adjusted for age, BMI, family history of breast cancer, supplement use, education level, occupation, alcohol consumption, smoking status, physical activity, parity, total energy intake, menopausal status, age at menarche.
						9.99-17.51	0.64 (0.38 - 1.07)	
						17.51-33.70	0.57 (0.34 - 0.95)	
						≥33.7	0.55 (0.32 - 0.96)	
					(pre)		1	
							0.57 (0.27 - 1.19)	
							0.38 (0.18 - 0.78)	
							0.49 (0.22 - 1.1)	
					(post)		1	
							0.55 (0.26 - 1.19)	
							1.02 (0.47 - 2.22)	
							0.62 (0.28 - 1.39)	
					Fatty fish	<3.42	1	
					(g/d)	3.42-<8.18	0.65 (0.39 - 1.08)	
						8.18-<15.39	0.54 (0.32 - 0.90)	
						≥15.39	0.23 (0.13 - 0.42)	
					(pre)		1	
							0.65 (0.31 - 1.35)	
							0.50 (0.25 - 0.99)	
							0.19 (0.08 - 0.45)	
					(post)		1	
							0.64 (0.31 - 1.31)	
							0.64 (0.29 - 1.42)	
							0.27 (0.11 - 0.66)	
					Lean fish	<4.63	1	
					(g/d)	4.63-<8.53	0.74 (0.43 - 1.26)	
						8.53-<15.27	0.61 (0.36 - 1.04)	
						≥15.27	1.21 (0.72 - 2.04)	
					(pre)		1	
							0.86 (0.42 - 1.78)	
							0.60 (0.29 - 1.22)	
							1.22 (0.58 - 2.57)	
					(post)		1	
							0.43 (0.19 - 0.98)	
							0.50 (0.22 - 1.16)	
							1.02 (0.47 - 2.21)	
Cho YA 2010	2007-2008	CC (hospital-based)	358 210(pre) 148(post)	360 196(pre) 164(post)	Total soy products (g/d)	<45.7	1	Matched by age
						45.7-75.1	0.58 (0.36 - 0.94)	
						75.1-122.2	0.64 (0.39 - 1.05)	Adjusted for BMI, family history of breast cancer, current use of dietary supplements, education, occupation, smoking, alcohol intake, physical activity, menopausal status (if applicable), age at menarche, parity, total energy intake and postmenopausal hormone use for postmenopausal women.
						≥ 122.2	0.36 (0.2 - 0.64)	
					(pre)		1	
							0.73 (0.38 - 1.39)	
							0.59 (0.3 - 1.18)	
							0.77 (0.35 - 1.7)	
					(post)		1	
							0.41 (0.19 - 0.89)	
							0.7 (0.33 - 1.45)	
							0.08 (0.03 - 0.22)	
					Legume	<1.1	1	
					(g/d)	1.1-2.0	0.63 (0.37 - 1.09)	
						2.0-4.4	0.74 (0.44 - 1.25)	
						≥ 4.4	1.41 (0.85 - 2.36)	
					(pre)		1	
							0.54 (0.27 - 1.09)	
							0.99 (0.48 - 2.05)	
							1.68 (0.83 - 3.38)	
					(post)		1	
							0.66 (0.27 - 1.59)	
							0.59 (0.26 - 1.33)	
							0.91 (0.42 - 2)	
					Tofu	<1.1	1	
					(g/d)	1.1-2.0	0.72 (0.44 - 1.17)	
						2.0-4.4	0.67 (0.41 - 1.11)	
						≥ 4.4	0.45 (0.26 - 0.77)	
					(pre)		1	
							0.9 (0.46 - 1.75)	
							0.79 (0.4 - 1.56)	
							0.74 (0.35 - 1.56)	
					(post)		1	
							0.52 (0.25 - 1.11)	
							0.46 (0.22 - 0.97)	
							0.17 (0.07 - 0.39)	
					Fermented soy paste	<1.1	1	
						1.1-2.0	1.28 (0.79 - 2.07)	
					(g/d)	2.0-4.4	0.75 (0.45 - 1.27)	

						≥ 4.4	0.31 (0.17 - 0.56)	
					(pre)		1	
							0.92 (0.48 - 1.76)	
							0.65 (0.32 - 1.33)	
							0.47 (0.2 - 1.1)	
					(post)		1	
							1.74 (0.83 - 3.68)	
							0.64 (0.29 - 1.42)	
							0.16 (0.07 - 0.4)	
					Soy milk	<0.01	1	
					(ml/d)	0.01-0.02	1.01 (0.59 - 1.74)	
						0.02-11.2	0.65 (0.36 - 1.17)	
						≥ 11.2	0.72 (0.41 - 1.24)	
					(pre)		1	
							1.66 (0.78 - 3.51)	
							0.8 (0.35 - 1.86)	
							0.87 (0.39 - 1.92)	
					(post)		1	
							0.7 (0.31 - 1.62)	
							0.71 (0.29 - 1.72)	
							0.69 (0.31 - 1.52)	
Shin A	2007-	CC	358	360	Mushroom	<2.61	1	Matched by age
2010	2008	(hospital-based)	210(pre)	196(pre)	(g/d)	2.61-5.36	0.96 (0.57 - 1.61)	
			148(post)	164(post)		5.36-11.37	0.84 (0.48 - 1.48)	Adjusted for BMI, family history
						≥ 11.37	0.43 (0.21 - 0.88)	of breast cancer, current use of
					(pre)		1	dietary supplements, education,
							0.76 (0.36 - 1.6)	job,smoking,alcohol intake,physical
							0.76 (0.34 - 1.7)	activity, menopausal status, age at
							0.35 (0.13 - 0.91)	menarche, parity, total energy
					(post)		1	intake, and vegetable intake
							1.2 (0.54 - 2.63)	
							0.77 (0.32 - 1.81)	
							0.74 (0.23 - 2.33)	
Yu H	2007-	CC	358	360	Fruits	≤102.64	1	Matched by age
2010	2008	(hospital-based)			(g/d)	102.64-02.35	1.27 (0.79 - 2.03)	
						202.35-45.7	0.94 (0.58 - 1.55)	Adjusted for BMI, family history.
						≥345.7	0.75 (0.44 - 1.28)	of breast cancer, current use of
					(pre)		1	dietary supplements, education,
							1.73 (0.93 - 3.21)	occupation,smoking,alcohol intake,
							1 (0.52 - 1.93)	physical activity,menopausal status,
							0.83 (0.4 - 1.72)	age at menarche, total energy
					(post)		1	intake
							1.12 (0.51 - 2.44)	
							1 (0.44 - 2.26)	
							0.81 (0.34 - 1.93)	
					Total vegetables	≤182.73	1	
					(g/d)	182.73	0.94 (0.59 - 1.52)	
						270.62	1.07 (0.65 - 1.74)	
						≥410.23	0.22 (0.12 - 0.41)	
					(pre)		1	
							1.19 (0.65 - 2.2)	
							1.17 (0.62 - 2.22)	
							0.18 (0.08 - 0.43)	
					(post)		1	
							0.65 (0.28 - 1.51)	
							0.69 (0.29 - 1.62)	
							0.17 (0.06 - 0.5)	

*Pre: premenopausal, post: postmenopausal

differences and food availability. The typical Korean diet includes steam-cooked rice, soups, and side dishes consisting of vegetables, soy foods, seafood, and meat. These side dishes were often cooked with condiments containing high salts.

According to WCRF (WCRF, 2007), both fruits and vegetables (non-starchy and allium) have been shown to protect against gastric cancer, while salt and high salt foods most likely increase gastric cancer risk. Allium vegetables and fruits reduced the risk of gastric cancer in the summary estimates as has been shown in previous research. Although the pooled risks were quite low, the summary estimates of vegetable consumption were not significantly associated with a reduced risk of gastric cancer. The coverage of vegetables was somewhat different across studies, and vegetables are often consumed with high salt condiments in the Korean population. Studies that report salted vegetables separately showed a positive association with gastric cancer risk. As expected, salt intake was a strong cause of gastric cancer in summary estimates, and Kimchi also showed a strong positive association. Pickled and preserved vegetables were significantly associated with gastric and esophageal cancer in studies conducted in other Asian countries (Jakszyn and González, 2006; Jiang, 2013; Kim et al, 2010; Lin et al, 2014). It is probably because of the salt, but also because of N-Nitrosodimethylamine (Chikan et al, 2012). Limited evidence was suggested that pulses (legumes) are associated with a reduced risk of gastric cancer (WCRF, 2007). However, the summary estimates showed a significant negative association between soy food intake and gastric cancer risk in the present meta-analysis, with the exception of soybean paste, which contains high salt levels. Because soy foods are widely consumed by the Korean population, the protective effect might be easily detected. Meat intake was not significantly associated with gastric cancer risk in the summary estimates. However, charcoal broiled meat was associated with an increased risk in a study (Park et al, 1998). While red or processed meats are generally suspected to be associated with cancer

Table 4. The Summary Estimates of Diet among Korean Population and Cancer Risk[a].

	Selected		95%CI		Heterogeneity	
	Study (n)	RR	Lower	Upper	p[b]	I^2
Gastric cancer						
Soy foods						
Soybean curd (tofu)	4	0.32	0.25	0.40	0.178	39
Soybean products [c]	4	0.56	0.45	0.71	0.609	0
Soymilk	2	0.67	0.46	0.98	0.235	29.2
Fruits and vegetables						
Total vegetables	2	0.66	0.37	1.16	0.919	0
Raw vegetables	4	0.63	0.34	1.16	0	86
Allium vegetables						
Green onion	2	0.37	0.26	0.53	0.112	60.5
Garlic	3	0.54	0.40	0.73	0.68	0
Onion	2	0.54	0.35	0.85	0.132	56
Fruits	4	0.61	0.42	0.88	0.118	48.9
Mushrooms	3	0.43	0.21	0.88	0.027	72.3
High salt foods						
Salt [d]	3	1.92	1.52	2.43	0.195	38.9
Salted vegetables	2	2.44	0.97	6.13	0.027	79.6
Kimchi	3	2.21	1.29	3.77	0.025	73
Soybean paste	3	1.27	0.71	2.27	0.032	71
Soybean paste stew	3	2.26	0.75	6.82	0.001	85.4
Salted fish	4	0.98	0.70	1.39	0.103	51.6
Others						
Meat	2	0.52	0.24	1.12	0.17	46.8
Seaweed	4	0.82	0.59	1.14	0.098	52.3
Milk and milk products	2	1.07	0.74	1.57	0.124	57.7
Colorectal cancer						
Soybean	3	1.01	0.70	1.47	0.297	17.6
Total vegetables	2	0.51	0.19	1.32	0.024	80.5
Meat	3	1.25	1.15	1.36	0.256	26.7
Breast cancer						
Soy foods						
Total soy products [e]	3	0.61	0.38	0.99	0.057	65.1
Soybean curd	3	0.47	0.34	0.66	0.133	50.4
pre-menopausal	2	0.41	0.13	1.29	0.029	78.9
post-menopausal	2	0.22	0.11	0.46	0.292	9.8
Legumes	3	1.01	0.61	1.70	0.055	65.4
pre-menopausal	2	1.42	0.79	2.55	0.391	0
post-menopausal	2	0.93	0.50	1.73	0.922	0
Soymilk	2	0.75	0.57	0.98	0.869	0
Soybean paste	2	0.49	0.22	1.10	0.014	83.5
Fruits and vegetables						
Total vegetables	2	0.41	0.12	1.39	0.002	89.5
Green/yellow vegetables	2	0.34	0.23	0.49	0.105	62
Light colored vegetables	2	0.44	0.21	0.90	0.378	0
Fruits	4	0.78	0.60	1.01	0.314	15.6
pre-menopausal	2	0.63	0.33	1.21	0.121	58.5
post-menopausal	2	0.62	0.30	1.30	0.266	19.2
Mushroom	4	0.45	0.36	0.57	0.308	16.7
pre-menopausal	3	0.47	0.26	0.86	0.348	5.2
post-menopausal	3	0.47	0.21	1.05	0.168	43.9
Fish						
Total fish	2	0.94	0.35	2.50	0.001	91.1
Lean fish	2	1.27	0.79	2.05	0.636	0
pre-menopausal	2	1.37	0.67	2.80	0.279	14.6
post-menopausal	2	1.07	0.54	2.11	0.816	0
Fatty fish	2	0.55	0.10	3.05	0	94.4
pre-menopausal	2	0.53	0.07	4.00	0.001	90.7
post-menopausal	2	0.54	0.14	2.03	0.031	78.5
Others						
Seaweed	2	0.72	0.52	0.99	0.678	0
Milk and milk products	2	0.91	0.81	1.02	0.513	0

[a] Random effects model was used if $p < 0.1$ from Q-test. [b] p values for heterogeneity from Q-test. [c] 'soybean products' (Kim et al., 2002; Ko et al., 2009), 'soybean/tofu' (Ko et al., 2013), and 'nonfermented soybean foods' (Zhang et al., 2009) were included. [d] 'salt' (Park et al., 1998) and 'sodium' (Zhang et al., 2009)were included. e 'pulse' (Lee et al., 2003b), 'total soy foods' (Do et al., 2007), and 'total soy products' (Cho et al., 2010) were included.

risk, most of the selected gastric cancer studies reported total meat intake only, thus a positive association could not be found.

The positive association between meat intake and colorectal cancer risk found in the summary estimates is consistent with previous results finding that red meats and processed meats are convincing causes of colorectal cancer (WCRF, 2007). Most selected studies reported the effect of total meat intake on colorectal cancer risk, nevertheless, a strong positive association was found. The summary estimates of the effect of meat intake on colorectal cancer showed homogenous results across the studies and did not change when including Wie et al (Wie et al, 2014), which reported red meat intake only.

Breast cancer was the most frequently studied cancer type for the effects of diet on cancer risk in the Korean population. Vegetables were mostly associated with a reduced risk of breast cancer in the summary estimates, although the summary estimate of total vegetables was not significantly associated. Soy foods were suspected to be associated with a lower incidence of breast cancer in Asian populations. Soy foods were inversely associated with breast cancer risk in Asian population (Dong and Qin, 2011; Liu et al, 2014; Yamamoto et al, 2003). Isoflavones, which are abundant in soybeans, have a similar chemical structure to human estrogen. Isoflavones exert anti-estrogenic effects in a high-estrogen environment and estrogenic effects in a low-estrogen environment (Messina, 1999). Thus it was hypothesized that the effects of isoflavones on breast cancer risk might vary by menopausal status. Soybean curd showed a protective effect only in post-menopausal women in the summary estimate. Although not statistically significant, the summary estimates of legumes on breast cancer also differed by menopausal status. However, it was suggested that the inverse association between soybeans and postmenopausal women might be related to lifestyle factors (Helferich et al, 2008) and increased time of soy consumption (Korde et al, 2009).

The majority of the selected studies were case-control design, which is more likely to have selection and information bias. The case-control studies reported the protective effects of dietary factors such as fruits and vegetables against various cancers, but a prospective cohort study showed no strong relation between nutrition and cancer. Thus it was suggested that the protective effects of diet on cancer were overstated (Michels, 2005). However, the case-control studies still suggest a diet-disease relationship (Kaaks and Riboli, 2005). The cohort study (Ko et al, 2009) could not find the significant association between gastric cancer and the tested food items. However, fruit and vegetable consumption were inversely associated with gastric cancer in both case-control and cohort studies in the previous meta-analysis using studies from all countries. The relationship might be very difficult to detect if the dietary factor effect size is quite low, given the difficulties of precise dietary assessment. The major limitation of the present meta-analysis is the very limited number of selected studies covering each diet type. The summary estimates could be easily affected by one paper and the publication bias could not be tested. Thus caution should be made when interpreting the results.

In conclusion, various diets such as soy foods, fruits and vegetables were mostly associated with a reduced risk of cancer in the Korean population. Intakes of high amounts of salt and salty foods, and meat were associated with an increased risk of gastric and colorectal cancer, respectively.

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