Dietary Patterns and A1C in Japanese Men and Women

Akiko Nanri, msc[1]
Tetsuya Mizoue, md, phd[2]
Daigo Yoshida, msc[1]

Ryota Takahashi, md[3]
Ryoichi Takayanagi, md, phd[4]

OBJECTIVE — Dietary patterns in Western populations have been linked to type 2 diabetes, but the role of diet in Japanese remains unclear. We investigated the association between major dietary patterns and glucose tolerance status as measured by A1C in Japanese adults.

RESEARCH DESIGN AND METHODS — The groups of subjects were comprised of 3,243 men and 4,667 women who participated in the baseline survey of an ongoing cohort study on lifestyle-related diseases in Fukuoka, Japan. Dietary patterns were derived by using principal-component analysis of the consumption of 49 food items, ascertained by a food-frequency questionnaire. Logistic regression analysis was used to estimate sex-specific odds ratios (ORs) of elevated A1C ($\geq 5.5\%$), with adjustment for potential confounding variables.

RESULTS — The Westernized breakfast pattern characterized by frequent intake of bread but infrequent intake of rice was inversely related to A1C concentrations ($P_{trend} = 0.02$ in both men and women); the multivariate-adjusted ORs for the highest versus lowest quintiles were 0.60 (95% CI 0.43–0.84) and 0.64 (0.46–0.90) for men and women, respectively. The seafood dietary pattern was positively associated with A1C concentrations in men only ($P_{trend} = 0.01$). Neither the healthy nor high-fat dietary pattern was related to A1C.

CONCLUSIONS — A dietary pattern featuring frequent intake of white rice may deteriorate glucose metabolism in Japanese men and women, and the salty seafood dietary pattern may have a similar effect in men.

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T he prevalence of type 2 diabetes is increasing worldwide (1). Likewise, the Japanese, who have experienced rapid economic growth during the past several decades, now have a high prevalence of type 2 diabetes (2). However, this situation seems peculiar given that obesity, a strong determinant of the disease (3), is much less common among Japanese than among Western populations (4,5). It has been postulated that the Japanese are predisposed to type 2 diabetes because of their low levels of insulin secretion and sensitivity, which may be determined by both genetic and environmental factors (4,5). The investigation of a Japanese

diet in relation to type 2 diabetes may provide a clue to the issue.

The relation of specific foods and nutrients such as vegetables (6), dietary fiber (7), and glycemic load (8) to risk of type 2 diabetes has been examined in many studies, but few have addressed the association with dietary patterns. Although the effect of a single nutrient, food, or food group on disease risk and morbid conditions has often been investigated, such an effect is difficult to assess in observational studies because foods and nutrients are consumed in combination, and their complex effects are likely to be interactive or synergistic (9). To overcome

problems relating to the close intercorrelation among foods or nutrients, analysis of dietary patterns has gained much interest. A dietary pattern is a comprehensive variable that integrates consumption of several foods or food groups and is expected to have a greater impact on disease risk than any single nutrient (9). Studies in Western populations have suggested that risk of type 2 diabetes is associated inversely with prudent or healthy dietary patterns (10–12) and positively with a Western dietary pattern (11–14). To the best of our knowledge, however, only one study reported an association between a Japanese dietary pattern and type 2 diabetes (15). The aim of the present study was, therefore, to investigate dietary patterns in relation to glucose tolerance status as measured by A1C concentrations in Japanese adults.

RESEARCH DESIGN AND
METHODS — The subjects were participants in the baseline survey of the ongoing cohort study on lifestyle-related diseases. Details of the study procedure have been described elsewhere (16). In short, eligible individuals were residents of the East Ward of Fukuoka City who were aged 50–74 years at the time of referral to the resident registry. Some areas in the ward were excluded with consideration for study efficiency and potential difficulties in the follow-up surveys. Eligible residents were invited to participate in the study by mail. Potential participants were informed of details of the baseline and follow-up surveys. Participants completed a self-administered questionnaire, blood pressure measurements, anthropometric measurements, and venous blood drawing. The questionnaire inquired about smoking, alcohol drinking, physical activity, sleeping, stress, dietary intake, diseases under current or previous treatment, use of drugs and supplements, and parental history of selected diseases. BMI was calculated as weight in kilograms divided by the square of height in meters. A1C concentrations were measured at an external laboratory (SRL, Hachiohji, Japan) by using latex agglutination turbidimetry on an autoanalyzer (JEOL, Tokyo, Japan). The study was approved by the ethics committee of Kyushu Uni-

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versity Faculty of Medical Sciences. All of the study subjects gave written informed consent before their participation in this study.

During the period between February 2004 and July 2006, a total of 10,447 individuals (22.9% of 45,634 eligible individuals) participated in the survey. The participation rate was higher among women and individuals aged 60 years or older than among those of younger ages. We excluded 910 subjects with a history of diabetes and an additional 1,619 subjects with a history of cardio- and cerebrovascular disease, cancer, liver disease, chronic renal failure, pancreas disease, adrenal disease, or alcohol addiction. After further exclusion of 8 subjects with missing information on covariates, 7,910 subjects (3,243 men and 4,667 women) remained for the analysis.

Dietary assessment

The food-frequency questionnaire method was used to assess intakes of 60 food and beverage items on average over the past year. Dietary questions were derived primarily from the 47-item food-frequency questionnaire (17), which was validated with 3-day weighted diet records; most of the nutrients showed correlation coefficients of 0.4–0.6 (18). Frequency of consumption of staple foods (rice, bread, and noodles) was measured on a scale of six categories ranging from almost null to daily for each breakfast, lunch, and supper. Regarding food items other than the staple foods, participants answered consumption frequency by choosing one of eight options ranging from almost null to three or more times/ day. The reported frequency of consuming each food was converted to a frequency of consumption per week, with somewhat conservative values assigned to greater frequency categories: 6.5 to 1 time/day, 10.5 to 2 times/day, and 17.5 to ≥3 times/day. Regarding each of the staple foods, values of weekly frequency (0– 6.5) were summed over the three meals. The amount consumed per occasion was asked for the staple foods, but this information was not used.

Statistical analysis

We performed principal component analysis based on 49 food items to derive dietary patterns; questions of beverages (six items) and dishes (five items) were not considered. Principal component analysis is a technique to reduce a number of variables into fewer independent factors. The

factors were rotated by orthogonal transformation (varimax rotation) to maintain uncorrelated factors and greater interpretability. We considered eigenvalues, the scree test, and the interpretability of the factors to determine the number of factors to retain. The factors satisfied the criteria for eigenvalues >1, and the scree plots dropped substantially after the third factor (from 2.37 to 1.68) and remained similar after the fourth factor (1.47 for the fifth and 1.40 for the sixth factor); thus, we decided to retain four factors. We confirmed that when the analysis was done separately for men and women, similar dietary patterns were extracted for each sex. Dietary patterns were named according to the food items showing high loading (absolute value) on each of four factors. The factor scores for each dietary pattern and for each individual were calculated by summing intakes of food items weighted by their factor loadings. Factor scores were categorized into quintiles based on the distribution for men and women separately.

The confounding variables considered were age (years), BMI (<22.5, 22.5–24.9, 25.0–27.4, and ≥27.5 kg/m^2), smoking (lifetime nonsmoker, former smoker, and current smoker with a consumption of <20 or ≥20 cigarettes/day), alcohol consumption (nondrinker, former drinker, and current drinker with a consumption of <30, 30–59, or ≥60 g ethanol/day), physical activity (quartile of MET hours per week), and parental history of diabetes (absent or present). The trend was assessed by using the Mantel-Haenszel χ^2 test for categorical variables and linear regression analysis for continuous variables, assigning ordinal numbers 0–4 to quintile categories of each dietary pattern.

We defined high levels of A1C concentration according to the definition used in the National Health and Nutrition Survey in Japan, in which those with A1C concentrations of 5.5–6.0 and ≥6.1% were regarded as having "possible" and "probable" diabetes, respectively. The cutoff of 5.5% for A1C gave a sensitivity of 80.1% and a specificity of 78.5%, and A1C of 6.1% corresponded with a 2-h plasma glucose level of 200 mg/dl in an oral glucose tolerance test (19). Multiple logistic regression was performed to estimate the odds ratio (OR) and 95% CI of elevated A1C (≥5.5%) according to quintiles of scores for each dietary pattern, taking the lowest quintile group as the reference. The first model

was adjusted for age only, and the second model was further adjusted for BMI, smoking, alcohol consumption, physical activity, and parental history of diabetes. Because the results were similar in these models, we present the fully adjusted results only. Trend association was assessed by assigning ordinal numbers 0–4 to quintile categories of each dietary pattern. We repeated the analysis by using a more specific outcome criterion (A1C concentrations of ≥6.1%) while excluding subjects who had A1C concentrations of 5.5–6.0%. Two-sided P values < 0.05 were regarded as statistically significant. All analyses were performed using SAS (version 8.2; SAS Institute, Cary, NC).

RESULTS — We identified four dietary patterns by principal component analysis (Table 1). The first factor was named a healthy dietary pattern because it represented frequent consumption of vegetables, fruit, soy products, fish, and yogurt. The second factor was characterized by frequent consumption of fried food, meat, processed meat, mayonnaise, and egg, and thus it was named a high-fat dietary pattern. The third factor represented frequent consumption of a variety of seafoods including shellfish, salted fish guts, fish roe, and fish paste products, and the pattern was named a seafood dietary pattern. The fourth factor was a Westernized breakfast pattern characterized by frequent consumption of bread, margarine, and coffee and infrequent consumption of rice and miso soup. The first to fourth dietary patterns accounted for 16.8, 5.5, 4.8, and 3.4%, respectively, of the variance in food intakes and totally explained 30.5% of the variability.

The characteristics according to quintile categories of dietary pattern scores are shown in Table 2. In both men and women, participants with a higher score of the healthy dietary pattern were more likely to be older and physically active in leisure time and were less likely to be a smoker and alcohol drinker. Participants with a higher score of the high-fat dietary pattern were on average younger and more likely to be a smoker. The high-fat dietary pattern was also associated positively with BMI and inversely with physical activity in leisure time in women. Both men and women with a higher score of the seafood dietary pattern tended to drink alcohol more frequently and have higher BMI. Women, but not men, with a higher score of the Westernized breakfast

Table 1—*Factor-loading matrix for major dietary patterns identified by principal component analysis*

	Healthy pattern	High-fat pattern	Seafood pattern	Westernized breakfast pattern
Green-leaf vegetables	0.67	0.16	—*	—
Carrots	0.66	0.28	—	—
Mushrooms	0.66	0.19	—	—
Other green-yellow vegetables	0.65	0.22	—	—
Other vegetables	0.65	0.35	—	—
Seaweeds	0.63	—	—	−0.16
Daikon (Japanese radish)	0.61	0.17	—	−0.15
Potatoes	0.61	0.25	—	—
Other fruits	0.60	—	—	0.23
Pumpkin	0.57	—	—	—
Cabbage	0.55	0.35	—	—
Citrus fruits	0.54	—	—	0.15
Broccoli	0.49	—	—	—
Burdock/bamboo shoot	0.46	0.15	0.19	—
Bone-edible small fish	0.46	—	0.34	−0.15
Natto and soybean	0.46	—	—	—
Tofu products	0.44	0.20	0.21	—
Yogurt	0.42	−0.19	—	0.25
Fish	0.37	—	0.31	—
Kiriboshi-daikon*	0.35	—	0.26	—
Tofu (soybean curd)	0.35	—	0.22	—
Japanese confectioneries	0.32	—	—	0.16
Deep-fried foods	—	0.59	0.25	—
Beef/pork	—	0.58	—	—
Stirred foods	0.29	0.57	—	—
Mayonnaise	—	0.54	0.16	—
Chicken	—	0.49	—	—
Ham, sausage, and bacon	—	0.43	0.16	0.25
Egg	—	0.35	0.22	—
Squid/octopus and shrimp/crab	—	—	0.61	—
Shellfish	0.20	—	0.60	—
Fish roe	—	—	0.52	—
Salted fish guts	—	—	0.43	—
Fish paste products	—	0.31	0.39	—
Tsukudani†	—	—	0.37	—
Bread	—	—	—	0.79
Margarine	—	—	—	0.56
Coffee	—	0.21	—	0.31
Miso soup	0.30	—	—	−0.47
Rice	—	—	—	−0.74

Factor loadings less than ±0.15 are represented by a dash for simplicity. Omitted in the table are food items with factor loadings less than ±0.30 for all dietary patterns (green tea, peanut/almond, garlic, canned tuna, milk, liver, Western-style confections, butter, and noodles). *Dried strips of daikon (Japanese radish);. †Seafoods simmered in soy and sugar.

pattern were younger and had lower BMI, and they were more likely to be a smoker and physically active. The Westernized breakfast pattern was positively associated with the frequency of alcohol drinking in women, whereas the opposite was observed in men.

The ORs of elevated A1C (≥5.5%) according to quintile categories of each dietary pattern score are shown in Table 3. Of the subjects, 442 men (13.6%) and 514 women (11.0%) were identified as having elevated A1C concentrations. The Westernized breakfast pattern was significantly and inversely related to the prevalence of elevated A1C in both men and women. Multivariate-adjusted ORs (95% CI) of elevated A1C for the highest versus lowest quintile of the Westernized breakfast pattern score were 0.60 (0.43–0.84) and 0.64 (0.46–0.90) for men and women, re-

spectively. The seafood dietary pattern was positively related to the prevalence of elevated A1C in men. The odds of having elevated A1C for the fourth quintile of the seafood dietary pattern score was increased by >70% compared with that for the lowest quintile. Such an association was not observed in women. The healthy and high-fat dietary patterns were not statistically significantly related to the prevalence of elevated A1C.

In an additional analysis using a stricter definition of outcome (A1C ≥6.1%), the associations with the seafood and Westernized breakfast patterns were strengthened in men. Multivariate-adjusted ORs (95% CI) for elevated A1C for the second, third, fourth, and fifth quintiles versus the lowest quintile of the seafood dietary pattern were 1.22 (0.62–2.40), 1.92 (1.03–3.59), 2.08 (1.10–3.93), and 2.25 (1.20–4.19), respectively (P_{trend} = 0.003). The corresponding values for the Westernized breakfast pattern were 0.60 (0.35–1.05), 0.77 (0.45–1.31), 0.49 (0.27–0.88), and 0.51 (0.29–0.90), respectively (P_{trend} = 0.02). The associations with other dietary patterns in men and those with any pattern in women were not statistically significant.

CONCLUSIONS — We investigated the relationship between major dietary patterns and glucose tolerance status as measured by A1C concentrations in Japanese adults. Of the four dietary patterns we identified, the Westernized breakfast pattern was inversely related to A1C concentrations in both men and women, and the seafood dietary pattern was positively related to A1C concentrations in men but not in women.

Major strengths of the present study include large sample size, adjustment of known and suspected risk factors of type 2 diabetes, and the use of measured A1C concentrations as the outcome. Our study also had some limitations. First, an association derived from a cross-sectional study does not necessarily indicate causality. However, we excluded participants with health conditions that might affect dietary habit or A1C concentrations to minimize the possibility of reverse causality. Second, the present study was based on data from the baseline survey of a cohort study, in which one-fourth of the eligible individuals participated. We had no information about lifestyle characteristics of nonparticipants, but compared with that in the National Health and Nutrition

Table 2—*Characteristics according to quintile categories of dietary pattern scores*

	Age (years)	BMI (kg/m²)	Smoking (current)	Alcohol use (current)	Physical activity*	Parental history of diabetes
Men						
Healthy dietary pattern						
Quintile 1 (low)	58.6 ± 6.1	23.6 ± 2.9	51.1	77.8	8.6	10.2
Quintile 5 (high)	65.2 ± 6.4	23.4 ± 2.5	21.0	69.1	22.4	11.0
P_{trend}†	<0.01	0.60	<0.01	<0.01	<0.01	0.73
High-fat dietary pattern						
Quintile 1 (low)	63.3 ± 6.5	23.5 ± 2.8	28.9	72.8	15.7	9.3
Quintile 5 (high)	60.3 ± 7.0	23.6 ± 2.9	35.6	74.7	14.4	12.2
P_{trend}	<0.01	0.30	<0.01	0.11	0.55	0.17
Seafood dietary pattern						
Quintile 1 (low)	61.7 ± 6.8	23.3 ± 2.7	32.6	64.8	15.0	11.4
Quintile 5 (high)	62.4 ± 6.9	23.8 ± 3.0	34.3	80.1	15.6	12.3
P_{trend}	0.14	<0.01	0.62	<0.01	0.78	0.53
Westernized breakfast pattern						
Quintile 1 (low)	62.5 ± 6.4	23.7 ± 2.8	29.8	79.2	15.6	11.4
Quintile 5 (high)	62.2 ± 7.0	23.6 ± 2.7	33.5	70.4	15.9	11.1
P_{trend}	0.36	0.09	0.11	<0.01	0.63	0.76
Women						
Healthy dietary pattern						
Quintile 1 (low)	58.7 ± 6.3	22.6 ± 3.3	14.5	33.9	7.3	15.2
Quintile 5 (high)	64.3 ± 6.6	22.6 ± 3.0	2.0	23.0	20.5	12.4
P_{trend}	<0.01	0.85	<0.01	<0.01	<0.01	0.02
High-fat dietary pattern						
Quintile 1 (low)	63.4 ± 6.4	22.4 ± 2.9	5.0	25.2	16.4	14.0
Quintile 5 (high)	60.0 ± 6.9	22.7 ± 3.0	8.5	27.8	11.1	15.5
P_{trend}	<0.01	0.03	<0.01	0.06	<0.01	0.14
Seafood dietary pattern						
Quintile 1 (low)	60.6 ± 6.5	22.3 ± 3.0	5.6	23.2	13.3	14.9
Quintile 5 (high)	63.3 ± 7.1	22.9 ± 3.1	6.1	29.3	16.3	11.7
P_{trend}	<0.01	<0.01	0.31	<0.01	0.04	0.02
Westernized breakfast pattern						
Quintile 1 (low)	62.8 ± 6.6	22.8 ± 3.3	5.7	25.3	10.9	12.4
Quintile 5 (high)	60.8 ± 6.9	22.1 ± 2.8	7.5	31.0	16.4	13.6
P_{trend}	<0.01	<0.01	0.04	0.02	<0.01	0.38

Data are means ± SD or %. *High recreational physical activity of ≥21 MET h/week. †Based on the Mantel-Haenszel χ^2 test for categorical variables and linear regression analysis for continuous variables, assigning ordinal numbers 0–4 to quintile categories of each dietary pattern.

Survey (20), the study participants had lower smoking prevalence (<5%) and lower mean A1C levels (0.2–0.3%) in both sexes and virtually all age-groups. This fact may suggest that participants had, on average, healthier lifestyles and better physical condition than nonparticipants. However, the differences appear to be moderate and thus unlikely to account for the present association. Nevertheless, the low participation rate may have somewhat distorted the diet-A1C associations. We infer that, in the case of a high participation rate, more pronounced associations would have been observed because of a presumably greater variation in both the exposure and the outcome among the study population. Third, estimation of total energy and nutrient intakes from the present questionnaire has not yet been completed. Because a higher score on a dietary pattern is probably related to greater energy intake and thus may confer type 2 diabetes risk, the lack of adjustment for energy intake might be an explanation for the positive association for the seafood dietary pattern or for the null finding for the healthy dietary pattern. However, energy adjustment should strengthen, rather than diminish, the inverse association between the Westernized breakfast pattern and A1C, which constitutes the major finding of the present study. Finally, there are limitations inherent to principal component analysis owing to arbitrary decisions in determining the number of factors to retain, in choosing the method of rotation of the initial factors, and in labeling the dietary patterns (9,21). In this regard, it is notable that dietary patterns extracted in the present study have also been identified elsewhere in Japan (15).

The Westernized breakfast pattern, characterized by frequent intake of bread, margarine, and coffee and infrequent intake of rice and miso soup, was inversely related to the prevalence of elevated A1C. This finding is in line with our previous observation in male self-defense officials (15). The quantity and quality of carbohydrate affect glucose and insulin responses (22). The glycemic indexes of bread and rice are comparable (23), and thus simple replacement of rice by bread does not affect the index. However, bread is usually consumed with other Western

Table 3—*Multivariate-adjusted ORs (95% CI) of elevated A1C (≥5.5%) according to quintile categories of dietary pattern scores*

	Quintile 1 (low)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (high)	P_{trend}*
Men						
Healthy dietary pattern	1.00	0.86 (0.62–1.21)	0.75 (0.53–1.06)	1.11 (0.80–1.54)	0.84 (0.59–1.20)	0.89
High-fat dietary pattern	1.00	0.86 (0.62–1.18)	1.08 (0.80–1.48)	0.76 (0.55–1.06)	0.74 (0.53–1.04)	0.07
Seafood dietary pattern	1.00	1.13 (0.80–1.61)	1.31 (0.92–1.84)	1.77 (1.26–2.47)	1.34 (0.95–1.89)	0.01
Westernized breakfast pattern	1.00	0.70 (0.51–0.97)	0.80 (0.58–1.09)	0.80 (0.59–1.10)	0.60 (0.43–0.84)	0.02
Women						
Healthy dietary pattern	1.00	1.37 (1.00–1.89)	1.10 (0.80–1.53)	1.21 (0.87–1.67)	1.38 (1.00–1.91)	0.18
High-fat dietary pattern	1.00	0.96 (0.71–1.30)	1.18 (0.88–1.58)	1.02 (0.75–1.37)	0.95 (0.70–1.30)	0.93
Seafood dietary pattern	1.00	1.18 (0.87–1.59)	1.13 (0.84–1.54)	1.18 (0.87–1.59)	0.86 (0.63–1.18)	0.40
Westernized breakfast pattern	1.00	1.13 (0.84–1.50)	1.24 (0.93–1.65)	1.03 (0.77–1.38)	0.64 (0.46–0.90)	0.02

Adjusted for age (years), BMI (<22.5, 22.5–24.9, 25.0–27.4, or ≥27.5 kg/m²), smoking (lifetime nonsmoker, former smoker, or current smoker with a consumption of <20 or ≥20 cigarettes/day), alcohol consumption (nondrinker, former drinker, and current drinker with a consumption of <30, 30–59, or ≥60 g ethanol/day), physical activity (quartile of MET hours/week), and parental history of diabetes (absent or present). *Based on multiple logistic regression analysis, assigning ordinal numbers 0–4 to quintile categories of each dietary pattern.

foods such as butter, milk, and cheese that have relatively high fat contents, which probably reduces the overall glycemic index of the diet. Therefore, a lower glycemic impact of a bread-based breakfast compared with a rice-based one could be an explanation for the decreased A1C concentrations among individuals with a higher score for this dietary pattern. The inverse association with this pattern may also be ascribed in part to frequent intake of coffee, a beverage consistently associated with lower risk of type 2 diabetes (24).

The seafood dietary pattern, characterized by frequent consumption of shellfish, salted fish guts, and fish paste products, was related to a higher prevalence of elevated A1C in men. We previously found a suggestion of a positive association between this dietary pattern and serum levels of C-reactive protein (CRP) (16), a marker of systemic inflammation, which may be involved in the pathogenesis of insulin resistance and type 2 diabetes and has been a predictor of type 2 diabetes (25). However, additional adjustment for CRP did not alter the results materially, indicating that the association with this dietary pattern is independent of inflammation. Higher scores of this dietary pattern probably accompany greater consumption of salt. There is evidence in humans that diets high in salt deteriorate insulin metabolism (26). A cohort study in Finland (27) also demonstrated that high salt intake independently predicted risk of type 2 diabetes. Although the underlying mechanism is unclear, our result, based on an analysis of dietary pattern, appears to be consistent with these data.

Healthy and prudent dietary patterns,

characterized by high intakes of vegetables and fruit, have been shown to be associated with a reduced risk of type 2 diabetes (10–12,15) and glucose tolerance abnormality (15). Moreover, we previously found a significant, inverse association between the healthy dietary pattern and CRP concentrations (16). In the present analysis, however, the healthy pattern was not associated with A1C concentrations, a finding consistent with the results of studies that reported either null (28) or nonlinear (29) association between similar dietary patterns and A1C concentrations. Why the discrepant findings were observed among studies that used a different measure of glucose tolerance abnormality should be clarified.

The high-fat dietary pattern, characterized by frequent consumption of fried food, meat, processed meat, mayonnaise, and egg, was not appreciably associated with elevated A1C concentrations in the present study. Comparable dietary patterns in Western populations (i.e., the Western dietary pattern) have been consistently shown to be associated with a higher risk of type 2 diabetes (11–14), although the relation to A1C concentrations has been inconsistent (28,29). The lack of an association in the present study may be ascribed to relatively high loadings of certain vegetables to the high-fat dietary pattern. Alternatively, fat and meat consumption in Japanese is largely under the level above which diabetes risk is conferred. Fat-derived energy intakes were 26–37% in the Health Professionals Follow-up Study in the U.S. (13), whereas fat intake accounted for roughly 25% of total energy intake in Japan (20).

In summary, a dietary pattern characterized by frequent consumption of bread

and margarine but infrequent consumption of rice and miso soup was associated with decreased A1C concentrations in Japanese men and women, whereas a dietary pattern characterized by frequent intake of shellfish, salted fish guts, and fish paste products was related to increased A1C concentrations in men. These findings suggest that adherence to some traditional dietary patterns in Japanese featuring white rice or salty seafoods may be related to deterioration of glucose metabolism and may explain, at least in part, why Japanese have a high prevalence of type 2 diabetes despite their relatively lean body mass. The present cross-sectional associations must be confirmed in prospective studies, and the underlying mechanisms need be clarified.

References
1. King H, Aubert RE, Herman WH: Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care* 21:1414–1431, 1998
2. Ministry of Health and Welfare: *Diabetes Mellitus Fact Sheet 2002: Rapid Report.* Tokyo, Japanese Ministry of Health and Welfare, 2003 [in Japanese]
3. Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, Marks JS: Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 289:76–79, 2003

4. Sone H, Ito H, Ohashi Y, Akanuma Y, Yamada N: Obesity and type 2 diabetes in Japanese patients. *Lancet* 361:85, 2003

5. Yazaki Y, Kadowaki T: Combating diabetes and obesity in Japan. *Nat Med* 12:73–74, 2006

6. Ford ES, Mokdad AH: Fruit and vegetable consumption and diabetes mellitus incidence among U.S. adults. *Prev Med* 32:33–39, 2001

7. Schulze MB, Schulz M, Heidemann C, Schienkiewitz A, Hoffmann K, Boeing H: Fiber and magnesium intake and incidence of type 2 diabetes: a prospective study and meta-analysis. *Arch Intern Med* 167:956–965, 2007

8. Salmeròn J, Manson JE, Stampfer MJ, Colditz GA, Wing AL, Willett WC: Dietary fiber, glycemic load, and risk of non-insulin-dependent diabetes mellitus in women. *JAMA* 277:472–477, 1997

9. Hu FB: Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* 13:3–9, 2002

10. Williams DE, Prevost AT, Whichelow MJ, Cox BD, Day NE, Mareham NJ: A cross-sectional study of dietary patterns with glucose intolerance and other features of the metabolic syndrome. *Br J Nutr* 83:257–266, 2000

11. Montonen J, Knekt P, Härkänen T, Järvinen R, Heliövaara M, Aromaa A, Reunanen A: Dietary patterns and the incidence of type 2 diabetes. *Am J Epidemiol* 161:219–227, 2005

12. Hodge AM, English DR, O'Dea K, Giles GG: Dietary patterns and diabetes incidence in the Melbourne Collaborative Cohort Study. *Am J Epidemiol* 165:603–610, 2007

13. van Dam RM, Rimm EB, Willett WC, Stampfer MJ, Hu FB: Dietary patterns and risk for type 2 diabetes mellitus in U.S. men. *Ann Intern Med* 136:201–209, 2002

14. Fung TT, Schulze M, Manson JE, Willett WC, Hu FB: Dietary patterns, meat intake and the risk of type 2 diabetes in women. *Arch Intern Med* 164:2235–2240, 2004

15. Mizoue T, Yamaji T, Tabata S, Yamaguchi K, Ogawa S, Mineshita M, Kono S: Dietary patterns and glucose tolerance abnormalities in Japanese men. *J Nutr* 136:1352–1358, 2006

16. Nanri A, Yoshida D, Yamaji T, Mizoue T, Takayanagi R, Kono S: Dietary patterns and C-reactive protein in Japanese men and women. *Am J Clin Nutr* 87:1488–1496, 2008

17. Tokudome S, Goto C, Imaeda N, Tokudome Y, Ikeda M, Maki S: Development of a data-based short food frequency questionnaire for assessing nutrient intake by middle-aged Japanese. *Asian Pac J Cancer Prev* 5:40–43, 2004

18. Tokudome Y, Goto C, Imaeda N, Hasegawa T, Kato R, Hirose K, Tajima K, Tokudome S: Relative validity of a short food frequency questionnaire for assessing nutrient intake versus three-day weighed diet records in middle-aged Japanese. *J Epidemiol* 15:135–145, 2005

19. *Review of Guidance Division of Diabetes Mellitus and Cardiovascular Disease in the Health Service for the Elderly*. Tokyo, Nihon Koushu Eisei Kyokai Press, 2002 [in Japanese]

20. Japan Ministry of Health Labour and Welfare: *Annual Reports of the National Health and Nutrition Survey, 2004*. Tokyo, Dai-ichi-shuppan, 2006 [in Japanese]

21. Martinez ME, Marshall JR, Sechrest L: Invited commentary: factor analysis and the search for objectivity. *Am J Epidemiol* 148:17–19, 1998

22. Willett W, Manson J, Liu S: Glycemic index, glycemic load, and risk of type 2 diabetes. *Am J Clin Nutr* 76:274S–280S, 2002

23. Murakami K, Sasaki S, Takahashi Y, Okubo H, Hosoi Y, Horiguchi H, Oguma E, Kayama F: Dietary glycemic index and load in relation to metabolic risk factors in Japanese female farmers with traditional dietary habits. *Am J Clin Nutr* 83:1161–1169, 2006

24. van Dam RM, Hu FB: Coffee consumption and risk of type 2 diabetes: a systematic review. *JAMA* 294:97–104, 2005

25. Pradhan AD, Manson JE, Rifai N, Buring JE, Ridker PM: C-reactive protein, interleukin 6, and risk of developing type 2 diabetes mellitus. *JAMA* 286:327–334, 2001

26. Thorburn AW, Brand JC, Truswell AS: Salt and the glycaemic response. *BMJ* 292:1697–1699, 1986

27. Hu G, Jousilahti P, Peltonen M, Lindstrom J, Tuomilehto J: Urinary sodium and potassium excretion and the risk of type 2 diabetes: a prospective study in Finland. *Diabetologia* 48:1477–1483, 2005

28. Fung TT, Rimm EB, Spiegelman D, Rifai N, Tofler GH, Willett WC, Hu FB: Association between dietary patterns and plasma biomarkers of obesity and cardiovascular disease risk. *Am J Clin Nutr* 73:61–67, 2001

29. Kerver JM, Yang EJ, Bianchi L, Song WO: Dietary patterns associated with risk factors for cardiovascular disease in healthy U.S. adults. *Am J Clin Nutr* 78:1103–1110, 2003