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Education, but not occupation or household income, is positively related to favorable dietary intake patterns in pregnant Japanese women: the Osaka Maternal and Child Health Study

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Received 30 September 2008; revised 12 February 2009; accepted 15 February 2009

Abstract

Although a large body of epidemiologic data accumulated in Western countries show that individuals with a higher socioeconomic position consume higher quality diets, information on such socioeconomic differences in the diets of non-Western populations, including Japanese, is absolutely lacking. This cross-sectional study examined the association of socioeconomic position with dietary intake in a group of pregnant Japanese women. Subjects were 1002 Japanese women during pregnancy. Socioeconomic position was assessed by education, occupation, and household income. Dietary intake was estimated using a validated, self-administered, comprehensive diet history questionnaire. Education was associated positively with intake of protein; total n-3 and marine-origin n-3 polyunsaturated fatty acids; dietary fiber; cholesterol; potassium; calcium; magnesium; iron; vitamins A, D, E, and C; and folate 9 and inversely with that of carbohydrate. No associations were seen between education and intake of total fat; saturated, monounsaturated, and total and n-6 polyunsaturated fatty acids; alcohol; or sodium. Regarding food, higher education was associated with a higher intake of vegetables, fish and shellfish, and potatoes and lower intake of rice. Education was not associated with intake of bread, noodles, confectioneries and sugars, fats and oils, pulses and nuts, meat, eggs, dairy products, or fruit. For occupation, housewives had a higher intake of dietary fiber, magnesium, iron, vitamin A, folate, and pulses and nuts than working women. Household income was not associated with any nutrient or food examined. In conclusion, education, but not occupation or household income, was positively associated with favorable dietary intake patterns in a group of pregnant Japanese women.

Keywords: Education; Occupation; Income; Diet; Pregnant women
Abbreviations: DHQ, diet history questionnaire; OMCHS, Osaka Maternal and Child Health Study.

1. Introduction

In many Western countries, socioeconomic differences in health have been widely indicated, with higher socioeconomic position associated with better health [1-3].

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doi:10.1016/j.nutres.2009.02.002

Socioeconomic differentials in diet have also been observed. Dietary intake studies have consistently shown that individuals with a higher socioeconomic position consume higher-quality diets than those with a lower position, including higher intake of whole grains, lean meats, fish, low-fat dairy products, and fresh vegetables and fruits, and lower intake of fatty meats, refined grains, and added fats, resulting in higher intake of key vitamins and minerals and dietary fiber [4-12]. Given the important role of nutrition in promoting health, this dietary intake pattern may be linked to inequalities in health [12,13].

Conversely, several Japanese studies have reported unclear or even inverse associations between socioeconomic position and health status. In a comparative analysis of Japan and England, Japanese men with a higher employment grade or education had a higher body mass index and waist-to-hip-ratio and lower (less favorable) high-density lipoprotein cholesterol level than those with a lower employment grade or education, whereas positive associations between socioeconomic position and health status were seen in England [14]. Other Japanese studies have observed unclear, rather than positive, associations of education and employment grade with several metabolic risk factors [15,16].

To our knowledge, however, the presence of socioeconomic differences in Japanese diets has not been examined. Given the similarity of socioeconomic gradients in health and diet in Western countries vs the differences in socioeconomic gradients in health between Western countries and Japan, the associations between socioeconomic position and diet between Western countries and Japan may differ. In addition, the association between socioeconomic position and diet has been poorly investigated among pregnant women, even in Western countries [17-21].

Here, using baseline data from the Osaka Maternal and Child Health Study (OMCHS), we conducted a cross-sectional study of the association between socioeconomic position and dietary intake in a group of pregnant Japanese women. We hypothesized that the association between socioeconomic position and dietary intake in Japanese somewhat differs from that observed in Western populations.

2. Methods and materials

2.1. Subjects

The subjects in this analysis were participants in the baseline survey of the OMCHS, an ongoing prospective cohort study investigating preventive and risk factors for maternal and child health problems. Details of the OMCHS have been published elsewhere [22,23]. Briefly, all pregnant women in Neyagawa City, Osaka Prefecture, were recruited between November 2001 and March 2003. Of 3639 eligible women, 627 (17.2%) took part in the study. An additional 375 pregnant women living in other neighborhood areas were enrolled between December 2001 and November 2003. A total of 1002 pregnant women completed the baseline survey and were included in this analysis. Basic characteristics of these 1002 women have been published elsewhere [23,24]. Written informed consent was obtained from each woman. The protocol of the OMCHS was approved by the ethics committee of the Osaka City University School of Medicine, Japan.

Table 1. Socioeconomic and dietary characteristics of the subjects (N = 1002)

Variable	Value
Education	
Low (≤12 y)	323 (32.2)
Medium (13-14 y)	413 (41.2)
High (≥15 y)	266 (26.6)
Occupation	
Housewife	714 (71.3)
Outside work	288 (28.7)
Household income	
Low (≤2 419 999 yen/y)	312 (31.1)
Medium (2 420 000-3 619 999 yen/y)	379 (37.8)
High (≥3 620 000 yen/y)	311 (31.0)
Nutrient intake	
Protein (% of energy)	13.4 ± 1.9
Total fat (% of energy)	29.9 ± 5.3
Saturated fatty acids (% of energy)	8.4 ± 2.0
Monounsaturated fatty acids (% of energy)	10.3 ± 2.3
Polyunsaturated fatty acids (% of energy)	6.7 ± 1.5
n-6 polyunsaturated fatty acids (% of energy)	5.6 ± 1.2
n-3 polyunsaturated fatty acids (% of energy)	1.16 ± 0.34
Marine-origin n-3 polyunsaturated fatty acids (% of energy) [a]	0.38 ± 0.22
Carbohydrate (% of energy)	55.7 ± 6.3
Alcohol (% of energy)	0.22 ± 1.53
Dietary fiber (g/4184 kJ)	6.4 ± 1.7
Cholesterol (mg/4184 kJ)	164.7 ± 58.6
Sodium (mg/4184 kJ)	2036 ± 440
Potassium (mg/4184 kJ)	1149 ± 258
Calcium (mg/4184 kJ)	295.4 ± 93.9
Magnesium (mg/4184 kJ)	120.9 ± 25.1
Iron (mg/4184 kJ)	3.63 ± 0.79
Vitamin A (μg retinol equivalents/4184 kJ)	336.6 ± 298.0
Vitamin D (mg/4184 kJ)	3.31 ± 1.71
Vitamin E (mg α-tocopherol/4184 kJ)	4.22 ± 0.92
Vitamin C (mg/4184 kJ)	58.5 ± 27.0
Folate (μg/4184 kJ)	155.8 ± 46.9
Food intake (g/4184 kJ)	
Rice	134.3 ± 55.0
Bread	38.7 ± 22.0
Noodles	41.4 ± 31.7
Potatoes	15.0 ± 10.8
Confectioneries and sugars	34.0 ± 16.8
Fats and oils	13.5 ± 6.3
Pulses and nuts	25.4 ± 16.0
Fish and shellfish	26.2 ± 14.1
Meat	32.3 ± 15.4
Eggs	18.0 ± 12.9
Dairy products	106.1 ± 67.2
Vegetables	113.8 ± 66.6
Fruits	93.3 ± 83.0

Values are number (percentage) of subjects for socioeconomic variables and means ± SD for dietary variables.

[a] Sum of eicosapentaenoic, docosapentaenoic, and docosahexaenoic acids.

2.2. Measurements

Baseline assessment of the OMCHS was primarily conducted using a set of 2 self-administered questionnaires. The participants mailed the answered questionnaires to the data management center. Research technicians completed missing or illogical data by telephone interview.

One of the self-administered questionnaires elicited information on the socioeconomic position of the participant, including education, occupation, and household income. Educational level was determined from age at the completion of education. Based on the starting age of compulsory education in Japan (7 years of age), the following 3 education groups were created: low (12 years or less), medium (13-14 years), and high (15 years or more). Occupation information was obtained from the participant's current occupation at the time of the survey and categorized as housewife and outside work. Annual household income (sum of the participant's and her partner's income) before taxation was obtained with 11

Table 2. Selected characteristics according to categories of education, occupation, and household income (N = 1002)

Variable	Education				Occupation			Household income			
	Low (n = 323)	Medium (n = 413)	High (n = 266)	P^a	Housewife (n = 714)	Outside work (n = 288)	P^a	Low (n = 312)	Medium (n = 379)	High (n = 311)	P^a
Age				.41			.12				<.0001
≤28 y	135 (41.8)	156 (37.8)	89 (33.5)		285 (39.9)	95 (33.0)		176 (56.4)	113 (29.8)	91 (29.3)	
29-31 y	79 (24.5)	126 (30.5)	94 (35.3)		203 (28.4)	96 (33.3)		70 (22.4)	138 (36.4)	91 (29.3)	
≥32 y	109 (33.8)	131 (31.7)	83 (31.2)		226 (31.7)	97 (33.7)		66 (21.2)	128 (33.8)	129 (41.5)	
Gestational age				.014			.95				.040
≤14 wk	127 (39.3)	150 (36.3)	80 (30.1)		254 (35.6)	103 (35.8)		120 (38.5)	142 (37.5)	95 (30.6)	
15-20 wk	106 (32.8)	131 (31.7)	92 (34.6)		236 (33.1)	93 (32.3)		91 (29.2)	140 (36.9)	98 (31.5)	
≥21 wk	90 (27.9)	132 (32.0)	94 (35.3)		224 (31.4)	92 (31.9)		101 (32.4)	97 (25.6)	118 (37.9)	
Parity				.033			<.0001				<.0001
Nulliparous	143 (44.3)	205 (49.6)	141 (53.0)		314 (44.0)	175 (60.8)		140 (44.9)	119 (31.4)	230 (74.0)	
Multiparous	180 (55.7)	208 (50.4)	125 (47.0)		400 (56.0)	113 (39.2)		172 (55.1)	260 (68.6)	81 (26.1)	
Cigarette smoking				<.0001			.40				.0001
Never	166 (51.4)	307 (74.3)	224 (84.2)		486 (68.1)	211 (73.3)		196 (62.8)	263 (69.4)	238 (76.5)	
Former	53 (16.4)	45 (10.9)	23 (8.7)		98 (13.7)	23 (8.0)		42 (13.5)	48 (12.7)	31 (10.0)	
Current	104 (32.2)	61 (14.8)	19 (7.1)		130 (18.2)	54 (18.8)		74 (23.7)	68 (17.9)	42 (13.5)	
Family structure				.0047			1.00				.82
Nuclear	274 (84.8)	354 (85.7)	247 (92.9)		624 (87.4)	251 (87.2)		271 (86.9)	332 (87.6)	272 (87.5)	
Expanded	49 (15.2)	59 (14.3)	19 (7.1)		90 (12.6)	37 (12.9)		41 (13.1)	47 (12.4)	39 (12.5)	
Changes in diet in the previous 1 mo				.011			.33				.0001
Never or seldom	118 (36.5)	119 (28.8)	63 (23.7)		221 (31.0)	79 (27.4)		113 (36.2)	114 (30.1)	73 (23.5)	
Slight	123 (38.1)	184 (44.6)	128 (48.1)		306 (42.9)	129 (44.8)		133 (42.6)	162 (42.7)	140 (45.0)	
Substantial	82 (25.4)	110 (26.6)	75 (28.2)		187 (26.2)	80 (27.8)		66 (21.2)	103 (27.2)	98 (31.5)	
Physical activity				.0045			.0073				.39
Low	221 (68.4)	229 (55.5)	153 (57.5)		449 (62.9)	154 (53.5)		195 (62.5)	203 (53.6)	205 (65.9)	
Medium or high	102 (31.6)	184 (44.6)	113 (42.8)		265 (37.1)	134 (46.5)		117 (37.5)	176 (46.4)	106 (34.1)	
Partner's education				<.0001			.16				<.0001
Low (≤12 y)	192 (59.4)	161 (39.0)	47 (17.7)		296 (41.5)	104 (36.1)		167 (53.5)	151 (39.8)	82 (26.4)	
Medium (13-14 y)	52 (16.1)	88 (21.3)	32 (12.0)		119 (16.7)	53 (18.4)		53 (17.0)	71 (18.7)	48 (15.4)	
High (≥15 y)	79 (24.5)	164 (39.7)	187 (70.3)		299 (41.9)	131 (45.5)		92 (29.5)	157 (41.4)	181 (58.2)	
Education				–			<.0001				<.0001
Low (≤12 y)	323 (100)	0 (0)	0 (0)		255 (35.7)	68 (23.6)		129 (41.4)	126 (33.3)	68 (21.9)	
Medium (13-14 y)	0 (0)	413 (100)	0 (0)		298 (41.7)	115 (39.9)		129 (41.4)	172 (45.4)	112 (36.0)	
High (≥15 y)	0 (0)	0 (0)	266 (100)		161 (22.6)	105 (36.5)		54 (17.3)	81 (21.4)	131 (42.1)	
Occupation				<.0001			–				<.0001
Housewife	255 (79.0)	298 (72.2)	161 (60.5)		714 (100)	0 (0)		255 (81.7)	299 (78.9)	160 (51.5)	
Outside work	68 (21.1)	115 (27.9)	105 (39.5)		0 (0)	288 (100)		57 (18.3)	80 (21.1)	151 (48.6)	
Household income				<.0001			<.0001				–
Low (≤2 419 999 yen/y)	129 (39.9)	129 (31.2)	54 (20.3)		255 (35.7)	57 (19.8)		312 (100)	0 (0)	0 (0)	
Medium (2 420 000-3 619 999 yen/y)	126 (39.0)	172 (41.7)	81 (30.5)		299 (41.9)	80 (27.8)		0 (0)	379 (100)	0 (0)	
High (≥3 620 000 yen/y)	68 (21.1)	112 (27.1)	131 (49.3)		160 (22.4)	151 (52.4)		0 (0)	0 (0)	311 (100)	

Values are number (percentage) of subjects.

[a] Mantel-Haenszel χ^2 test.

response alternatives. To take account of differences in household size and composition, household income (midpoint of each income category) was divided by the household's equivalent adult size using the modified Organization for Economics Cooperation and Development equivalence scale: the respondent, 1; other adult (ie, partner), 0.5; and each child, 0.3 [25]. This household income variable was then categorized into approximate tertiles of low (2 419 999 yen/y or less), medium (2 420 000-3 619 999 yen/y), and high (3 620 000 yen/y or more).

The other self-administered questionnaire used was a validated, self-administered, comprehensive diet history questionnaire (DHQ) that assessed dietary habits during the preceding month [26-29]. The DHQ is a 16-page structured questionnaire that asks about the consumption frequency and portion size of selected foods commonly consumed in Japan as well as general dietary behavior and usual cooking methods [26]. Estimates of daily intake for foods (150 items in total), nutrients, and energy were calculated using an ad hoc computer algorithm for the DHQ [26,29] based on the Standard Tables of Food Composition in Japan [30,31]. Nutrient and food intake values were energy-adjusted using the density method (ie, percentage of energy for energy-providing nutrients and the amount per 4184 kJ of energy for other nutrients and foods) to minimize the influence of dietary misreporting, an ongoing controversy in studies that collect dietary information using self-report instruments [32].

The validity of the DHQ and its structure and the methods used to calculate dietary intake have been detailed elsewhere [26-28]. Briefly, Pearson correlation coefficients were 0.37 to 0.75 for energy-providing nutrients and 0.38 to 0.68 for other nutrients between the DHQ and 3-day estimated dietary records in 47 women [26]; 0.34 to 0.79 for energy-providing nutrients and 0.35 to 0.69 for other nutrients between the DHQ and 16-day weighed dietary records in 92 women, with Spearman correlation coefficients for food groups from 0.36 to 0.64 (S. Sasaki, unpublished observations, 2004); 0.23 for sodium and 0.40 for potassium between the DHQ and 24-hour urinary excretion in 69 women [27]; and 0.66 between the DHQ and serum phospholipid concentrations for marine-origin n-3 polyunsaturated fatty acids (sum of eicosapentenoic, docosapentaenoic, and docosahexaenoic acids) in 44 women [28].

The 2 self-administered questionnaires also elucidated information on potential confounding factors, including age (28 years or less, 29-31 years, and 32 years or more), gestational age (14 weeks or less, 15-20 weeks, and 21 weeks or more), parity (nulliparous and multiparous), cigarette smoking (never, former, and current), family structure (nuclear and expanded), changes in diet in the previous 1 month (never or seldom, slight, and substantial), physical activity (low; and medium or high), and partner's education (low [12 years or less], medium [13-14 years], and high [15 years or more]).

2.3. Statistical analyses

All statistical analyses were performed using SAS statistical software version 9.1 (SAS Institute Inc, Cary, NC). Using the PROC GLM procedure, linear regression models were constructed to examine the association of socioeconomic position (education, occupation, and household income) with dietary intake of selected nutrients and foods. Mean (and standard error) values of nutrient and food intake were calculated by categories of education, occupation, and household income with adjustment for potential confounding factors, including age, gestational age, parity, cigarette smoking, family structure, changes in diet in the previous month, physical activity, and partner's education. For each of the socioeconomic position variables, the other 2 socioeconomic position variables were further included as potential confounding factors. Trends of association were assessed by a linear regression model assigning consecutive integers to the levels of the socioeconomic position variables. All reported P values are 2-tailed, and a P value of less than .05 was considered statistically significant.

3. Results

Socioeconomic and dietary characteristics of the 1002 pregnant women are shown in Table 1. The percentage of women in the low, medium, and high education groups was 32%, 41%, and 27%, respectively, with about 71% housewives and 29% outside workers. Median household income was 3 000 000 yen, ranging from 280 000 to 9 500 000 yen, with the percentage of women in the low, medium, and high categories of 31%, 38%, and 31%, respectively. Mean percentages of intake of protein, total fat, and carbohydrate were 13.4%, 29.9%, and 55.7% of energy, respectively.

Associations between socioeconomic position and selected characteristics are shown in Table 2. Among those in the higher categories of education, fewer women had a younger gestational age or were multiparous, current smokers, or less physically active. Women with higher education also tended to live in a nuclear family, have changes in diet during the previous month, have a partner with higher education, work outside, and have a higher household income. Regarding occupation, the proportion of multiparous women and those who were physically inactive was larger among housewives than those with outside work. Housewives also tended to have a partner with lower education and lower household income than women working outside. Among women in the higher categories of household income, fewer had a younger gestational age, were multiparous, or were current smokers. Women with higher education also tended to have changes in diet during the previous month, have a partner with higher education, have higher education, and work outside.

Table 3 shows independent associations among socioeconomic position and dietary intake. Education was

Table 3. Dietary intake according to categories of education, occupation, and household income (N = 1002)

Variable	Education[a]				Occupation			Household income[b]			
	Low (n = 323)	Medium (n = 413)	High (n = 266)	P^c	Housewife (n = 714)	Outside work (n = 288)	P^c	Low (n = 312)	Medium (n = 379)	High (n = 311)	P^c
Nutrient intake											
Protein (% of energy)	13.1 ± 0.1	13.4 ± 0.1	13.8 ± 0.1	.0001	13.4 ± 0.1	13.2 ± 0.1	.16	13.4 ± 0.1	13.3 ± 0.1	13.4 ± 0.1	.74
Total fat (% of energy)	29.3 ± 0.3	30.1 ± 0.3	30.1 ± 0.3	.09	30.0 ± 0.2	29.6 ± 0.3	.33	29.8 ± 0.3	29.6 ± 0.3	30.2 ± 0.3	.47
Saturated fatty acids (% of energy)	8.3 ± 0.1	8.5 ± 0.1	8.5 ± 0.1	.15	8.5 ± 0.1	8.3 ± 0.1	.12	8.4 ± 0.1	8.4 ± 0.1	8.6 ± 0.1	.30
Monounsaturated fatty acids (% of energy)	10.3 ± 0.1	10.3 ± 0.1	10.4 ± 0.1	.53	10.4 ± 0.1	10.2 ± 0.1	.38	10.4 ± 0.1	10.2 ± 0.1	10.4 ± 0.1	.87
Polyunsaturated fatty acids (% of energy)	6.7 ± 0.1	6.6 ± 0.1	6.8 ± 0.1	.58	6.7 ± 0.1	6.6 ± 0.1	.09	6.8 ± 0.1	6.6 ± 0.1	6.7 ± 0.1	.87
n-6 polyunsaturated fatty acids (% of energy)	5.6 ± 0.1	5.6 ± 0.1	5.7 ± 0.1	.99	5.7 ± 0.1	5.5 ± 0.1	.11	5.7 ± 0.1	5.5 ± 0.1	5.6 ± 0.1	.70
n-3 polyunsaturated fatty acids (% of energy)	1.13 ± 0.02	1.16 ± 0.02	1.20 ± 0.02	.044	1.17 ± 0.01	1.13 ± 0.02	.11	1.17 ± 0.02	1.14 ± 0.01	1.18 ± 0.01	.66
Marine-origin n-3 polyunsaturated fatty acids (% of energy)[d]	0.35 ± 0.01	0.38 ± 0.01	0.42 ± 0.01	.0005	0.39 ± 0.01	0.36 ± 0.01	.16	0.38 ± 0.01	0.37 ± 0.01	0.39 ± 0.01	.71
Carbohydrate (% of energy)	56.4 ± 0.4	55.6 ± 0.3	55.0 ± 0.4	.014	55.6 ± 0.2	56.0 ± 0.4	.34	55.5 ± 0.4	56.1 ± 0.3	55.4 ± 0.4	.95
Alcohol (% of energy)	0.22 ± 0.09	0.13 ± 0.08	0.36 ± 0.1	.41	0.22 ± 0.06	0.23 ± 0.09	.88	0.32 ± 0.09	0.13 ± 0.08	0.24 ± 0.1	.48
Dietary fiber (g/4184 kJ)	6.2 ± 0.1	6.4 ± 0.1	6.7 ± 0.1	.0012	6.5 ± 0.1	6.1 ± 0.1	.0005	6.3 ± 0.1	6.4 ± 0.1	6.5 ± 0.1	.27
Cholesterol (mg/4184 kJ)	156.8 ± 3.5	168.6 ± 2.9	168.2 ± 3.8	.028	164.9 ± 2.2	164.1 ± 3.6	.85	165.2 ± 3.5	163.1 ± 3.1	166.0 ± 3.7	.93
Sodium (mg/4184 kJ)	2030 ± 26	2037 ± 22	2040 ± 29	.79	2042 ± 17	2020 ± 27	.50	2051 ± 26	2018 ± 24	2041 ± 28	.72
Potassium (mg/4184 kJ)	1101 ± 15	1161 ± 13	1188 ± 17	.0002	1159 ± 10	1124 ± 15	.06	1146 ± 15	1144 ± 13	1158 ± 16	.64
Calcium (mg/4184 kJ)	283.0 ± 5.3	297.0 ± 4.4	307.8 ± 5.9	.0031	298.0 ± 3.4	288.9 ± 5.5	.17	290.5 ± 5.3	295.8 ± 4.8	299.7 ± 5.7	.26
Magnesium (mg/4184 kJ)	118.0 ± 1.4	121.3 ± 1.2	123.7 ± 1.6	.013	122.1 ± 0.9	117.9 ± 1.5	.023	120.2 ± 1.5	120.2 ± 1.3	122.4 ± 1.6	.39
Iron (mg/4184 kJ)	3.52 ± 0.05	3.63 ± 0.04	3.75 ± 0.05	.0012	3.67 ± 0.03	3.52 ± 0.05	.010	3.65 ± 0.05	3.58 ± 0.04	3.66 ± 0.05	.93

Vitamin A (μg retinol equivalents/4184 kJ)	302.0 ± 17.4	328.6 ± 14.5	390.9 ± 19.4	.0016	349.9 ± 11.2	303.5 ± 18.1	.034	357.1 ± 17.5	315.7 ± 15.7	341.4 ± 18.7	.46
Vitamin D (mg/4184 kJ)	2.95 ± 0.10	3.32 ± 0.08	3.71 ± 0.11	<.0001	3.35 ± 0.06	3.21 ± 0.10	.27	3.29 ± 0.10	3.28 ± 0.09	3.36 ± 0.11	.63
Vitamin E (mg α-tocopherol/4184 kJ)	4.07 ± 0.05	4.25 ± 0.04	4.35 ± 0.06	.0008	4.26 ± 0.03	4.13 ± 0.06	.06	4.21 ± 0.05	4.17 ± 0.05	4.30 ± 0.06	.35
Vitamin C (mg/4184 kJ)	55.3 ± 1.6	59.4 ± 1.3	61.1 ± 1.8	.018	59.5 ± 1.0	56.1 ± 1.6	.08	57.3 ± 1.6	58.4 ± 1.4	59.9 ± 1.7	.29
Folate (μg/4184 kJ)	147.4 ± 2.7	157.4 ± 2.3	163.4 ± 3.0	.0002	158.1 ± 1.7	149.9 ± 2.8	.015	158.1 ± 2.7	152.8 ± 2.4	157.0 ± 2.9	.68
Food intake (g/4184 kJ)											
Rice	144.2 ± 3.2	128.8 ± 2.7	130.8 ± 3.6	.0056	132.5 ± 2.1	138.7 ± 3.4	.13	139.2 ± 3.3	133 ± 2.9	130.9 ± 3.5	.09
Bread	38.1 ± 1.3	40.1 ± 1.1	37.1 ± 1.5	.70	38.3 ± 0.8	39.6 ± 1.4	.44	38.4 ± 1.3	39.5 ± 1.2	37.9 ± 1.4	.88
Noodles	43.4 ± 1.9	39.1 ± 1.6	42.6 ± 2.1	.68	42.1 ± 1.2	39.8 ± 1.9	.34	41.2 ± 1.9	43.8 ± 1.7	38.7 ± 2.0	.48
Potatoes	13.0 ± 0.6	15.3 ± 0.5	17.0 ± 0.7	<.0001	15.3 ± 0.4	14.4 ± 0.7	.26	15.2 ± 0.6	15.2 ± 0.6	14.6 ± 0.7	.62
Confectioneries and sugars	32.2 ± 1.0	36.0 ± 0.8	33.0 ± 1.1	.47	34.1 ± 0.6	33.7 ± 1.0	.79	33.1 ± 1.0	33.9 ± 0.9	35.0 ± 1.1	.22
Fats and oils	13.6 ± 0.4	13.4 ± 0.3	13.4 ± 0.4	.66	13.5 ± 0.2	13.4 ± 0.4	.80	13.4 ± 0.4	13.3 ± 0.3	13.7 ± 0.4	.63
Pulses and nuts	24.9 ± 0.9	25.1 ± 0.8	26.3 ± 1.0	.36	26.4 ± 0.6	22.8 ± 1.0	.0019	25.4 ± 0.9	24.1 ± 0.8	26.9 ± 1.0	.39
Fish and shellfish	23.6 ± 0.8	26.6 ± 0.7	28.9 ± 0.9	<.0001	26.3 ± 0.5	26.2 ± 0.9	.93	26.2 ± 0.8	26.0 ± 0.7	26.6 ± 0.9	.76
Meat	32.5 ± 0.9	31.6 ± 0.8	33.3 ± 1.0	.66	32.6 ± 0.6	31.8 ± 0.9	.47	34.0 ± 0.9	31.2 ± 0.8	32 ± 1.0	.11
Eggs	17.4 ± 0.8	18.6 ± 0.6	17.8 ± 0.9	.68	18.0 ± 0.5	18.0 ± 0.8	1.00	18.0 ± 0.8	17.9 ± 0.7	18.1 ± 0.8	.96
Dairy products	103.8 ± 3.9	106.7 ± 3.3	107.9 ± 4.4	.50	105.8 ± 2.5	106.8 ± 4.1	.84	103.6 ± 3.9	105.7 ± 3.5	109.1 ± 4.2	.37
Vegetables	107.5 ± 3.9	113.2 ± 3.3	122.2 ± 4.3	.019	116.4 ± 2.5	107.3 ± 4.0	.06	116.2 ± 3.9	109.9 ± 3.5	116.1 ± 4.2	.88
Fruits	87.6 ± 4.9	97.8 ± 4.1	93.2 ± 5.4	.41	96.1 ± 3.1	86.5 ± 5.0	.11	85.8 ± 4.9	97.3 ± 4.4	96 ± 5.2	.14

Values are means ± standard errors. Adjustment was made for age (28 years or less, 29-31 years, and 32 years or more), gestational age (14 weeks or less, 15-20 weeks, and 21 weeks or more), parity (nulliparous and multiparous), cigarette smoking (never, former, and current), family structure (nuclear and expanded), changes in diet previous 1 month (never or seldom, slight, and substantial), physical activity (low, and medium or high), and partner's education (low [12 years or less], medium [13-14 years], and high [15 years or more]). For education, further adjustment was made for occupation and household income. For occupation, further adjustment was made for education and household income. For household income, further adjustment was made for education and occupation.

[a] Twelve years or less for low, 13-14 years for medium, and 15 years or more for high categories.

[b] 2 419 999 yen/y or less for low, 2 420 000-3 619 999 yen/y for medium, and 3 620 000 yen/y or more for high categories.

[c] Test for linear trend in general linear regression.

[d] Sum of eicosapentaenoic, docosapentaenoic, and docosahexaenoic acids.

associated positively with the intake of protein; total n-3 and marine-origin n-3 polyunsaturated fatty acids; dietary fiber; cholesterol; potassium; calcium; magnesium; iron; vitamins A, D, E, and C; and folate and inversely with that of carbohydrate. No associations were seen between education and intake of other nutrients, including total fat, saturated, monounsaturated, total and n-6 polyunsaturated fatty acids, alcohol, or sodium. At the food level, higher education was associated with a higher intake of vegetables, fish and shellfish, and potatoes and lower intake of rice. Education was not associated with the intake of other foods, including bread, noodles, confectioneries and sugars, fats and oils, pulses and nuts, meat, eggs, dairy products, or fruit. By occupation, housewives had a higher intake of dietary fiber, magnesium, iron, vitamin A, folate, and pulses and nuts than working women. No differences between the 2 occupation groups were seen in the intake of other nutrients or foods. Household income was not associated with any of the nutrients or foods.

4. Discussion

In this cross-sectional study of a group of pregnant Japanese women, higher education was associated with favorable dietary intake patterns, such as a higher intake of protein, total and marine-origin n-3 polyunsaturated fatty acids; dietary fiber; potassium; calcium; magnesium; iron; vitamins A, D, E, and C; and folate and a higher intake of vegetables, fish and shellfish, and potatoes. Conversely, occupation and household income did not seem to be materially associated with dietary intake, although housewives had higher intake than working women of several important nutrients including dietary fiber, magnesium, iron, vitamin A, and folate. To our knowledge, this is the first study to investigate the association of socioeconomic position with dietary intake in a Japanese population.

A large number of Western studies have indicated positive association between socioeconomic position and diet quality. Generally, individuals with higher education, occupation, or income level have a higher intake of 'healthy' foods such as whole grains, lean meats, fish, low-fat dairy products, and fresh vegetables and fruits and a lower intake of 'unhealthy' foods such as fatty meats, refined grains, and added fats, resulting in higher intake of important nutrients such as dietary fiber, calcium, iron, and vitamin C [4-12]. The different socioeconomic indicators (ie, education, occupation, and income) appear to have similar, but independent, effects on nutrition and diet [4-8], although several studies have shown that education is the strongest determinant of socioeconomic differences in diet [9-12]. In this study, education, but not occupation or household income, was positively associated with favorable dietary intake patterns, a finding not fully consistent with previous Western studies. The strong influence of education (but not occupation or household income) on diet we observed may be due, at least in part, to the fact that the subjects were pregnant women. During pregnancy, women likely care more seriously about their diet and have a greater knowledge of dietary recommendations, and thus, their food choices are likely determined based on the ability to understand dietary recommendations (ie, education) rather than other socioeconomic factors (eg, occupation and income). In this regard, a small study of pregnant Austrian women reported that the influence of education on diet quality was stronger than that of occupation and income [17]. Positive associations between education and diet quality have also been reported in several other groups of pregnant women, although these studies did not take other socioeconomic factors sufficiently into account [18-21]. Alternatively, the inconsistency between our present and previous Western studies may reflect different socioeconomic-diet associations between Western countries and Japan. The present results support our hypothesis that the association between socioeconomic position and dietary intake in Japanese somewhat differs from that observed in Western populations. Further investigation in the general Japanese population is warranted.

The strengths of this study include the homogeneity of the study subjects, who consisted of pregnant Japanese women with a similar residential background; use of the 3 core indicators of socioeconomic position (ie, education, occupation, and income); assessment of habitual diets using a validated instrument (ie, DHQ); and adjustment for extensive information on potential confounding factors.

Several limitations also warrant mention. First, response rate for the 627 women living in Neyagawa City was only 17.2%, whereas that for the remaining 375 living in other areas could not be calculated because the exact number of eligible subjects among the sources from which they were recruited was not available. The participants were also women during pregnancy. Thus, the study subjects were likely not representative of Japanese women in the general population, and distribution of socioeconomic position in fact differed considerably from that in the general Japanese population (47.4% low, 32.1% medium, and 15.5% high education [33]; 67.6% outside work [34]; and median household income [adjusted for household size and composition] 2 627 000 yen) [35], although for intakes of energy, protein, fat, and carbohydrate at least, mean values in this study (1829 kcal/d, 61.0 g/d, 61.4 g/d, and 253.1 g/d, respectively) were relatively comparable with those of the general population (1771 kcal/d, 66.3 g/d, 53.9 g/d, and 244.6 g/d, respectively) [36]. Therefore, the present results may not be extrapolatable to the general Japanese population.

Second, as with many other studies, dietary intake information relied on the participants' self-reported dietary behavior. Higher socioeconomic groups generally have a greater knowledge of dietary recommendations [3] and may therefore be more inclined to report 'more favorable' dietary behaviors [37]. We used energy-adjusted values of dietary intake to minimize the potential dietary reporting bias associated with socioeconomic position [38]. We cannot quantify the effects of possible reporting error on the results of this study because of a lack of information on reporting bias associated with socioeconomic position. Nevertheless, it is unlikely that potential reporting bias fully accounts for our observed findings because the positive association with dietary intake was found only for education and not for occupation or income. Finally, the cross-sectional nature of the study hampers the drawing of conclusions on any causal inferences between socioeconomic position and dietary intake.

In conclusion, education, but not occupation or household income, was positively associated with favorable dietary intake patterns in a group of pregnant Japanese women. Nutrition education taking into consideration these socioeconomic differences in diet would be effective for pregnant Japanese women. Because the relation between socioeconomic position and dietary intake is an important public health topic, further research is needed to determine whether the results obtained in this specific group of subjects would also be observed in a more representative sample of the Japanese population.

Acknowledgment

We thank the Neyagawa City Government, Hirakata City Government, Katano City Government, Shijonawate City Government, Kaizuka City Government, Takaishi City Government, Hannan City Government, Neyagawa City Medical Association, Hirakata City Medical Association, and Kadoma City Medical Association for their valuable support, and Tomoko Shibazaki, Nahoko Nishimura, and Naomi Takaoka for their assistance. This study was supported by a Grant-in-Aid (13770206, 16790351) for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology and Health and Labour Sciences Research Grants, Research on Allergic Disease and Immunology from the Ministry of Health, Labour and Welfare. Other members of the OMCHS Group are as follows: Shoichi Miyamoto (Department of Public Health, Osaka City University Graduate School of Medicine); Ichiro Matsunaga, Toshiaki Yoshida, and Hajime Oda (Osaka Prefectural Institute of Public Health); Hideharu Kanzaki and Mitsuyoshi Kitada (Department of Obstetrics and Gynecology, Kansai Medical University); Yorihiko Horikoshi (Department of Obstetrics and Gynecology, Kansai Medical University Kori); Osamu Ishiko, Yuichiro Nakai, Junko Nishio, and Seiichi Yamamasu (Department of Obstetrics and Gynecology, Osaka City University Graduate School of Medicine); Jinsuke Yasuda (Department of Obstetrics and Gynecology, Matsushita Memorial Hospital); Seigo Kawai (Department of Obstetrics and Gynecology, Hoshigaoka Koseinenkin Hospital); Kazumi Yanagihara (Yanagihara Clinic); Koji Wakuda (Department of Obstetrics and Gynecology, Jujimoto Hospital); Tokio Kawashima (Kyoritsu Women's Clinic); Katsuhiko Narimoto (Ishida Hospital Obstetrics, Gynecology); Yoshihiko Iwasa (Iwasa Women's Clinic); Katsuhiko Orino (Orino Lady's Clinic); Itsuo Tsunetoh (Tsunetoh Obstetrics and Gynecology); Junichi Yoshida (Yoshida Clinic); Junichi Iito (Iito Obstetrics and Gynecology Clinic); Takuzi Kaneko (Kaneko Sanfujinka); Takao Kamiya (Kamiya Ladies Clinic); Hiroyuki Kuribayashi (Kuribayashi Clinic); Takeshi Taniguchi (Taniguchi Hospital); Hideo Takemura (Kosaka Women's Hospital); and Yasuhiko Morimoto (Aizenbashi Hospital).

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Nutrition 25 (2009) 640–646

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Neighborhood food store availability in relation to food intake in young Japanese women

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Manuscript received November 4, 2008; accepted January 2, 2009.

Abstract

Objective: Information on the association between the local food environment and the diet of individuals is limited, particularly in settings with high population density and, hence, high food-store density, such as Japan. This cross-sectional study examined the association between neighborhood food-store availability and individual food intake in a group of young Japanese women.

Methods: Participants were 990 female Japanese dietetic students 18–22 y of age. Neighborhood food-store availability was defined as the number of food stores within a 1-km mesh-block of residence, derived from the census of commerce. Dietary intake was estimated using a validated, comprehensive self-administered diet-history questionnaire.

Results: After adjustment for potential confounding factors, including household socioeconomic status, geographic variables, and the frequency of eating out, neighborhood store availability for confectioneries and bread (based on confectionery stores/bakeries, supermarkets, and grocery and convenience stores) was significantly positively associated with the intake of confectioneries and bread. No significant independent association was seen between neighborhood store availability for the other foods examined, including meat (meat stores, supermarkets, and grocery stores), fish (fish stores, supermarkets, and grocery stores), fruit and vegetables (fruit/vegetable stores, supermarkets, and grocery stores), and rice (rice stores, supermarkets, and grocery and convenience stores) with intake of each food.

Conclusion: In a group of young Japanese women, increasing neighborhood store availability for confectioneries and bread was independently associated with higher intake of confectioneries and bread. In contrast, no association between availability and intake was seen for meat, fish, fruit and vegetables, or rice.

Keywords: Neighborhood; Food-store availability; Food intake; Young women; Japan; Epidemiology

Introduction

Growing recognition of the importance of diet on health has been accompanied by increasing attention to factors associated with access to healthy foods. However, findings in the increasing, albeit still limited, number of studies examining associations between local food environments and resident diets have been inconsistent [1–7]. In a number of U.S. studies, the availability of a least one supermarket in census tracts was associated with a higher likelihood of meeting guidelines for fruit and vegetables and guidelines for total fat and saturated fat in adults who lived in these census tracts [1]; a shorter distance from home to a food store was associated with a greater use of fruit in low-income households [2]; proximity to a supermarket was associated with a better diet quality in pregnant women [3]; and participants with no supermarket near their homes were less likely to have a healthy diet than those with the most stores [4]. In a national study in New Zealand, conversely, access to supermarkets

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0899-9007/09/$ – see front matter © 2009 Published by Elsevier Inc.
doi:10.1016/j.nut.2009.01.002

was not associated with fruit and vegetable consumption, although better access to convenience stores was associated with a lower intake of vegetables, but not of fruit [5]. In addition, better access to food stores was not associated with consumption of fruit or vegetables in U.S. adults [6] or in a British population [7].

Except for the study in the United Kingdom, however, which has a population density of 244 persons/km^2, these previous studies were to our knowledge conducted in settings with a low population density and, hence, low food-store density, namely the United States and New Zealand (population densities 32 and 15 persons/km^2, respectively) [8]. Information is lacking for settings with a high population density and, hence, high food-store density, including Japan (population density 339 persons/km^2) [8]. In addition, most of these studies focused only on fruit and vegetable intake and gave little or no consideration to other food groups [1,2,5–7], and only a few used a validated dietary assessment instrument [1,3,4].

We speculated that several characteristics of the Japanese diet (e.g., high intake of rice) [9] and food store environment (e.g., high density of a wide variety of stores, including fresh-produce stores) [10] would provide insights into the influence of a local food environment on an individual diet. We conducted a cross-sectional study of the association between neighborhood food-store availability and food intake as assessed using a validated, comprehensive self-administered diet-history questionnaire (DHQ) [11–14] in a group of young Japanese women.

Materials and methods

Study sample

The present study was based on data from the Japan Dietetic Students' Study for Nutrition and Biomarkers, a cross-sectional multicenter survey conducted from February to March 2006 and from January to March 2007 in female dietetic students from 15 institutions in Japan. A total of 1176 Japanese women took part. A detailed description of the study design and survey procedure has been published elsewhere [15–17]. In the present study, 1-km mesh-blocks (approximately a 1- × 1-km square) were used as approximations of neighborhoods. Using their home addresses as reported in the lifestyle questionnaire, study participants were geocoded to 1-km mesh-blocks by exact address matching.

For the present analysis, we selected women 18–22 y of age (n = 1154). We then excluded women not providing sufficient information on their home addresses (n = 163), those who reported extremely low or high energy intakes (<500 or >4000 kcal/d, n = 3), and those with missing information on the variables used (n = 1). Because some participants were in more than one exclusion category, the final analysis sample comprised 990 women who resided in 704 neighborhoods (i.e., 1-km mesh-blocks).

This study was approved by the ethics committee of the National Institute of Health and Nutrition, Japan. Written informed consent was obtained from each participant and from a parent for participants younger than 20 y.

Neighborhood food-store availability

Neighborhood food-store availability was characterized by the number of stores offering foods in the neighborhood (i.e., 1-km mesh-block) in which a participant lived. Data on the number of food stores within the 1-km mesh-blocks were derived from the census of commerce of 2002 [10], which included data on supermarkets, grocery stores, meat stores, fish stores, fruit/vegetable stores, confectionery stores/bakeries, rice stores, and convenience stores (but not dining establishments). Confectionery stores and bakeries were combined in this census, mainly because of the widespread availability in Japan of various breads with sweet fillings (e.g., sweetened *azuki* bean paste), and bakeries commonly offer not only bread but also confectioneries such as cakes, cookies, and biscuits.

In Japan, supermarkets and grocery stores generally provide a wide range of food options including fresh produce, whereas convenience stores generally offer a variety of processed foods such as confectioneries and ready-to-eat meals including rice bowls and sandwiches with a limited amount of meat, fish, fruit, and vegetables as ingredients. Based on this, neighborhood store availability for each food was defined as follows: for meat, the sum of the number of meat stores, supermarkets, and grocery stores; for fish, the sum of the number of fish stores, supermarkets, and grocery stores; for fruit and vegetables, the sum of the number of fruit/vegetable stores, supermarkets, and grocery stores; for confectioneries and bread, the sum of the number of confectionery stores/bakeries, supermarkets, grocery stores, and convenience stores; and for rice, the sum of the number of rice stores, supermarkets, grocery stores, and convenience stores.

Food intake

Dietary habits during the preceding month were assessed using a comprehensive self-administered DHQ. Details of the DHQ's structure, calculation of dietary intake, and validity for commonly studied nutritional factors have been published elsewhere [11–14]. Briefly, the DHQ is a structured 16-page questionnaire that asks about the consumption frequency and portion size of selected foods commonly consumed in Japan, general dietary behavior, and usual cooking methods [11]. Estimates of daily intake for foods (150 items in total) and energy were calculated using an ad hoc computer algorithm for the DHQ [11,12] based on the standard tables of food composition in Japan [18].

In accordance with the data for neighborhood food-store availability, the following five food groups were considered: meat, fish, fruit and vegetables, confectioneries and bread, and rice (categorization of food groups has been published elsewhere [19]). To minimize the influence of dietary misreporting, an ongoing controversy in studies that collect dietary information using self-report instruments [20], the intake of each food group was adjusted by energy using the density method (grams per 1000 kcal). In a previous study of 92 women 31–69 y of age, Pearson's correlation coefficients between the DHQ and 16-d weighed dietary records were 0.66 for meat, 0.55 for fish and shellfish, 0.51 for fruit and vegetables, 0.51 for confectioneries and bread, and 0.64 for rice (S. Sasaki, unpublished observations, 2006), suggesting satisfactory validity of the DHQ in terms of these food groups.

Other variables

Based on the reported home address, each participant was grouped into one of six regions (Hokkaido and Tohoku, Kanto, Hokuriku and Tokai, Kinki, Chugoku and Shikoku, and Kyushu) and into one of three municipality levels (ward, city, and town and village). The participant was also grouped into one of four institution types (4-y private, 2-y private, 4-y public, and 2-y public) based on the institution she attended and into one of three living statuses (living with family, living alone, and living with others) as self-reported in the lifestyle questionnaire. Frequency of eating out (including school cafeteria) was self-reported as part of the DHQ (at least once per day, four to six times per week, two to three times per week, once per week, and less than once per week). Body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively, while wearing light clothes and no shoes. Body mass index was calculated as body weight (kilograms) divided by the square of body height (meters).

Statistical analysis

All statistical analyses were performed using SAS 9.1 (SAS Institute, Cary, NC, USA). For each of the five foods examined, linear regression models were constructed to examine the association of neighborhood food-store availability with food intake, using the PROC GLM procedure. For analyses, participants were categorized into approximate quartiles according to neighborhood store availability for each food. Multivariate adjusted mean values (with 95% confidence interval) of intake of each food were calculated by approximate quartile of neighborhood store availability for each food. Three models were constructed with a range of potential confounding factors. In model 1, the association was examined with adjustment for survey year (2006 and 2007). In model 2, household socioeconomic variables, i.e., institution type [21] and living status [19], and frequency of eating out were also included. In model 3, geographical variables, i.e., region and municipality level, were also included. We tested for linear trends with increasing levels of neighborhood food-store availability by assigning each participant the median value for the category and modeling this value as a continuous variable. All reported P values are two-tailed, and $P < 0.05$ was considered statistically significant. Because 90% of neighborhoods (i.e., 1-km mesh-blocks) had only one study participant, and only 3% had five or more participants, no special methods were needed to account for within-neighborhood correlations in outcomes.

Table 1
Participant characteristics (n = 990)*

Variable	
Age (y)	19.6 ± 1.0
Body height (cm)	158.2 ± 5.5
Body weight (kg)	53.6 ± 7.8
Body mass index (kg/m^2)	21.4 ± 2.8
Region	
Hokkaido and Tohoku	2.5
Kanto	56.1
Hokuriku and Tokai	10.8
Kinki	11.4
Chugoku and Shikoku	2.9
Kyushu	16.3
Municipality level	
Ward	17.3
City	76.3
Town and village	6.5
Survey year	
2006	41.6
2007	58.4
Institution type	
4-y private	70.8
2-y private	6.0
4-y public	14.2
2-y public	9.0
Living status	
Living with family	64.7
Living alone	32.1
Living with others	3.2
Frequency of eating out	
≥1 time/d	9.4
4–6 times/wk	21.0
2–3 times/wk	29.3
1 time/wk	19.7
<1 time/wk	20.6
Food intake (g/1000 kcal)	
Meat	33.8 ± 16.8
Fish	28.5 ± 15.1
Fruit and vegetables	180.6 ± 93.5
Confectioneries and bread	69.3 ± 32.1
Rice	156.6 ± 63.7
Neighborhood food store availability (number of food stores within 1-km mesh-block of residence)	
Meat	2.29 ± 2.48
Fish	2.31 ± 2.45
Fruit and vegetables	3.17 ± 3.51
Confectioneries and bread	8.70 ± 8.64
Rice	5.15 ± 5.34

* Values are means ± SDs or percentages of participants.

Results

Characteristics of participants are listed in Table 1. As expected, neighborhood store availability for the five foods examined was highly correlated (Pearson's correlation coefficients 0.82–0.94). Potential confounding factors according to approximate quartile category of neighborhood store availability for confectioneries and bread (as an example) are listed in Table 2. Neighborhood store availability for confectioneries and bread was associated with region, municipality level, institution type, and living status. The higher quartiles of neighborhood store availability for confectioneries and bread (higher availability) included more participants living in Kanto and fewer participants living in Hokuriku and Tokai and Kyushu; more participants living in wards and fewer living in cities and towns and villages; more participants attending 4-y private institutions and fewer attending 2-y private and 4-y public institutions; and more participants living alone and fewer living with family. No association was seen for survey year or frequency of eating out. According to approximate quartile category of neighborhood store availability for other foods, namely meat, fish, fruit and vegetables, and rice, similar patterns were observed for potential confounding factors (data not shown).

Food intake according to approximate quartile category of neighborhood store availability for each food is presented in Table 3. No association between intake and neighborhood food-store availability was seen for meat, fish, or fruit and vegetables, regardless of adjustment for potential confounding factors. However, increasing neighborhood store availability for confectioneries and bread was significantly associated with higher intakes of these items after adjustment for survey year. This significant positive association remained after further adjustment for not only household socioeconomic variables (institution type and living status) and frequency of eating out but also geographic variables (region and municipality level). Conversely, increasing neighborhood store availability for rice was significantly associated with lower intakes of rice after adjustment for

Table 2
Geographical and household socioeconomic status characteristics and frequency of eating out according to approximate quartile category of neighborhood store availability for confectioneries and bread (n = 990)*

Variable	Quartile 1 (n = 280)	Quartile 2 (n = 245)	Quartile 3 (n = 218)	Quartile 4 (n = 247)	$P^{\dagger}$
Region					<0.0001
Hokkaido and Tohoku	2.1	3.7	3.7	0.8	
Kanto	38.6	55.5	56.9	75.7	
Hokuriku and Tokai	16.4	12.7	8.3	4.9	
Kinki	13.9	4.5	15.6	11.7	
Chugoku and Shikoku	3.6	3.3	5.1	0	
Kyushu	25.4	20.4	10.6	6.9	
Municipality level					<0.0001
Ward	3.9	13.5	18.4	35.2	
City	82.9	80.0	77.1	64.4	
Town and village	13.2	6.5	4.6	0.4	
Survey year					0.80
2006	40.7	41.6	39.9	44.1	
2007	59.3	58.4	60.1	55.9	
Institution type					<0.0001
4-y private	60.4	70.6	70.2	83.4	
2-y private	12.9	6.5	1.8	1.2	
4-y public	17.5	14.3	14.7	10.1	
2-y public	9.3	8.6	13.3	5.3	
Living status					<0.0001
Living with family	78.9	59.2	70.6	48.6	
Living alone	18.2	38.8	26.2	46.6	
Living with others	2.9	2.0	3.2	4.9	
Frequency of eating out					0.17
≥1 time/d	6.8	10.6	8.7	11.7	
4–6 times/wk	17.9	19.2	26.6	21.5	
2–3 times/wk	29.3	33.1	28.4	26.3	
1 time/wk	22.1	20.4	16.5	19.0	
<1 time/wk	23.9	16.7	19.7	21.5	

* Values are percentages of participants. According to approximate quartile category of neighborhood store availability for other foods including meat, fish, fruit and vegetables, and rice, similar patterns were observed.

† Chi-square test.

survey year and household socioeconomic variables. However, this association disappeared after further adjustment for geographic variables.

Discussion

In this cross-sectional study of a group of young Japanese women, we found that neighborhood store availability for confectioneries and bread was independently and positively associated with dietary intake of these items. Conversely, no independent association between availability and dietary intake was observed for meat, fish, fruit and vegetables, or rice. To our knowledge, this is the first study to investigate the association between neighborhood food-store availability and dietary intake regarding a variety of foods in a setting with a high population density and, hence, a high density of food stores.

Our finding that local food environment is associated with at least some aspects of a resident's diet is consistent with several previous studies [1–5]. Our present association of neighborhood food-store availability with the intake of confectioneries and bread only, and not with that of other foods, including meat, fish, fruit and vegetables, or rice, is reasonable, considering that confectioneries and bread are generally ready to eat, whereas most other foods require a degree of preparation (e.g., cooking and peeling). The inverse association between neighborhood store availability for rice and rice intake observed before adjustment for geographic variables may be due to regional differences in rice intake consistently observed in Japan (in particular, a high intake in Kyushu and a low intake in Kanto) [9].

Table 3
Food intake (grams per 1000 kcal) according to approximate quartile category of neighborhood food store availability (number of food stores within a 1-km mesh-block of residence; n = 990)*

Variable	Quartile 1	Quartile 2	Quartile 3	Quartile 4	$P^{\dagger}$
Neighborhood store availability for meat	0 (0)	1 (1)	3 (2–3)	5 (4–17)	
n	255	212	319	204	
Meat intake					
Model 1‡	35.0 (33.0–37.1)	33.7 (31.4–35.9)	31.4 (29.5–33.2)	36.1 (33.8–38.4)	0.95
Model 2§	34.6 (32.6–36.6)	34.0 (31.8–36.2)	32.4 (30.6–34.2)	34.7 (32.4–36.9)	0.68
Model 3‖	34.1 (32.0–36.2)	34.5 (32.3–36.7)	32.7 (30.9–34.5)	34.4 (32.0–36.8)	0.75
Neighborhood store availability for fish	0 (0)	1 (1)	2 (2–3)	4 (4–20)	
n	254	230	231	275	
Fish intake					
Model 1‡	26.2 (24.3–28.0)	29.0 (27.1–30.9)	32.1 (30.1–34.0)	27.4 (25.6–29.1)	0.53
Model 2§	25.6 (23.8–27.4)	29.4 (27.6–31.3)	31.0 (29.2–32.8)	28.4 (26.7–30.1)	0.09
Model 3‖	25.5 (23.6–27.3)	29.5 (27.6–31.4)	30.9 (29.0–32.7)	28.6 (26.8–30.3)	0.08
Neighborhood store availability for fruit and vegetables	0 (0)	1 (1)	3 (2–5)	6 (6–25)	
n	222	199	337	232	
Fruit and vegetable intake					
Model 1‡	180.7 (168.4–193.0)	191.0 (178.0–203.9)	182.4 (172.5–192.4)	169.2 (157.1–181.2)	0.06
Model 2§	177.7 (165.3–190.2)	194.0 (181.1–206.9)	180.0 (170.0–189.9)	172.9 (160.8–185.1)	0.16
Model 3‖	175.4 (162.5–188.4)	195.1 (182.0–208.1)	180.0 (170.0–189.9)	174.3 (161.4–187.2)	0.27
Neighborhood store availability for confectioneries and bread	1 (0–2)	5 (3–6)	9 (7–13)	17 (14–55)	
n	280	245	218	247	
Confectionery and bread intake					
Model 1‡	64.1 (60.4–67.8)	68.7 (64.7–72.7)	69.6 (65.4–73.8)	75.5 (71.5–79.5)	<0.0001
Model 2§	66.1 (62.3–69.8)	67.7 (63.8–71.6)	69.7 (65.6–73.9)	74.1 (70.2–78.1)	0.003
Model 3‖	66.9 (63.0–70.8)	68.2 (64.3–72.1)	69.1 (64.9–73.2)	73.2 (69.0–77.5)	0.04
Neighborhood store availability for rice	1 (0–1)	2 (2–3)	6 (4–7)	12 (8–38)	
n	283	193	323	191	
Rice intake					
Model 1‡	166.5 (159.1–173.8)	159.3 (150.4–168.1)	151.3 (144.4–158.1)	148.1 (139.2–157.0)	0.001
Model 2§	163.1 (155.8–170.5)	160.4 (151.7–169.1)	153.2 (146.5–160.0)	148.5 (139.7–157.4)	0.007
Model 3‖	158.5 (150.8–166.2)	160.9 (152.2–169.6)	155.7 (148.8–162.5)	150.8 (140.9–160.7)	0.16

* Values are medians (ranges) for neighborhood food store availability or means (95% confidence intervals) for food intake.

† A linear trend test was used with the median value in each quintile category as a continuous variable in linear regression.

‡ Adjusted for survey year (2006 and 2007).

§ Adjusted for survey year, institution type (4-y private, 2-y private, 4-y public, and 2-y public), living status (living with family, living alone, and living with others), and frequency of eating out (at least once per day, four to six times per week, two to three times per week, once per week, and less than once per week).

‖ Adjusted for survey year, institution type, living status, frequency of eating out, region (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu), and municipality level (ward; city; and town and village).

However, our results are based on a highly selected population and thus are not likely to extrapolate to the general Japanese population. The participants were selected female dietetic students, and owing to the recruitment procedure used, the response rate could not be precisely determined, although the approximate rate was 56%. These elements of the design may have produced recruitment bias. As such the participants likely had a higher education level and a greater knowledge of diet and nutrition than the general population. Given the finding of an association in this population, in which education and nutritional knowledge likely had a greater influence on food choice than the local food environment, associations between availability and intake might be expected to be stronger in the general Japanese population.

Several limitations of the present study deserve mention. First, the cross-sectional nature of the study hampers the drawing of any conclusions on causal inferences between neighborhood food-store availability and food intake. Second, we did not have information on where participants actually shopped for food. As such our exposure variable is only a proxy for the neighborhood food environment. Third, we used an arbitrary unit (i.e., 1-km mesh-block) as approximations of neighborhoods, but these units may not represent the area of actual relevance to the food-shopping habits of a particular individual. For example, reliance on the neighborhood environment for food may differ by other factors such as transportation use, information that was not available in the present study. Fourth, the number and type of stores used as proxies for the availability of several foods may be a limitation; more specific information regarding the types and costs of foods sold at these establishments may have been useful. Fifth, because data for food stores (2002) and dietary intake (2006 and 2007) were collected at different times, the present study had to be based on the assumption that the food environment remained constant from 2002 to 2007. Sixth, we were unable to control for other factors that may influence individual dietary choices, and these may also be associated with the neighborhood food environment (e.g., personal food preferences).

Conclusion

In young Japanese women, increasing neighborhood store availability for confectioneries and bread was independently associated with a higher intake of these items, whereas no such association was seen for meat, fish, fruit and vegetables, or rice. Because of the cross-sectional design, any firm conclusions on this issue require additional studies.

Acknowledgments

The authors thank Keika Mine, Yoko Hosoi, Mami Itabashi, Tomono Yahata, Asako Ishiwaki, and Kyoko Saito (National Institute of Health and Nutrition) for data collection.

Appendix

The members of the Japan Dietetic Students' Study for Nutrition and Biomarkers Group (in addition to the authors) are as follows: Mitsuyo Yamasaki, Yuko Hisatomi, Junko Soezima, and Kazumi Takedomi (Nishikyushu University); Toshiyuki Kohri and Naoko Kaba (Kinki University); Etsuko Uneoka (Otemae College of Nutrition); Hitomi Hayabuchi and Yoko Umeki (Fukuoka Women's University); Keiko Baba and Maiko Suzuki (Mie Chukyo University Junior College); Reiko Watanabe and Kanako Muramatsu (Niigata Women's College); Kazuko Ohki, Seigo Shiga, Hidemichi Ebisawa, and Masako Fuwa (Showa Women's University); Tomoko Watanabe, Ayuho Suzuki, and Fumiyo Kudo (Chiba College of Health Science); Katsumi Shibata, Tsutomu Fukuwatari, and Junko Hirose (The University of Shiga Prefecture); Toru Takahashi and Masako Kato (Mimasaka University); Toshinao Goda and Yoko Ichikawa (University of Shizuoka); Junko Suzuki, Yoko Niida, Satomi Morohashi, Chiaki Shimizu, and Naomi Takeuchi (Hokkaido Bunkyo University); Jun Oka and Tomoko Ide (Tokyo Kasei University); and Yoshiko Sugiyama and Mika Furuki (Minamikyushu University).

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