RESEARCH COMMUNICATION

Dietary Patterns and Stomach Cancer among Middle-aged Male Workers in Tokyo

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Abstract

Many epidemiological studies have examined the associations of nutrients and foods with risk of stomach cancer. Few studies have addressed the dietary patterns that reflect various components of food consumption and their interactions. We identified major four dietary patterns; "vegetable and fruit", "Western breakfast", "meat", and "rice/snack" with principal component analysis using food consumption questionnaire in a prospective study of 5,765 middle-aged male workers in Tokyo. After 10 years of follow-up between September 1988 and August 1998, 84 incident cases of stomach cancer were documented. Using proportional hazards regression to estimate risk ratios, we found no clear association between each of dietary pattern and stomach cancer risk. After adjustment for age and other potential confounding factors and after exclusion of the cases diagnosed in first follow-up year, the risk ratio(RR) associated with high tertile compared to low tertile was 0.78(95%CI 0.42-1.44) for "vegetable and fruit" pattern and 0.71(95%CI 0.40-1.24) for "Western breakfast" pattern. The V-shaped associations between dietary patterns and stomach cancer risk were appeared in the "meat"(RR=1.00, 0.55, and 1.10) and the "rice/snack"(RR=1.00, 0.52, and 1.19) patterns, while the linear trend of these associations was statistically on borderline. The roll of overall dietary patterns in predicting stomach cancer risk requires further investigation.

Key Words: stomach cancer - cohort study - dietary pattern - principal component analysis

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Introduction

A wide variety of epidemiological investigations have revealed that dietary factors have played an important role in etiology of stomach cancer. A high consumption of vegetables and fruits was convinced to be protective, whereas a diet high in salt was probable to be associated with an increased risk of stomach cancer (World Cancer Research Fund, 1997). These associations, however, were unclear in large-scale prospective studies. A modest role of plant food in reducing the risk of stomach cancer was confirmed only in men (McCullough et al., 2001), and vegetable and fruit consumption or intake of nitrate and nitrite were not clearly associated with stomach cancer risk (Loon et al., 1998; Botterweck, van den Brandt, and Goldbohm, 1998). The results of recent prospective studies of Japanese cases indicated that, in addition to the protective role of vegetables and fruits (Kobayashi et al., 2002), soy intake might reduce the risk of stomach cancer (Nagata et al., 2002). A diet high in salt and low in vitamins, however, might be associated with the increased risk (Ngoan et al., 2002) and green tea consumption had no inverse or no clear associations (Tsubono et al., 2001a; Hoshiyama et al., 2002). In these studies, the association of diet with stomach cancer has focused on individual foods or nutrients, and few attentions have been paid to identify an eating pattern. Since nutrients are consumed through various foods, and it is difficult to identify specific effects of individual nutrients on stomach cancer due to their interactions.

In this study, we attempted to identify dietary patterns that may change stomach cancer risk using principal component analysis, which aggregates interrelated variables into several components. These components will characterize individuals with respect to combinations they eat and contribute better understanding between diet and stomach cancer.

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Materials and Methods

Study Cohort

The subjects were cohort members of the Health Insurance Society of Tokyo Stockbrokerage, the fund-based society providing medical expenses, welfare, and health promoting activities for workers employed in stockbrokerage firms in Tokyo areas. Our cohort study was started on September 1, 1988 as a part of The JACC Study, the Japan Collaborative Cohort Study for Evaluation of Cancer Risk, which is a nation-wide multicenter prospective study to evaluate various risks on cancer incidence and mortality. The aim and outline of the JACC study have been described elsewhere (Ohno, Tamakoshi, JACC Study Group, 2001). The subjects of the JACC comprised more than 200,000 inhabitants living in various parts of Japan. Most of them were living in rural areas, while our cohort members were in Tokyo and its surrounding areas. In the summer of 1988, annual health checkup was planned for 9,222 members of the society aged 40 and over. Among the eligible members, 5,765 men ages from 40 through 69 had participated in medical examinations and completed their self-recording health questionnaire. We obtained informed consent for participation with a signature on the cover page of the questionnaire. The responses to the questionnaire were ascertained and checked by health professionals at the time of examination. We excluded the subjects who had retired from their firms before the start of the study (n=8), having a past history of cancer (n=11), incomplete description of food consumption questionnaire (n=102), leaving 5,644 subjects eligible for the study.

Questionnaire and Dietary Assessment

The details of health questionnaire included frequency of consumption of selected foods, health condition, medical history, smoking and drinking habits, exercise and leisure time, places of birth, and working situation. For food frequency, subjects were asked the average consumption frequency of 33 items of food and food groups along five categories during the past two or three years. The food items were: rice; miso soup; bread; green leafy vegetables; carrot; perilla leaf; tomato; cabbage and lettuce; Chinese cabbage; wild plants; potatoes; oranges; other fruits; seaweeds; pickled vegetables; boiled beans; bean curd (raw or fried) and natto (fermented soybeans); dried or salted fish; fresh fish; eggs; milk; butter and cheese; yogurt; cookies; beef; pork; ham and sausage; chicken; organ meats; coffee; black tea; green tea; fruit juice. Five frequency categories (assumed weekly consumption) were as follows: almost everyday (6), three to four times per week (3.5), one to two times per week (1.5), one or two times per month (0.4), and rarely (0). There was no question about the usual portion size consumed in the food list. Among the food items, perilla leaf, wild plants, boiled beans, yogurt, organ meats, black tea, and green tea were excluded due to high percentage of almost everyday (green tea) and of one or two times per month or rarely (except for green tea). Finally, 26 items were used for the analysis. Eating patterns were identified using principal components analysis in the SAS program (version 8.2; SAS Institute Inc.). We selected statistically meaningful components whose eigenvalues were greater than 1.25. In addition to identifying eating patterns, the principal component scores of eating patterns were calculated for each individual.

Follow-up of the cohort and Identification of stomach cancer

We followed the subjects from September 1, 1988 through August 31, 1998. During the 10 years of follow-up, 86 incident cases of stomach cancer have been identified by one of the authors (M.T) through detailed statements of medical care which was performed for insured persons by medical care facilities. Stomach cancer was considered to be the underlying cause of death corresponding to the code of International Classification of Disease (ICD) with 151 (ICD-9) or C16 (ICD-10). Of the 86 incident cases, two cases were excluded due to incomplete information of food consumption. Finally, 84 cases in which six cases were with other cancers; colon (3), esophagus (1), liver (1), and lung (1) were used for analysis. There was no histological confirmation for each case of stomach cancer. We also identified the dates of diagnoses of cancers other than stomach, the dates of deaths other than cancers, and those of retirement from the firm. We identified a total of 310 cases of cancer, among which stomach cancer accounted for the greatest numbers, followed by colorectal (n=68) and lung (n=29) cancer.

Statistical Analysis

We calculated person-years of follow-up for each subject until the dates of the events or the end of follow-up (August 31, 1998) whichever occurred first. Those followed by the end of the study accounted for 37.8% of the subjects, leaving 3.6% for cancers other than stomach, 0.9% for death, 56.2% for retirement. Cox proportional hazard regression model was used to estimate the rate ratios (RRs) using the SAS PHREG procedure (SAS Institute, Inc., 1996). The RRs were adjusted for the following variables; age (10 years age groups), cigarette smoking (never, former current), alcohol drinking (no or current drinker), and history of peptic ulcer and family history of stomach cancer (yes or no). We made the analyses for both 84 cases of stomach cancer and those excluding 13 cases confirmed in the first year of follow-up.

Results

Principal component analysis identified four dietary patterns that explained 39% of total variance (Table1), accounting for 18%, 9%, 6%, and 6%, respectively. The first dietary pattern was labeled “vegetable and fruit” since it loaded greatly on cabbage, lettuce, green leafy vegetables, carrots, oranges and other fruits. The second dietary pattern was one in which bread, butter, cheese, hum sausage, and coffee were consumed more often in contrast to rice, seaweeds, bean curd, and pickled vegetables and was

Table 1. Principal-loading Matrix for the Four Dietary Patterns among Middle-aged Male Workers

	Component			
	1 "vegetable and fruit"	2 "Western breakfast"	3 "meat"	4 "rice/snack"
Rice		-.20		.30
Miso soup		-.27		.27
Bread		.45		
Green leafy vegetables	.26		.20	
Carrots	.26			-.25
Tomatoes	.25		-.25	
Cabbage, lettuce	.28			-.35
Chinese cabbage	.24			-.33
Potatoes	.24			
Oranges	.22			.29
Other fruit	.24		-.25	.29
Seaweeds	.23	-.24		
Pickled vegetables		-.21		
Bean curd (raw or fried), natto (fermented soybeans)	.22	-.23		
Dried or salted fish		-.21		
Fresh fish		-.20		
Eggs				
Milk				
Butter, cheese		.40		
Cookies				.37
Beef			.44	
Pork			.50	
Ham, sausage		.23	.26	
Chicken			.34	
Coffee		.22		
Fruit juice*				.32
Eigenvalue	4.75	2.39	1.68	1.32
Proportion	.18	.09	.06	.05
Cumulative	.18	.27	.34	.39

*Only in summer season
Absolute values of <.20 were excluded from the table

designated "Western breakfast". The third pattern, "meat", was one that positively loaded on pork, beef, and chicken and negatively on tomatoes and other fruits. The "rice/snack" pattern, rather uneasy to interpret, was the fourth pattern in which rice, miso soup, cookies, and orange juice loaded heavily in contrast to negative levels of vegetables. Table 2 provides baseline characteristics of the subjects according to tertiles of component score in dietary patterns. Age, cigarette smoking, and alcohol drinking were significantly associated with all of the dietary patterns. The "vegetable and fruit", "Western breakfast" and "rice/snack" patterns showed a similar trend in relation to age and smoking and drinking habits. Those who had a high score on "vegetable and fruit " or "Western breakfast" or "rice/snack" pattern tended to be older and more likely to be non-smokers and non-drinkers. In addition, those who had a higher score on " vegetable and fruit" or "Western breakfast" pattern tended to have higher levels of education and greater percentage of history of peptic ulcer. On the other hand, those who had a higher score for the "meat" pattern were more likely to have greater percentage of current smokers and heavy drinkers.

Rate ratios of stomach cancer case and its 95% confidence interval (CI) according to tertiles of scores on the dietary patterns are provided in Table 3 for the whole stomach cancer cases (n=84) and the cases excluding those ascertained within the first year of follow-up (n=71). There were no clear associations between the four major dietary patterns and stomach cancer risk in both analyses. In the analysis for the whole cases, there was a suggestion of an inverse association between the "Western breakfast" pattern and stomach cancer. The RRs for the highest compared to the lowest tertile were 0.80 (95%CI 0.48-1.33) in age-adjusted and 0.77(95%CI 0.46-1.31) in multi-adjusted models, but these associations were not statistically significant. There were v-shaped associations between the "meat" and "rice/snack" patterns and stomach cancer risk, while the

Table 2. Baseline Characteristics of the Subject by Tertiles of Component Scores in Dietary Patterns

	Vegetable and fruit				Western breakfast				Meat				Rice/snacks			
	Low	Middle	High	p	Low	Middle	High	p	Low	Middle	High	p	Low	Middle	High	p
Entire cohort (%)	33.4	34.5	32.1		32.6	32.9	34.5		33.7	35.5	30.8		33.6	32.9	33.5	
Mean age (years)	50.1	51.7	53.2	<.00	51.9	50.8	52.0	<.00	53.4	51.1	50.1	<.00	51.4	51.1	52.4	<.00
Mean BMI	23.1	23.2	23.2	.57	23.4	23.2	23.0	<.00	23.2	23.2	23.2	.99	23.1	23.2	23.2	<.43
Education (% university)	58.9	62.3	64.4	.00	54.6	62.0	68.5	<.00	63.9	60.0	61.7	.04	60.3	63.0	62.4	.21
History of peptic ulcer (% yes)	17.9	20.1	22.3	.00	20.5	18.0	21.6	.02	21.5	20.3	18.2	.04	21.4	18.8	20.0	.15
Family history of* stomach cancer (% yes)	10.3	8.3	10.9	.02	10.7	8.6	10.0	.10	10.3	8.9	10.2	.25	10.0	9.4	10.0	.83
Cigarette smoking (%)																
Never	18.8	21.1	21.1		17.8	21.6	21.6		22.4	19.2	19.4		16.0	18.9	26.1	
Past	21.2	29.3	34.3		28.6	26.0	29.9		33.8	26.8	23.6		27.5	27.4	29.6	
Current	60.1	49.7	44.6	<.00	53.7	52.4	48.6	.00	43.8	54.0	57.1	<.00	56.4	53.7	44.4	<.00
Alcohol drinking(%)																
No♦	17.2	18.3	19.6		12.1	18.9	23.7		23.2	15.9	15.8		13.2	15.8	26.0	
Light❖	32.4	36.3	38.3		27.9	34.7	43.9		38.8	37.0	30.6		33.1	36.5	37.4	
Heavy⌘	50.4	45.4	42.1	<.00	60.0	46.4	32.5	<.00	38.0	47.1	53.6	<.00	53.8	47.7	36.6	<.00

*Having at least one first-degree relative with a history of stomach cancer
♦include ex-drinkers
❖alcohol consumption<30ml/day
⌘alcohol consumption_30ml/day

associations were not statistically significant. The "vegetable and fruit" pattern showed no association with stomach cancer risk.

In the analysis excluding those ascertained within the first year of follow-up, the association was similar to the estimates for the whole cases except for "vegetable and fruit" pattern in which the high tertile indicated about 20% reduction of stomach cancer risk compared to the low tertile. But this association was still not statistically significant. For the "meat" and "rice/snack" patters, the linear trend of RRs

Table 3. Rate Ratios for Stomach Cancer According to Tertiles of Dietary Pattern

	Vegetable and fruit			p for	Western breakfast			p for
	Low	Middle	High	trend	Low	Middle	High	trend
No. of cases	25	30	29		32	24	28	
No. of person years	13465	13408	11930		12585	12934	13284	
RR								
Age-adjusted	1.00	1.09 (0.64-1.85)	1.07 (0.62-1.83)	.95	1.00	0.77 (0.45-1.30)	0.80 (0.48-1.33)	.55
Multivariate-adjusted*	1.00	1.03 (0.60-1.78)	1.00 (0.58-1.74)	.99	1.00	0.80 (0.47-1.36)	0.77 (0.46-1.31)	.57
Multivariate-adjusted+	1.00	1.06 (0.61-1.87)	0.78 (0.42-1.44)	.56	1.00	0.59 (0.33-1.08)	0.71 (0.40-1.24)	.20
	Meat			p for	Rice/snack			p for
	Low	Middle	High	trend	Low	Middle	High	trend
No. of cases	31	22	31		32	17	35	
No. of person years	2368	14029	12406		13223	12756	12825	
RR								
Age-adjusted	1.00	0.71 (0.41-1.23)	1.22 (0.74-2.01)	.15	1.00	0.57 (0.31-1.02)	1.06 (0.65-1.71)	.09
Multivariate-adjusted*	1.00	0.71 (0.41-1.23)	1.20 (0.72-2.01)	.17	1.00	0.57 (0.32-1.03)	1.12 (0.68-1.82)	.07
Multivariate- adjusted+	1.00	0.55 (0.29-1.01)	1.10 (0.64-1.89)	.07	1.00	0.52 (0.27-1.01)	1.19 (0.71-2.02)	.05

RR: rate ratio, *Analyses with the all cases (n=84), adjusted for age, BMI, education, history of peptic ulcer, family history of stomach cancer, status of cigarette smoking and alcohol drinking, see Table 2 for categories. Values in parentheses are 95 % confidence intervals.
+Analyses with the cases excluding those identified within first year follow-up (n=71)

was statistically on borderline suggesting positive association of stomach cancer risk with tertiles of these patterns in spite of v-shaped associations.

Discussion

We found no clear association between four major dietary patterns and stomach cancer risk. There was nothing but a suggestion that the "vegetable and fruit" and "Western breakfast" patterns may be associated with decreased risk of stomach cancer, whereas the "meat" and "rice/snack" patterns may be associated with the increased risk. A few studies relating to the association of dietary patterns with stomach cancer indicated that the "vitamin-rich" pattern was negatively associated and the "traditional" pattern, where factors loading to total protein, starch, alcohol, and nitrate were great in Italy, and the "meat" pattern was positively associated with distal stomach cancer (Palli, Russo, and Decarli, 2001; Chen et al., 2002).

The validity of a dietary pattern analysis has been widely discussed (Martinets, Marshall, and Sechrest, 1998; Hu et al., 1999; Pryer et al. 2001; Quatromoni et al., 2001; Erickson, 2002). Some critical aspects include that labeling of the components are subjective or arbitrary and the manner in which the components are finally labeled are based on subjective criteria and are liable to different interpretations. Another question arises from that several components can explain only small percentage of total variance of food consumption. In this context, there has been no enough research for the Japanese cases analyzing cancer risk with dietary pattern. It is, however, quite interesting to note that our "vegetable and fruit", "Western breakfast" and "meat" patterns are similar to those labeled "prudent", "coffee and roll", and "Western" in US populations (Tseng and DeVallis, 2000; Slattery et al., 1998). This may imply dietary patterns in somewhat common to several populations. The "rice/snack" pattern might be distinctive for Japanese and be surrogated for "traditional" or "unbalanced" pattern (Palli, Russo, and Decarli, 2001).

The limitations of our study include the relatively small size of cohort, food consumption data in summer only, case ascertainment only through medical records provided by various clinical sites, and in consequence, no data on histological classification of stomach cancer. While the subjects were asked to respond food consumption as a yearly average, they might be confused and reported the current situation of food consumption in summer season. The food consumption data were obtained through food frequency questionnaire (FFQ) and portion size and energy intake were not available in this study. There have been several attempts to identify reproducibility and validity of FFQ (Byers, 2001; Tsubono et al., 1996; Tsubono et al., 2001b), but, unlike with the studies for the US and European populations, little attention has been paid for the effectiveness of dietary patterns. Further investigations will be required for making better use of component or factor analysis in nutritional epidemiology.

In respect to accuracy of case ascertainment, the diagnostic technique for stomach cancer has been established in Japan, particularly in large-scaled hospitals in urban areas. The subjects of this study were almost living in Tokyo area and it is unlikely to cause any bias in case ascertainment among the medical facilities. When the number of incident cases of stomach cancer in this study was compared with those figured out by the incident rate on the Osaka Cancer Registry in 1993 (Osaka Medical Center for Cancer and Cardiovascular Diseases, 1996), one of the regional cancer register systems in Japan, the number of incident cases were estimated to be 75 and this value showed no great difference from the actual one (n=86). Then we probably have no great missing cases. Among 84 stomach cancer cases, we obtained information on the presence or absence of a history of infection with Helicobacter pylori (HP) for 15 cases. We analyzed the effect of HP infection on stomach cancer with nested case-control study (Sekikawa, Masaki, and Nakamura, 1998), but no clear association was admitted.

Finally, the dietary patterns extracted by principal component analysis for Japanese yielded the patterns similar to those found in other populations. Unfortunately we did not find any significant association between dietary patterns and stomach cancer risk. While the effectiveness of factor or principal component analyses depend on their future applications, these methods may be very useful in situations where reasonable explanations with a few interpretable factors are possible (Martinez, Marshall, and Sechrest, 1998) and will advance further investigations in prediction of cancer risk.

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