RESEARCH ARTICLE

Association between Smoking Status and Food and Nutrient Consumption in Japanese: a Large-Scale Cross-Sectional Study

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Abstract

Background: In Japan, in comparison with the rest of the world the death rate of lung cancer is low although the smoking rate is relatively high. This is the so-called "Japanese smoking paradox". A healthy diet is proposed to attenuate the risk without quitting smoking. We here examined the relationships between smoking status (SS) and the consumption of food and nutrient in Japan. Materials and Methods: Totals of 5,587 men and 2,718 women were divided into three (non-smokers, smokers and heavy smokers) and two (non-smokers and smokers) groups, respectively, according to pack-year, which represents the amount of smoking over a long period. Food and nutrient consumption was estimated with a validated food frequency questionnaire. Using general linear models, food and nutrient consumption was estimated for each group in men and women, separately. Results: In men, SS was positively related to consumption of rice, 3 alcoholic beverages, carbohydrate, alcohol and other 8 foods/nutrients ($p< 0.05$ for all) and negatively to those of protein animal, fat, fatty acids, dietary fiber, isoflavones and 36 other foods/nutrients ($p<0.05$ for all). In women, SS was positively associated with intake of 13 foods/nutrients, while being negatively associated with those of rice, energy, dietary fiber, and 14 other foods/nutrients ($p<0.05$ for all). Conclusions: Our results support lower intake of vegetables and fruits rich in antioxidants, which are thought as preventive factors for many diseases, in smokers.

Keywords: Smoking status - foods and nutrients - a large-scale cross-sectional study - self-reported psychological stress

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Introduction

Smoking is a major cause of lung cancer (International Agency for Research on Cancer, 2004). To prevent tobacco epidemic, the WHO Framework Convention on Tobacco Control was adopted in 2003 (World Health Organization, 2003). However, it is suggested numbers of countries will not accomplish a 30% reduction of tobacco use until 2025 (Bilano et al., 2015). Therefore, smoking is needed to cope with the current situation globally. Dietary consumption of fruits and foods containing carotenoids have probably decreased risk of lung cancer (World Cancer Research Fund American Institute for Cancer Research, 2007). Vegetables, fruits and the related nutrients have protective effects against lifestyle related disease (LSRD) such as cardiovascular disease (Nagura et al., 2009) and diabetes mellitus (Yao et al., 2014). In Japan, the percentages of smokers are still higher, while mortality and incidence rates of lung cancer are lower in the world. It is so-called "*Japanese smoking paradox*" (Nakaji et al., 2003; Takahashi et al., 2008). Japanese diet, which is rich in vegetables and fruits, is thought as one of the reasons.

The associations between consumption of foods and nutrients and LSRD including lung cancer were adjusted for smoking status (SS) (Bellavia et al., 2013; Mursu et al., 2014). Rothman et al (Rothman et al., 2008) noted the criteria for confounding factors: 1) a confounding factor must be an extraneous risk factor for the disease, 2) a confounding factor must be associated with the exposure under study in the source population (the population at risk from which the cases are derived), and 3) a confounding factor must not be affected by the exposure or the disease. However, associations between SS and consumption of foods and nutrients have not been fully investigated in Japanese (Kato et al., 1989; Dyer et al., 2003; Sugiura et al., 2009).

In Japan, the percentage of deaths related to psychological stress including work stress, i.e. suicide was leading cause of death from 15 to 39 years old (Cabinet Office, Government of Japan, 2014). To prevent such death, employers must check psychological stress (PS) levels of their employees from December 2015 (the Ordinance on Industrial Safety and Health). Psychiatric disorders such as major depression (Wilhelm et al., 2003)

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and schizophrenia (Leon and Diaz, 2005; Shinozaki et al., 2011) are associated with smoking. PS is associated with SS. Thus, an effect on the past or present history of psychiatric disorder is needed to be considered, and PS levels are also needed to be investigated along with SS is investigated. Until now, however, psychiatric disorders and PS have not been taken into account yet (Poisson et al., 2012; Vlassopoulos et al., 2013). Therefore, in the present study, we examined the association between SS and dietary consumption of foods and nutrients in a large-scale cross-sectional study in Japan profoundly, excluding the subjects with psychiatric disorders and considering self-reported psychological stress (SRPS) as one of confounding factors.

Materials and Methods

Subjects

The examinees of a health checkup at a local health center were invited to participate as study subjects from July 2005 to March 2007. The aim of the study was explained face-to-face and written informed consent for participation in the study was obtained from 12,066 subjects. Of those subjects, after 3,761 (31.2%) were excluded, 5,587 (46.3%) men and 2,718 (22.5%) women were included in the analyses. Details of the study design and the selection of study subjects are presented in our previous studies (Mochizuki et al., 2011; Endoh et al., 2015). In brief, the study exclusion criteria were 1) age younger than 29 years old or older than 61 years old, 2) missing data on SRPS, 3) past or present history of depression or being treated with an anti-depressant or a tranquilizer, 4) total energy intake and body mass index (BMI) greater or less than 2 standard deviations from the mean, 5) no data on lifestyle factors, 6) less than 1 or over 65 hours of sleeping time per day, and 7) past or present disease history of stroke, myocardial infarction, or cancer. This study was conducted according to the guidelines of the Declaration of Helsinki and all procedures involving subjects were approved by the Ethics Committee of the University of Shizuoka.

Questionnaire and measurements

Height and weight were measured by trained staffs at a local health center. Information on age, SS (number of cigarettes smoked per day and duration of smoking),

Table 1. Characteristics of Subjects According to Smoking Status[a]

	Men				Women		
	Non-smokers (0)[b]	Smokers (0.1–45.0)[b]	Heavy smokers (≥45.0)[b]	P value	Non-smokers (0)[b]	Smokers (≥0.1)[b]	P value
	(n = 2324)	(n = 1704)	(n = 1559)		(n = 2423)	(n = 295)	
Age (years old)[c]	48.1 (47.8–48.4)	45.4 (45.0–45.7)	51.1 (45.7–51.4)	<0.001	46.6 (46.3–46.9)	45.2 (44.4–46.1)	0.005
BMI (kg/m^2)[c]	23.6 (23.5–23.7)	23.4 (23.3–23.5)	23.5 (23.4–23.6)	0.047	21.3 (21.2–21.4)	21.3 (21.1–21.6)	0.857
Energy (kcal/day)[c]	2138 (2118–2157)	2178 (2155–2201)	2131 (2107–2155)	0.009	1598 (1585–1610)	1540 (1503–1576)	0.003
Alcohol (g/1000kcal/day)[c]	11.7 (11.1–12.4)	15.5 (14.8–16.2)	18.8 (14.8–16.2)	<0.001	3.6 (3.3–4.0)	9.3 (8.3–10.3)	<0.001
Sleeping time (hours/day)[c]	6.32 (6.29–6.36)	6.36 (6.32–6.40)	6.36 (6.32–6.40)	<0.001	6.26 (6.23–6.30)	6.32 (6.22–6.42)	0.290
History of hypertension (%)							
Yes	4.5	2.6	3.1	<0.001	4.2	0.3	0.137
No	37.1	27.9	24.8		84.9	10.6	
History of diabetes mellitus (%)							
Yes	1.4	0.8	1.8	<0.001	0.9	0	0.101
No	40.2	29.7	26.1		88.2	10.9	
Habitual exercise (%)							
Yes	19.8	16.2	16.2	<0.001	40.9	4.5	0.154
No	21.8	14.3	11.7		48.3	6.4	
SRPS (%)							
Low	12.3	7.9	7.7	<0.001	21.3	2.2	0.415
Moderate	23.9	18.0	16.3		55.4	6.9	
High	5.4	4.6	3.9		12.5	1.7	

*SRPS; Self-reported psychological stress; [a]Based on the general linear model for continuous variables and chi-squared test or Fisher's exact test for categorical variables, with assignment of the ordinal numbers 0–2 for men and 0–1 for women; [b]Pack year ["number of cigarettes per day"/20 × "duration of smoking (years)"] ranges of each group are shown in parentheses.[c]Data are means (95% confidence intervals)

Table 2. Adjusted Means (95% Confidence Interval) of Foods in Men and Women with Smoking Status[a]

(g/1000 kcal/day)	Men				Women		
	Non-smokers(0)[b]	Smokers (0.1-45.0)[b]	Heavy smokers(45≤)[b]	p value	Non-smokers(0)[b]	Smokers(≥0.1)[b]	p value
	(n=2324)	(n=1704)	(n=1559)		(n=2423)	(n=295)	
Rice	209.5(206.7-212.4)	215.8(212.5-219.1)	217.0(213.5-220.5)	0.000	205.9(203.2-208.6)	203.6(195.8-211.5)	0.000
Bread	21.0(20.3-21.7)	20.5(19.6-21.3)	21.4(20.5-22.3)	0.288	28.8(28.0-29.6)	30.5(28.2-32.9)	0.272
Buckwheat noodles	15.6(14.9-16.3)	16.2(15.4-17.0)	16.5(15.7-17.4)	0.000	9.9(9.4-10.4)	10.2(8.8-11.6)	0.183
Japanese wheat noodles	13.1(12.5-13.7)	12.7(12.0-13.4)	12.4(11.7-13.1)	0.911	13.1(12.6-13.7)	11.2(9.6-12.7)	0.701
Chinese noodles	14.9(14.3-15.5)	15.2(14.5-15.9)	18.1(17.4-18.9)	0.631	9.6(9.1-10.0)	11.6(10.3-12.8)	0.015
Spaghetti and macaroni	10.3(9.8-10.7)	10.4(9.9-10.9)	10.4(9.8-10.9)	0.426	10.6(10.2-11.0)	12.5(11.3-13.7)	0.003
Chicken	306.0(297.7-314.3)	300.1(290.3-309.9)	302.8(292.4-313.2)	0.198	291.2(283.2-299.2)	291.6(268.2-315.0)	0.974
Pork and beef	13.9(13.6-14.3)	14.1(13.7-14.6)	14.5(14.0-14.9)	0.304	17.1(16.7-17.5)	18.4(17.2-19.6)	0.042
Ham, sausage, and bacon	3.6(3.5-3.7)	3.7(3.5-3.9)	3.8(3.6-3.9)	0.532	4.0(3.9-4.2)	4.3(3.9-4.7)	0.292
Liver	1.1(1.0-1.2)	1.1(1.0-1.2)	1.0(1.0-1.1)	0.323	0.9(0.8-0.9)	1.0(0.8-1.2)	0.313
Squid, octopus, shrimp, and clams	7.2(6.9-7.4)	7.0(6.7-7.2)	6.9(6.6-7.2)	0.009	6.6(6.4-6.8)	7.5(6.9-8.2)	0.007
Small fish with bones	2.5(2.4-2.6)	2.3(2.2-2.5)	2.2(2.0-2.3)	0.646	2.5(2.4-2.7)	2.3(1.9-2.7)	0.350
Canned tuna	1.5(1.4-1.6)	1.4(1.3-1.5)	1.4(1.3-1.5)	0.342	1.6(1.5-1.7)	1.6(1.4-1.8)	0.868
Dried fish and salted fish	5.7(5.5-6.0)	6.0(5.7-6.3)	5.8(5.5-6.1)	0.147	6.6(6.4-6.9)	7.1(6.4-7.8)	0.243
Oily fish	7.8(7.5-8.0)	7.6(7.3-7.9)	7.4(7.1-7.7)	0.003	8.1(7.9-8.4)	7.4(6.6-8.1)	0.064
Non-oily fish	6.8(6.6-7.1)	6.2(6.0-6.5)	6.3(6.0-6.6)	0.373	6.8(6.6-7.1)	6.9(6.1-7.6)	0.921
Low fat milk and yogurt	13.1(12.0-14.2)	13.3(12.0-14.6)	11.8(10.4-13.2)	0.000	14.5(13.2-15.8)	12.9(9.1-16.7)	0.435
Milk and yogurt	34.0(32.5-35.5)	30.6(28.8-32.4)	24.5(22.6-26.4)	0.663	49.2(47.5-51.0)	43.6(38.6-48.7)	0.040
Egg	13.7(13.3-14.1)	14.1(13.6-14.6)	14.0(13.5-14.5)	0.000	15.8(15.4-16.2)	15.9(14.7-17.1)	0.880
Tofu and Tofu products	14.1(13.7-14.5)	13.4(12.9-13.9)	12.2(11.7-12.8)	0.000	19.0(18.5-19.5)	17.2(15.8-18.6)	0.019
Natto (fermented soy beans)	5.6(5.4-5.9)	5.1(4.8-5.4)	4.2(3.9-4.5)	0.000	6.3(6.1-6.6)	5.9(5.1-6.7)	0.300
Potatoes	10.1(9.7-10.4)	9.8(9.4-10.2)	8.9(8.5-9.3)	0.299	15.5(15.1-15.9)	13.5(12.3-14.7)	0.002
Salted green and yellow vegetable pickles	3.8(3.6-4.0)	3.9(3.7-4.1)	4.0(3.8-4.2)	0.035	3.5(3.3-3.7)	4.2(3.6-4.8)	0.024
Other salted vegetable pickles (excluding salted pickled plum)	4.7(8.2-8.7)	5.1(8.1-8.6)	5.1(7.9-8.5)	0.492	5.8(5.5-6.1)	6.0(5.2-6.8)	0.606
Raw vegetables used in salad (cabbage and lettuce)	8.4(8.2-8.7)	8.3(8.1-8.6)	8.2(7.9-8.5)	0.001	10.0(9.7-10.3)	9.5(8.8-10.3)	0.254
Green leafy vegetables	12.0(11.6-12.4)	11.8(11.3-12.3)	10.8(10.3-11.3)	0.000	19.3(18.8-19.9)	19.5(17.9-21.1)	0.806
Cabbage and Chinese cabbage	12.2(11.8-12.5)	11.9(11.5-12.3)	11.8(11.4-12.2)	0.335	16.2(15.8-16.7)	16.9(15.6-18.2)	0.378
Carrots and pumpkins	4.9(4.7-5.0)	4.7(4.5-4.9)	4.3(4.2-4.5)	0.484	7.8(7.6-8.0)	7.2(6.5-7.8)	0.486
Radishes and turnips	6.5(6.3-6.8)	6.5(6.2-6.7)	6.3(6.0-6.5)	0.000	9.8(9.5-10.1)	9.6(8.7-10.5)	0.054

Other root vegetables (onions, burdock and lotus root)	246.6(238.6-254.5)	253.8(244.4-263.2)	251.7(241.8-261.7)	0.000	369.5(359.5-379.4)	347.5(318.4-376.6)	0.650
Tomatoes, tomato ketchup, boiled tomato and stewed tomato	6.9(6.6-7.2)	6.7(6.4-7.1)	5.9(5.5-6.3)	0.020	9.1(8.7-9.4)	8.1(7.1-9.1)	0.164
Mushrooms	5.4(5.2-5.6)	5.2(5.0-5.4)	4.7(4.5-5.0)	0.000	9.0(8.7-9.2)	8.0(7.3-8.7)	0.078
Seaweeds	6.3(6.0-6.5)	6.0(5.8-6.3)	5.7(5.4-6.0)	0.000	8.9(8.7-9.2)	8.0(7.2-8.8)	0.015
Citrus fruit including oranges	11.7(11.1-12.3)	11.0(10.3-11.7)	8.4(7.7-9.2)	0.000	19.0(18.1-19.9)	15.2(12.5-17.8)	0.421
Strawberries, persimmons and kiwi fruits	6.0(5.7-6.4)	5.7(5.3-6.1)	4.8(4.3-5.2)	0.398	10.3(9.7-10.9)	7.7(6.0-9.4)	0.008
Other fuits	15.6(15.0-16.3)	13.8(13.1-14.6)	12.4(11.6-13.2)	0.344	24.2(23.4-25.1)	17.4(15.0-19.9)	0.005
Cakes, cookies, and biscuits	4.8(4.6-5.0)	4.1(3.8-4.3)	4.1(3.9-4.4)	0.081	8.4(8.1-8.7)	7.7(6.8-8.6)	0.038
Japanese-style sweets	1.6(1.6-1.7)	1.5(1.4-1.6)	1.4(1.3-1.5)	0.016	2.9(2.7-3.0)	2.6(2.2-2.9)	0.156
Rice crackers, rice cakes, and Japanese-style pancakes	2.6(2.5-2.7)	2.5(2.3-2.6)	2.4(2.3-2.6)	0.000	3.9(3.7-4.0)	3.8(3.3-4.2)	0.148
Ice cream	8.7(8.2-9.2)	7.6(7.0-8.2)	8.1(7.5-8.7)	0.000	8.8(8.2-9.3)	9.5(7.8-11.1)	0.650
Mayonnaise and salad dressing	2.7(2.6-2.8)	2.8(2.7-2.9)	2.7(2.6-2.8)	0.219	3.2(3.2-3.3)	3.4(3.1-3.7)	0.000
Green tea	178.5(174.0-182.9)	178.8(173.6-184.0)	181.8(176.3-187.3)	0.000	220.5(216.0-225.1)	207.3(193.9-220.7)	0.005
Black and oolong tea (including other Chinese tea)	39.2(36.4-42.1)	37.6(34.3-41.0)	36.2(32.6-39.8)	0.080	52.7(49.4-56.1)	50.5(40.7-60.3)	0.067
Coffee	86.7(82.7-90.8)	105.0(100.3-109.8)	148.7(143.6-153.7)	0.189	89.0(85.3-92.7)	141.6(130.8-152.3)	0.673
Soda	18.4(16.9-19.8)	19.4(17.7-21.1)	21.0(19.2-22.8)	0.000	9.8(8.9-10.8)	14.4(11.8-17.1)	0.000
Fruit juice and vegetable juice	17.4(16.1-18.7)	15.5(14.0-17.1)	16.5(14.8-18.1)	0.001	15.2(14.0-16.3)	15.4(11.9-18.8)	0.002
Sake	9.7(8.2-11.2)	15.1(13.3-16.9)	16.0(14.1-17.9)	0.000	1.8(1.3-2.4)	5.2(3.6-6.9)	0.000
Beer	101.2(95.5-106.9)	118.9(112.1-125.6)	116.0(108.9-123.1)	0.000	36.7(32.5-40.9)	89.1(77.1-101.1)	0.000
Shochu and shochu mixed with water or a carbonated beverage	24.1(22.1-26.0)	33.7(31.4-36.0)	42.8(40.4-45.3)	0.373	5.9(5.0-6.9)	17.6(14.8-20.4)	0.000
Whiskey	1.6(1.1-2.0)	2.6(2.0-3.1)	3.4(2.8-3.9)	0.001	0.2(0-0.4)	1.4(0.9-1.9)	0.000
Wine	4.3(3.6-5.1)	4.1(3.2-5.0)	3.5(2.5-4.4)	0.000	5.3(4.4-6.2)	7.5(4.9-10.1)	0.119

[a]Adjusted means were adjusted for the following covariates: age, BMI, energy (kcal/day), alcohol (g/1000 kcal/day), history of hypertension and diabetes mellitus, sleeping time (hours/day), exercise (yes or no), and self-reported psychological stress (low, moderate, high); [b]Pack year ["number of cigarettes per day"/20 × "duration of smoking (years)"] ranges of each group are shown in parentheses

habitual exercise (yes or no), sleeping time (hours per day), SRPS, and history of diseases was obtained by trained medical staffs. To calculate BMI (kg/m^2), weight (kg) was divided by height (m) squared. SRPS was assessed with the following question: "*Do you feel stressed?*" The four response choices (no, little, moderate, and extreme) were classified as follows: low (n = 206 for "*no*" and n = 1,993 for "*little*"), moderate (n = 4,938 for "moderate"), and high (n = 1,168 for "*extreme*"). SS was defined in "*pack years*" ["*number of cigarettes per day*"/20 × "*duration of smoking (years)*"], which represents the amount of tobacco smoked over a long period. Considering there are fewer female smokers in Japan (Ministry of Health, Labour and Welfare 2014), subjects were also divided into three groups (non-smokers, smokers, and heavy smokers) and two SS (non-smokers and smokers) for men and women, respectively. In here, we defined heavy smokers as men with ≥45 pack years of median value of SS.

A validated food frequency questionnaire (FFQ) (Kobayashi et al., 2011; Kobayashi et al., 2012) including 58 food items was used. Based on each food consumption, intakes of total energy and 42 nutrients were calculated, and then individual food and nutrient consumption was adjusted for total energy intake (mg, μg or g/1000 kcal/

Table 3. Adjusted means (95% confidence interval) of nutrients in men and women with smoking status[a]

(g or mg/1000 kcal/day)	Men				Women		
	Non-smokers(0)[b]	Smokers (0.1-45.0)[b]	Heavy smokers(45≤)[b]	p value	Non-smokers(0)[b]	Smokers (≥0.1)[b]	p value
	(n=2324)	(n=1704)	(n=1559)		(n=2423)	(n=295)	
Energy	2152(2133-2172)	2153(2130-2176)	2136(2112-2161)	0.549	1600(1587-1613)	1518(1481-1555)	0.000
Protein	30.2(30.0-30.4)	29.9(29.6-30.1)	29.5(29.3-29.7)	0.000	33.4(33.2-33.6)	33.5(32.9-34.0)	0.785
Animal protein	15.1(14.9-15.3)	14.8(14.6-15.1)	14.5(14.3-14.8)	0.001	16.9(16.7-17.1)	17.0(16.4-17.6)	0.677
Vegetable protein	15.1(15.0-15.1)	15.0(14.9-15.1)	15.0(14.9-15.1)	0.506	16.5(16.4-16.6)	16.5(16.2-16.7)	0.681
Fat	24.0(23.8-24.2)	23.5(23.3-23.8)	23.2(22.9-23.4)	0.000	28.4(28.2-28.7)	28.6(27.9-29.2)	0.748
Animal fat	10.6(10.5-10.7)	10.4(10.2-10.5)	10.2(10.0-10.4)	0.002	12.1(12.0-12.3)	12.2(11.8-12.6)	0.663
Vegetable fat	13.4(13.3-13.6)	13.2(13.0-13.3)	13.0(12.8-13.2)	0.001	16.3(16.2-16.5)	16.3(15.9-16.8)	0.975
Carbohydrate	135.8(135.2-136.4)	137.1(136.4-137.8)	138.0(137.3-138.8)	0.000	142.4(141.8-142.9)	141.8(140.2-143.4)	0.494
Alcohol	11.8(11.2-12.4)	15.8(15.1-16.5)	18.3(17.6-19.0)	0.001	3.6(3.3-3.9)	9.4(8.4-10.4)	0.248
Protein (En%)[d]	12.1(12.0-12.1)	11.9(11.9-12.0)	11.8(11.7-11.9)	0.000	13.4(13.3-13.4)	13.4(13.2-13.6)	0.936
Fat (En%)[d]	21.6(21.4-21.8)	21.2(20.9-21.4)	20.8(20.6-21.1)	0.000	25.6(25.4-25.8)	25.5(25.0-26.1)	0.772
Carbohydrate (En%)[d]	54.3(54.1-54.6)	54.8(54.6-55.1)	55.2(54.9-55.5)	0.000	56.9(56.7-57.2)	56.9(56.2-57.5)	0.894
Alcohol (En%)[d]	8.2(7.8-8.7)	11.1(10.6-11.6)	12.8(12.3-13.4)	0.000	2.5(2.3-2.8)	6.5(5.8-7.2)	0.000
SFA	5.87(5.80-5.93)	5.65(5.58-5.73)	5.54(5.46-5.62)	0.000	7.06(6.99-7.12)	7.04(6.84-7.24)	0.871
MUFA	8.46(8.38-8.55)	8.34(8.24-8.44)	8.26(8.15-8.36)	0.012	10.01(9.93-10.10)	10.13(9.89-10.37)	0.381
PUFA	6.50(6.44-6.57)	6.42(6.34-6.50)	6.30(6.22-6.38)	0.001	7.54(7.47-7.60)	7.56(7.37-7.75)	0.836
n-3 PUFA	1.36(1.34-1.37)	1.34(1.32-1.36)	1.30(1.28-1.32)	0.000	1.56(1.54-1.57)	1.54(1.49-1.59)	0.531
n-6 PUFA	5.45(5.39-5.51)	5.38(5.31-5.44)	5.29(5.22-5.37)	0.005	6.33(6.27-6.38)	6.36(6.19-6.53)	0.688
n-6 PUFA / n-3 PUFA	4.1(4.1-4.1)	4.1(4.1-4.1)	4.2(4.1-4.2)	0.142	4.1(4.1-4.2)	4.2(4.2-4.3)	0.041
Cholesterol	138(136-140)	137(135-140)	135(133-138)	0.216	159(157-161)	160(154-166)	0.690
Soluble dietary fiber	1.2(1.2-1.2)	1.1(1.1-1.2)	1.1(1.1-1.1)	0.000	1.5(1.5-1.5)	1.4(1.4-1.5)	0.018
Insoluble dietary fiber	3.7(3.6-3.7)	3.6(3.6-3.7)	3.5(3.5-3.6)	0.000	4.5(4.5-4.5)	4.3(4.2-4.5)	0.009
Total dietary fiber	5.0(5.0-5.1)	5.0(4.9-5.0)	4.8(4.7-4.9)	0.000	6.3(6.2-6.3)	6.0(5.8-6.2)	0.006
Daidzein	4.9(4.8-5.1)	4.6(4.5-4.8)	4.1(4.0-4.3)	0.000	5.9(5.7-6.0)	5.5(5.1-5.9)	0.061
Genistein	8.3(8.1-8.6)	7.9(7.6-8.1)	7.0(6.8-7.3)	0.000	10.0(9.7-10.2)	9.3(8.7-9.9)	0.058
Retinol	187(182-193)	183(176-189)	177(170-183)	0.063	192(187-197)	196(181-211)	0.605
Carotene	1053(1029-1077)	1026(998-1055)	955(925-985)	0.000	1568(1536-1600)	1519(1425-1612)	0.335

Retinol equivalent[e]	362(354-369)	353(344-361)	335(326-344)	0.000	451(444-459)	448(426-469)	0.745
Vitamin De	4.2(4.1-4.3)	4.0(3.9-4.1)	3.9(3.8-4.0)	0.006	4.5(4.4-4.6)	4.4(4.1-4.7)	0.391
Vitamin E	3.8(3.7-3.8)	3.7(3.7-3.8)	3.6(3.6-3.7)	0.000	4.6(4.6-4.6)	4.6(4.4-4.7)	0.493
Vitamin K[e]	186(182-189)	181(177-184)	171(167-175)	0.000	232(228-235)	225(215-235)	0.201
Vitamin B1	0.32(0.32-0.32)	0.31(0.31-0.32)	0.30(0.30-0.31)	0.000	0.39(0.38-0.39)	0.38(0.37-0.39)	0.112
Vitamin B2	0.58(0.57-0.58)	0.57(0.56-0.57)	0.55(0.54-0.55)	0.000	0.67(0.67-0.68)	0.66(0.64-0.67)	0.176
Niacin	7.6(7.5-7.7)	7.7(7.6-7.7)	7.8(7.7-7.9)	0.012	8.0(7.9-8.0)	8.4(8.2-8.6)	0.000
Vitamin B6	0.53(0.53-0.54)	0.53(0.52-0.53)	0.50(0.50-0.51)	0.004	0.59(0.58-0.59)	0.57(0.56-0.59)	0.056
Vitamin B12[e]	3.6(3.6-3.7)	3.6(3.5-3.6)	3.4(3.4-3.5)	0.000	3.6(3.6-3.7)	3.71(3.52-3.89)	0.388
Folate[e]	144(142-146)	142(140-144)	138(135-140)	0.000	174(173-176)	171(166-176)	0.265
Pantothenic acid	2.83(2.81-2.85)	2.78(2.76-2.80)	2.67(2.65-2.70)	0.000	3.21(3.19-3.23)	3.12(3.07-3.18)	0.008
Vitamin C	44(43-45)	43(42-44)	40(40-41)	0.554	60(59-61)	55(53-58)	0.001
Sodium	1923(1907-1938)	1922(1904-1940)	1935(1916-1954)	0.000	2115(2100-2130)	2154(2110-2198)	0.106
Potassium	980(971-989)	967(957-978)	951(939-962)	0.000	1189(1179-1199)	1172(1144-1201)	0.298
Calcium	192(190-195)	185(182-188)	173(170-177)	0.001	237(235-240)	227(219-235)	0.022
Magnesium	109(109-110)	109(108-110)	107(106-108)	0.000	121(120-122)	121(119-124)	0.743
Phosphorus	442(439-445)	436(433-439)	425(421-429)	0.000	491(489-494)	487(479-496)	0.370
Iron	3.2(3.2-3.2)	3.2(3.1-3.2)	3.1(3.1-3.1)	0.000	3.8(3.8-3.8)	3.8(3.7-3.8)	0.276
Zinc	3.7(3.7-3.7)	3.7(3.7-3.7)	3.6(3.6-3.7)	0.000	4.1(4.1-4.1)	4.1(4.1-4.2)	0.796
Copper	0.57(0.57-0.57)	0.57(0.56-0.57)	0.56(0.55-0.56)	0.059	0.63(0.62-0.63)	0.61(0.60-0.62)	0.051
Manganese	1.87(1.85-1.89)	1.89(1.87-1.91)	1.90(1.88-1.92)	0.398	2.09(2.08-2.11)	2.03(1.98-2.08)	0.025

SFA; Saturated fatty acid, MUFA; Monounsaturated fatty acid, PUFA;polyunsaturated fatty acid; [a]Adjusted means were adjusted for the following covariates: age, BMI, energy (kcal/day), alcohol (g/1000 kcal/day), history of hypertension and diabetes mellitus, sleeping time (hours/day), exercise (yes or no), and self-reported psychological stress (low, moderate, high); [b]Pack year ["*number of cigarettes per day*"/20 × "*duration of smoking (years)*"] ranges of each group are shown in parentheses; [c]kcal/day; [d]Energy percentages of protein, carbohydrate, and fat were calculated; [e]μg/1000 kcal/day

day).

Statistical analyses

Statistical analysis was performed for men and women, separately. Characteristics of subjects were analyzed using general linear models for continuous variables, and chi-squared test or Fisher's exact test for categorical variables. Using general linear models, adjusted mean intakes of food and nutrient were calculated by stratification of SS. The following variables were used as confounding factors: age (years), BMI (kg/m^2), dietary energy intake (kcal/day), alcohol consumption (g/day), sleeping time (hours/day), habitual exercise (yes or no), past or present history of hypertension and diabetes mellitus (yes or no), and SRPS. All p values were based on two-tailed tests. Statistical analyses were conducted using PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA); p values < 0.05 were statistically considered significant.

Results

Table 1 shows the characteristics of study subjects, according to SS. In men, age, BMI, energy, alcohol, sleeping time, percentages of history of hypertension and diabetes mellitus, habitual exercise, and SRPS were significantly different among the 3 groups ($p<0.05$ for all). In women, age, total energy intake, and alcohol were significantly different between the 2 groups ($p<0.05$ for all).

Table 2 shows adjusted means of foods in men and women, according to SS. In men, SS was positively associated with consumption of rice, buckwheat noodles, egg, "*salted green and yellow vegetable pickles*", other root vegetables (i.e., onions, burdock and lotus roots), green tea, soda, sake, beer and whiskey, and negatively with those of "*squid, octopus, shrimp, and clams*", oily fish, "*low fat milk and yogurt*", "*tofu and tofu products*", natto (fermented soy beans), "*raw vegetables used in salad (i.e., cabbage and lettuce)*", green leafy vegetables, "*radishes and turnips*", "*tomatoes, tomato ketchup, boiled tomatoes and stewed tomatoes*", mushrooms, seaweeds, citrus fruit including oranges, Japanese-style sweets, "*rice crackers, rice cakes, and Japanese-style pancakes*", ice

cream, citrus fruit including oranges, "*fruit juice and vegetable juice*", and wine ($p<0.05$ for all). In women, SS was positively associated with those of Chinese noodles, "*spaghetti and macaroni*", "*pork and beef*", "*squid, octopus, shrimp, and clams*", "*salted green and yellow vegetable pickles*", "*mayonnaise and salad dressing*", soda, "*fruit juice and vegetable juice*", sake, beer, "*shochu and shochu mixed with water or a carbonated beverage*" and whiskey, and negatively with those of rice, "*milk and yogurt*", "*tofu and tofu products*", potatoes, "*radishes and turnips*", seaweeds, "*cakes, cookies, and biscuits*", "*strawberries, persimmons and kiwi fruits*", other fruits and green tea ($p<0.05$ for all).

Table 3 shows adjusted means of nutrients in men and women, respectively, according to SS. In men, SS is positively associated with consumption of, carbohydrate, alcohol, energy percent of carbohydrate and alcohol, niacin, and sodium, and negatively with those of animal protein, fat, animal fat, vegetable fat, energy percent of protein and fat, saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), n-3 PUFA, n-6 PUFA, soluble, insoluble, and total dietary fiber, daizein, genistein, retinol, carotene, retinol equivalent, vitamin D, E, K, B1, B2, B6, and B12, folate, pantothenic acid, potassium, calcium, magnesium, phosphorus, iron and zinc ($p<0.05$ for all). In women, SS is positively associated with energy percent of alcohol, n-6 PUFA/n-3 PUFA, dietary intake of niacin, and negatively with those of energy, soluble, insoluble and total dietary fiber, pantothenic acid, vitamin C, calcium copper and manganese ($p<0.05$ for all).

Discussion

Compared with previous studies, we showed thorough relationships between SS and dietary intakes of foods and nutrients in men. SS was positively associated with the consumption of rice, soda and some alcoholic beverages and negatively associated with those of soy products, some vegetables, fruits, vitamins and minerals.

Until today, the association between SS and consumption of foods and nutrients has not fully been investigated in Japanese (Kato et al., 1989; Dyer et al., 2003; Sugiura et al., 2009). SS was negatively associated with consumption of 17 foods, including 6 vegetables, soy products and citrus fruits and 28 nutrients, including PUFAs, dietary fibers, isoflavones, 12 vitamins and 6 minerals. It is widely known that vegetables and fruit and the related nutrients, i.e. vitamins have a protective role for LSRDs (Wang et al., 2014). Nevertheless our results suggested that SS is negatively associated with the consumption of foods and nutrients which have protective roles, but our study have 3 strengths. First, regarding "*Japanese smoking paradox*", our study results will be helpful to investigate the association between dietary consumption and risk of lung cancer in Japanese, even if we did not show the risk. Smoking status is one of important confounding factors according to Rothman et al. (2008) because consumption of foods and nutrients is associated with SS. Second, a dose-response relationship of SS by pack-year and consumption of foods and nutrients was enlarged. Third, psychiatric disorders were considered for relationships because of being related to smoking (Wilhelm et al., 2003; Leon and Diaz, 2005; Shinozaki et al., 2011). Psychiatric disorders are also increasing globally (Murray et al., 2012) as an important public health issue, but have not been considered previously (Poisson et al., 2012; Vlassopoulos et al., 2013).

We showed that SS was also positively associated with alcohol consumption in men and women. Drinking in addition to smoking is also a risk factor for LSRDs. Unhealthy lifestyle such as smoking, drinking, no or less exercise and obesity are associated each other (Heikkila et al., 2013). We have found that the interaction between drinking and SRPS in relation to diet in Japanese (Endoh et al., 2015). Physical activity is also proposed to decrease the risk of lung cancer (World Cancer Research Fund American Institute for Cancer Research, 2007). However, it is needed to examine the association between exercise and diet because of being not fully understood especially in Japanese.

We assessed the SS by pack year, which a scale to determine the amount a person has smoked during long time. There are two reasons to choose pack year as SS. Lifestyle factors such as smoking and diet are developed in long-term. Pack year is associated with age since it is linked to the amount of tobacco during a long period of time. However, the effect of age was controlled to some extent because consumption of foods and nutrients were adjusted for age. A dose-response relationship between smoking and dietary intakes of foods and nutrients has not been demonstrated previously (Kato et al., 1989; Dyer et al., 2003; Sugiura et al., 2009).

The present study had several limitations. First, a cause-effect relationship between SS and diet could not be clearly demonstrated in our cross-sectional study, but we excluded the subjects with psychiatric disorders, which are related to SS. In contrast to previous studies, we also assessed SS by pack-year to investigate a dose-response relationship. These were not considered in previous studies. Second, we did not collect information about socioeconomic status, including household income, occupation, job position, and marital status (Galobardes et al., 2001). Third, we assessed SRPS with a single question. In our previous study, however, we have demonstrated that significant higher proportion of badly lifestyle (i.e., drinker, smoker and non-exerciser) was among the subjects with the higher level of SRPS (Endoh et al., 2015). Finally, we did not consider the starting age of smoking. Considering current SS is important because smoking cessation increases BMI (John et al., 2005). Regarding SS, however, we assessed SS by pack year and could analyze the linear relation between SS and dietary intake of food and nutrients.

Our results imply that SS is negatively associated with the consumption of foods and nutrients which are rich in antioxidants and have protective roles, and positively with dietary factors for increased risks of various diseases such as cancer, especially in men. Further studies are needed to clarify "*Japanese smoking paradox*".

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