Original Article

Effects of healthy dietary pattern and other lifestyle factors on incidence of diabetes in a rural Japanese population

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This study assessed the effects of dietary habits and other lifestyle factors on the incidence of diabetes in a rural Japanese population. This 10.3-year study investigated a cohort of 1,995 men and 3,670 women aged 40-69 years without diabetes at baseline who underwent health check-ups between April 1990 and March 1992. Participants were followed up until diabetes was confirmed or until the end of 2006. The incidence of diabetes was determined from fasting and random levels of plasma glucose, HbA1c levels or being under medical treatment for diabetes. Principal component analysis identified a major dietary pattern characterized by more frequent consumption of vegetables, potatoes, seaweeds, fruits and soybean products that we labeled "healthy". Diabetes developed in 446 of the participants during 58,151 person-years of follow-up. Consuming a healthy diet was associated with a lower risk of diabetes (multivariable-adjusted hazard ratio for highest vs lowest quartiles, 0.78 [95% CI, 0.61-0.95]. In addition, scores for a healthy diet were associated with a lower risk for diabetes among persons who consumed regular meals (0.76 [0.58-0.96]), persons with an exercise habit (0.65 [0.44-0.96]) and non- and ex-smokers (0.72 [0.53-0.96]). Our findings suggest that consuming a healthy diet is associated with a lower risk for diabetes among the Japanese, particularly among those who eat regularly, those who habitually exercise and non- and ex-smokers.

Key Words: diabetes mellitus, prospective study, dietary habits, lifestyle, Japanese

INTRODUCTION

The worldwide prevalence of type 2 diabetes is alarmingly high.[1] Dietary factors are potentially modifiable risk factors.[2] The main interest in the link between dietary factors and risk of diabetes has focused on individual foods and nutrients. However, foods are consumed in many complex combinations, and nutrients might have interactive and synergistic effects. The recent factor analysis of dietary patterns has emerged as a useful tool for elucidating relationships between diet and health.[3-5] American and European studies have concluded that desirable dietary patterns to prevent diabetes include increased consumption of vegetables, fruits and fish.[6,7] However, because dietary patterns in Japan differ from those of other countries, the effects could be different. Nevertheless, little is known about the role of diets typically consumed by the Japanese. In addition, the effect of dietary patterns on diabetes incidence and other lifestyle factors, such as regular meals, exercise and smoking, has never been assessed in a Japanese population.

The present study therefore aimed to identify dietary patterns in a rural Japanese population and to assess the effects of dietary patterns and other lifestyle factors on the incidence of diabetes in a 10.3-year (mean length) prospective study.

METHODS

Study participants

This epidemiological study analyzed diabetes in a rural area of Nagano Prefecture in Japan.[8-10] To establish a baseline between April 1990 and March 1992, 7,160 community residents (2,584 men and 4,576 women) aged 40-69 years underwent a health check-up at a central hospital. We included 5,812 of them based on six eligibility criteria at baseline and on one criterion during follow-up: no history of diabetes; fasting plasma glucose <7.0 mmol/L (126 mg/dL); random plasma glucose <11.1

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Manuscript received 19 December 2011. Initial review completed 13 April 2012. Revision accepted 30 April 2012.

mmol/L (200 mg/dL); no history of cardiovascular or cerebrovascular diseases; no history of liver disease; and complete covariates' data. Each participant also had to undergo a blood test by March 2006, which was the end of the follow-up. Furthermore, we excluded 147 incident cases in the first 3 years of the follow-up. A total of 5,665 (1,995 men and 3,670 women) participants aged 40 to 69 years were eligible for our analysis. The Ethical Committee of Saku Central Hospital approved the study (approval number: 21-15).

Baseline data

Baseline data including: demographic information, medical history and lifestyle factors such as dietary intake, regular meals, exercise habits and smoking status were obtained using a self-administered questionnaire that was partially supported and reconfirmed by a personal interview with physicians or nurses. Meal regularity was categorized as regular (fixed meal times) or irregular (irregular meal times or skipped breakfast, lunch or dinner). Exercise habit was categorized as yes or no, and smoking status was categorized as current, ex- and non-smoker. Nurses measured weight, height and blood pressure. The participants were weighed while wearing light clothing, and height was measured without shoes. The body mass index (BMI, kg/m^2) was calculated as weight (kg) divided by the square of height (m). Blood parameters were determined and plasma glucose was measured using the glutamate dehydrogenase method. Total cholesterol and triglycerides were determined using cholesterol oxidase-DAOS and the ultraviolet method, respectively.

Assessment of dietary intake

Dietary intake at baseline was assessed using a 16-item food frequency questionnaire. The 16 food items were meat (including beef, pork, chicken, lamb and ham sausage), fish (including finfish, cuttlefish, shellfish and boiled fish paste), eggs, dairy products (including milk, yogurt and cheese), soybean products (including soybean, tofu and fermented soybeans), green vegetables, other vegetables, seaweeds, fruits, potatoes (including potato, taro, yam and sweet potato), dressing oil and butter (including dressing oil, mayonnaise, butter and margarine), miso soup, pickles, rice, bread and alcoholic beverages (including whiskey, beer, *sake* [Japanese rice wine] and *shochu* [Japanese distilled beverage similar to vodka]). Participants were asked to indicate how often, on average, they had consumed each food during the previous year. Participants were given a choice of five responses ranging from "one serving or less per week" to "at least 3 servings per day" for most dietary items and from "one serving or less per week" to "over 8 servings per week" for meat, fish, eggs, dairy products and soybean products. The five response options for alcoholic beverage consumption ranged from "never" to "seven days per week".

Follow-up and definition of diabetes incidence

We followed up the 5,665 participants annually until they developed diabetes or until the end of 2006. Individuals who did not undergo blood tests during the follow-up were censored on the date of their last blood test. The presence of diabetes was confirmed based on at least one of the following criteria: fasting plasma glucose ≥7.0 mmol/L (126 mg/dL); random plasma glucose ≥11.1 mmol/L (200 mg/dL); HbA1c ≥6.5% (National Glycohemoglobin Standardization Program: NGSP); or under medical treatment for diabetes. Fasting was defined as having not ingested food for at least 10 hours. The HbA1c (%) was estimated as an NGSP equivalent value (%) calculated using the formula HbA1c (%)= HbA1c (Japan Diabetes Society %) + 0.4%.[11]

Statistical analysis

We applied the principal component method with varimax rotation in the factor analysis to identify dietary consumption patterns. Table 1 shows the factor-loading matrix for dietary patterns identified from a rural Japanese population. We labeled one factor with eigenvalues of >2.5 as a "healthy" pattern of dietary consumption (Table 1; pattern 1) and discarded other factors with eigenvalues of <1.5 based on the results of a screening test and the interpretability of the factors (Table 1; patterns 2 and 3).[12] The factor score for the healthy dietary consumption pattern was computed by summing the observed variables multiplied by their factor loadings. We used these scores to rank participants according to the degree to which they conformed to the dietary pattern. Because we divided dietary pattern scores into quartiles, each participant was grouped into healthy dietary pattern quartiles.

We compared baseline risk characteristics according to quartiles of healthy dietary pattern scores using the analysis of variance for continuous variables with normal distribution, the Kruskal-Wallis H-test for continuous variables with non-normal distribution, and the chi-square test for dichotomous variables. Hazard ratios (HR) and 95% confidence intervals (CI) for the incidence of diabetes according to quartile of healthy dietary pattern scores were estimated using the Cox proportional-hazards model. We estimated HRs for developing diabetes using two models. To adjust for confounding factors, age and sex were included in model 1, and blood glucose level, fasting status (yes or no), body mass index, systolic blood pressure level, total cholesterol level, log-transformed triglyceride level, family history of diabetes (yes or no), exercise habit (yes or no) and smoking status (non-, ex-, current smoker) were also included in model 2. We also stratified participants according to other lifestyle factors, namely, meal regularity, exercise habit or smoking status, and the HRs for incidence of diabetes according to quartiles of healthy dietary pattern scores were estimated using the Cox proportional-hazards model. To adjust for confounding factors, age and sex were included in model 1, and the above variables except for the stratifying variable were included in model 2. All data were statistically analyzed using SAS (Version 9.1; SAS Institute Inc., Cary, NC) statistical software. All probability values were two-tailed with a significance level of p <0.05, and all confidence intervals were estimated at the 95% level.

RESULTS

The dietary pattern that we labeled as a healthy was characterized by more frequent consumption of vegetables, potatoes, seaweeds, fruits and soybean products (Table 1). Table 2 shows the baseline characteristics according to

Table 1. Factor-loading matrix for dietary patterns identified from a rural Japanese population (n=5,665)

Food group	Pattern 1†	Pattern 2†	Pattern 3†
Green vegetables	0.62	0.21	0.03
Potatoes	0.56	0.14	0.07
Other vegetables	0.55	0.26	0.03
Seaweeds	0.53	0.23	0.01
Fruits	0.48	0.16	-0.20
Soybean products	0.38	0.24	0.06
Dressing oil and butter	0.29	0.35	0.04
Miso soup	0.27	-0.01	0.50
Pickles	0.22	-0.05	0.32
Fish	0.20	0.22	0.36
Dairy products	0.13	0.28	-0.13
Alcoholic beverages	-0.12	0.13	0.44
Rice	0.10	0.10	0.51
Eggs	0.09	0.45	0.08
Meat	0.08	0.54	0.06
Bread	-0.06	0.10	-0.36
Variance explained (%)	16.2	5.1	3.8

†Values are factor loadings.

quartiles of healthy dietary pattern scores. All variables, except for a family history of diabetes, BMI, a history of hypertension, systolic blood pressure and triglycerides, significantly differed among the 4 groups. In the highest quartile group of those with healthy dietary pattern scores, 98.3%, 95.0%, 98.9%, 85.2%, 92.6% and 91.4% consumed green vegetables, potatoes, other vegetables, seaweeds and fruits more than once per day and soybean products at least three times per week, respectively.

The mean follow-up in the present study was 10.3 years (total person-years: 58,151) and 446 participants developed confirmed diabetes during that period. Table 3 shows the multivariable-adjusted HRs and 95% CIs for diabetes according to quartile of healthy dietary pattern scores. The healthy dietary pattern was associated with reduced risk for diabetes (HR for highest vs lowest quartiles, 0.78 [95% CI, 0.61－0.95]; *p* for trend=0.008), after adjustment for age, sex, blood glucose level, fasting status, BMI, systolic blood pressure level, total cholesterol level, log-transformed triglyceride level, family history of diabetes, exercise habit and smoking status. Results were essentially the same when analyzed from the stratification analysis by sex.

Table 4 shows the multivariable-adjusted HRs and 95% CIs for diabetes according to quartiles of healthy dietary pattern scores and other lifestyle factors. An inverse association of healthy dietary pattern with diabetes was observed in persons who consumed regular meals (multivariable-adjusted HR for highest vs. lowest quartiles, 0.76 [95% CI, 0.58－0.96]; *p* for trend=0.012) and not in those who consumed meals irregularly (*p* for interaction=0.019). Similarly, an inverse association of healthy dietary pattern with diabetes was observed in persons who habitually exercised (0.65 [0.44－0.96]; *p* for trend=0.018) and not in those who did not habitually exercise (*p* for interaction=0.046). An inverse association of healthy dietary pattern with diabetes was observed in non- and ex-smokers (0.72 [0.53－0.96]; *p* for trend=0.001) and not in current smokers (*p* for interaction=0.032).

DISCUSSION

This prospective study discovered that a diet rich in vegetables, potatoes, seaweeds, fruits and soybean products is associated with a reduced risk of diabetes. The finding was strengthened for individuals who ate regularly, those who habitually exercised and non- and ex-smokers; but not in those who consumed meals irregularly, those who did not habitually exercise and current-smokers.

The finding that a healthy dietary pattern was associated with a reduced risk of diabetes supports the results of the Health Professionals Follow-up Study and the Finnish Mobile Clinic Health Examination Survey.[6,7] Those studies showed that a prudent dietary pattern characterized by high consumption of fruits and vegetables is associated with a reduced risk for type 2 diabetes.[6,7] Additionally, the finding supports the result of the Singapore Chinese Health Study.[13] That study showed that a dietary pattern with higher intake of vegetables, fruits, and soy foods was inversely associated with risk of incident type 2 diabetes in Chinese men and women.[13] Furthermore, it has been reported that a higher consumption of a healthy pattern with higher intake of vegetables, fruits, seaweeds and bonefish was inversely associated with the metabolic syndrome which is an important risk factor of diabetes in Korean women.[14] The inverse association between the healthy dietary pattern and incidence of diabetes might represent beneficial effects of each food or nutrient. The results of previous studies suggest that the intake of vegetables, fruits, seaweeds and/or potatoes is associated with a reduced risk of type 2 diabetes.[15-17] Substances that are abundant in vegetables, fruits, seaweeds and/or potatoes that have been linked to a reduced risk of diabetes or insulin resistance include: fiber,[18] carotenoids,[19] magnesium,[20] and antioxidants.[21] Furthermore, phytoestrogens in soy protein apparently improve glucose metabolism.[22] In addition to the independent effects of these foods or nutrients, complex interactions among them might constitute a healthy dietary pattern.

In this study, a healthy dietary pattern was associated with a lower risk for diabetes among persons who ate

Table 2. Baseline characteristics according to quartiles of healthy dietary pattern scores (n=5,665)

	Healthy dietary pattern quartile				
	1 (lowest) (n=1,416)	2 (n=1,416)	3 (n=1,417)	4 (highest) (n=1,416)	*p*-value†
Male (n, %)	739 (52.2)	408 (28.8)	490 (34.6)	358 (25.3)	<0.001
Age (years) (mean ± SD)	54.0±8.6	56.5±8.3	55.6±8.5	57.9±7.8	<0.001
Occupation (n, %)					<0.001
Full-time farmer	338 (23.9)	428 (30.2)	385 (27.2)	462 (32.6)	
Farmer with side job	494 (34.8)	585 (41.3)	573 (40.4)	635 (44.9)	
Non-farmer	519 (36.7)	327 (23.1)	392 (27.7)	240 (16.9)	
Unemployed	65 (4.6)	76 (5.4)	67 (4.7)	79 (5.6)	
Family history of diabetes (n, %)	96 (6.8)	89 (6.3)	116 (8.2)	90 (6.4)	0.160
Body mass index (kg/m^2) (mean±SD)	23.3±3.0	23.3±2.9	23.4±2.9	23.4±2.8	0.762
Hypertension (n, %)	242 (17.1)	251 (17.7)	260 (18.3)	255 (18.0)	0.843
Systolic blood pressure (mmHg) (mean±SD)	126.6±17.2	126.5±16.4	126.7±17.3	127.3±17.4	0.535
Diastolic blood pressure (mmHg) (mean±SD)	79.7±10.4	78.7±10.0	79.3±10.7	78.6±10.4	0.016
Total cholesterol (mmol/L) (mean±SD)	5.10±0.88	5.18±0.92	5.12±0.92	5.17±0.90	0.035
Triglycerides (mmol/L)‡	1.20 (0.82-1.81)	1.17 (0.82-1.75)	1.18 (0.80-1.75)	1.14 (0.80-1.69)	0.083
Exercise habit (n, %)	482 (34.0)	549 (38.8)	508 (35.9)	590 (41.7)	<0.001
Current smoking (n, %)	430 (30.4)	190 (13.4)	243 (17.1)	162 (11.4)	<0.001
Dietary intake (n, %)§					
Green vegetables					<0.001
One serving or less/wk	107 (7.6)	15 (1.1)	3 (0.2)	3 (0.2)	
One serving every 2 - 6 days	808 (57.0)	339 (23.8)	116 (8.1)	21 (1.5)	
One serving/day	468 (33.1)	874 (61.8)	720 (50.8)	233 (16.5)	
Two servings/day	30 (2.1)	178 (12.6)	495 (35.0)	694 (49.0)	
At least three servings/day	3 (0.2)	10 (0.7)	83 (5.9)	465 (32.8)	
Potatoes					<0.001
One serving or less/wk	211 (14.9)	37 (2.6)	22 (1.6)	4 (0.3)	
One serving every 2 - 6 days	953 (67.3)	611 (43.2)	329 (23.2)	66 (4.7)	
One serving/day	244 (17.2)	718 (50.7)	849 (59.9)	438 (30.9)	
Two servings/day	7 (0.5)	47 (3.3)	205 (14.5)	654 (46.2)	
At least three servings/day	1 (0.1)	3 (0.2)	12 (0.8)	254 (17.9)	
Other vegetables					<0.001
One serving or less/wk	29 (2.0)	2 (0.1)	0 (0.0)	0 (0.0)	
One serving every 2 - 6 days	394 (27.8)	99 (7.0)	26 (1.8)	15 (1.1)	
One serving/day	822 (58.1)	803 (56.7)	554 (39.1)	132 (9.3)	
Two servings/day	146 (10.3)	401 (28.4)	603 (42.6)	664 (46.9)	
At least three servings/day	25 (1.8)	111 (7.8)	234 (16.5)	605 (42.7)	
Seaweeds					<0.001
One serving or less/wk	192 (13.6)	57 (4.0)	29 (2.0)	12 (0.8)	
One serving every 2 - 6 days	933 (65.8)	703 (49.5)	417 (29.5)	198 (14.0)	
One serving/day	274 (19.4)	602 (42.6)	797 (56.2)	538 (38.0)	
Two servings/day	14 (1.0)	49 (3.5)	160 (11.3)	474 (33.5)	
At least three servings/day	3 (0.2)	5 (0.4)	14 (1.0)	194 (13.7)	
Fruits					<0.001
One serving or less/wk	185 (13.1)	38 (2.7)	24 (1.7)	8 (0.6)	
One serving every 2-6 days	621 (43.8)	348 (24.6)	197 (13.9)	96 (6.8)	
One serving/day	559 (39.5)	846 (59.8)	823 (58.1)	540 (38.1)	
Two servings/day	47 (3.3)	165 (11.6)	332 (23.4)	555 (39.2)	
At least three servings/day	4 (0.3)	19 (1.3)	41 (2.9)	217 (15.3)	
Soybean products					<0.001
One serving or less/wk	30 (2.1)	5 (0.4)	1 (0.1)	1 (0.1)	
1-2 servings/wk	560 (39.5)	324 (22.8)	187 (13.2)	121 (8.5)	
3-5 servings/wk	595 (42.1)	688 (48.6)	649 (45.8)	526 (37.1)	
6-8 servings/wk	189 (13.3)	333 (23.5)	469 (33.1)	560 (39.6)	
More than eight servings/wk	42 (3.0)	66 (4.7)	111 (7.8)	208 (14.7)	

†For continuous variables of normal distribution, analysis of variance was used; for continuous variables of non-normal distribution, Kruskal-Wallis H-test was used; for dichotomous and categorical variables, chi-square test was used.
‡Values are median (25th - 75th percentile).
§Six food items with factor loadings of ≥ 0.30 are shown.

regularly, those who habitually exercised and non- and ex-smokers, but not with a lower risk for diabetes among those who ate irregularly, those who did not habitually exercise and current smokers. Our findings support the possibility of effect modification by meal regularity, exercise habit and smoking status on the association between healthy dietary pattern and diabetes risk. It has been reported an inverse association between isoflavone intake and risk of lung cancer was observed in non-smokers and not in current smokers.[23] Moreover, it has

Table 3. Multivariable-adjusted hazard ratios and 95% confidence intervals for diabetes according to quartiles of healthy dietary pattern scores (n = 5,665)

	Healthy dietary pattern quartile				*p*-value for trend
	1 (lowest) (n=1,416)	2 (n=1,416)	3 (n=1,417)	4 (highest) (n=1,416)	
Person-years	13,685	14,979	14,630	14,857	
Cases (n)	127	117	103	99	
Incidence (/1,000 person-years)	9.3	7.8	7.0	6.7	
HR (95% CI): Model 1†	1.0	0.84 (0.65-1.08)	0.77 (0.59-1.01)	0.71 (0.54-0.91)	0.005
HR (95% CI): Model 2‡	1.0	0.90 (0.72-1.21)	0.83 (0.64-1.08)	0.78 (0.61-0.95)	0.008

HR: hazard ratio, CI: confidence interval.
†Adjusted for age (y, continuous) and sex (male or female).
‡Adjusted for age (y, continuous), sex (male or female), blood glucose level (mmol/L, continuous), fasting status (yes or no), body mass index (kg/m^2, continuous), systolic blood pressure level (mmHg, continuous), total cholesterol level (mmol/L, continuous), log-transformed triglyceride level (mmol/L, continuous), family history of diabetes (yes or no), exercise habit (yes or no) and smoking status (non-, ex-, or current smoker).

Table 4. Multivariable-adjusted hazard ratios and 95% confidence intervals for diabetes according to quartiles of healthy dietary pattern scores and other lifestyle factors (n = 5,665)

	Healthy dietary pattern quartile				*p*-value for trend
	1 (lowest)	2	3	4 (highest)	
Meal regularity					
Regular (n)	1,207	1,288	1,287	1,309	
HR (95% CI): Model 1†	1.0	0.80 (0.61-1.06)	0.71 (0.54-0.94)	0.69 (0.52-0.92)	0.008
HR (95% CI): Model 2‡	1.0	0.89 (0.68-1.18)	0.77 (0.58-1.02)	0.76 (0.58-0.96)	0.012
Irregular (n)	209	128	130	107	
HR (95% CI): Model 1†	1.0	1.13 (0.50-2.57)	1.41 (0.64-3.10)	0.75 (0.61-2.13)	0.847
HR (95% CI): Model 2‡	1.0	1.37 (0.58-3.19)	1.89 (0.84-4.26)	1.32 (0.45-3.94)	0.790
Exercise habit					
Yes (n)	482	549	508	590	
HR (95% CI): Model 1†	1.0	1.01 (0.67-1.51)	0.68 (0.44-1.05)	0.62 (0.39-0.94)	0.013
HR (95% CI): Model 2§	1.0	1.08 (0.78-1.77)	0.76 (0.48-1.19)	0.65 (0.44-0.96)	0.018
No (n)	934	867	909	826	
HR (95% CI): Model 1†	1.0	0.72 (0.52-1.01)	0.82 (0.59-1.14)	0.78 (0.55-1.09)	0.103
HR (95% CI): Model 2§	1.0	0.78 (0.56-1.10)	0.87 (0.62-1.21)	0.91 (0.65-1.29)	0.428
Smoking status					
Non- and ex-smoker (n)	986	1,226	1,174	1,254	
HR (95% CI): Model 1†	1.0	0.84 (0.63-1.12)	0.73 (0.54-0.99)	0.66 (0.49-0.89)	0.003
HR (95% CI): Model 2¶	1.0	0.89 (0.66-1.19)	0.80 (0.59-1.09)	0.72 (0.53-0.96)	0.001
Current smoker (n)	430	190	243	162	
HR (95% CI): Model 1†	1.0	0.80 (0.44-1.43)	0.91 (0.54-1.52)	0.97 (0.54-1.74)	0.736
HR (95% CI): Model 2¶	1.0	0.89 (0.49-1.61)	0.89 (0.53-1.51)	0.99 (0.55-1.80)	0.858

HR: hazard ratio, CI: confidence interval.
†Adjusted for age (y, continuous) and sex (male or female).
‡Adjusted for age (y, continuous), sex (male or female), blood glucose level (mmol/L, continuous), fasting status (yes or no), body mass index (kg/m^2, continuous), systolic blood pressure level (mmHg, continuous), total cholesterol level (mmol/L, continuous), log-transformed triglyceride level (mmol/L, continuous), family history of diabetes (yes or no), exercise habit (yes or no) and smoking status (non-, ex-, or current smoker).
§Adjusted for age (y, continuous), sex (male or female), blood glucose level (mmol/L, continuous), fasting status (yes or no), body mass index (kg/m^2, continuous), systolic blood pressure level (mmHg, continuous), total cholesterol level (mmol/L, continuous), log-transformed triglyceride level (mmol/L, continuous), family history of diabetes (yes or no) and smoking status (non-, ex-, or current smoker).
¶Adjusted for age (y, continuous), sex (male or female), blood glucose level (mmol/L, continuous), fasting status (yes or no), body mass index (kg/m^2, continuous), systolic blood pressure level (mmHg, continuous), total cholesterol level (mmol/L, continuous), log-transformed triglyceride level (mmol/L, continuous), family history of diabetes (yes or no) and exercise habit (yes or no).

been reported an inverse association of dietary fiber intake with cardiovascular disease was observed in non-smokers and not in current smokers.[24] Interaction was observed by meal regularity and exercise habit in addition to smoking status in our study. Therefore, we found that a healthy dietary pattern combined with other healthy lifestyle parameters is important to prevent diabetes.

Limitations of factor analysis arise from arbitrary decisions involved in determining the number of factors to retain, in choosing the method of rotation of the initial factors to increase the interpretability of dietary patterns, and in labeling dietary patterns according to their factor loadings.[3] The Japan Public Health Center-based Study (JPHC Study), which was a large-scale prospective study of four rural Japanese areas, identified major dietary patterns (a healthy, traditional and Western dietary pattern) using factor analysis.[25,26] The healthy dietary pattern identified in the present study was similar to the findings of the healthy dietary pattern in that study, which was characterized by more frequent consumption of vegetables, fruits, seaweeds, potatoes, soybean products, mushrooms and yogurt.[26] This finding can suggest that a healthy dietary pattern is common in the rural Japanese population. Fish was not significant in healthy dietary pattern in our study. It has been reported fish is associated with a traditional dietary pattern which was characterized by pickled vegetables, salted fish and roe, fish, rice, miso soup and alcoholic beverages.[26,27] Fish was associated with dietary pattern 3 which resembled the traditional dietary pattern in our study.

The strength of this study is a follow-up period of more than 10 years. Furthermore, diabetes cases were screened every year by measuring blood glucose and HbA1c. This study also has several limitations. Firstly, the present data are limited to one area in Japan. Further studies should include individuals with various occupational backgrounds in various areas of Japan. Secondly, an issue regarding dietary assessment is that total energy and nutrient intake determined from the questionnaire were not calculated and validated. Persons with a high score for a dietary pattern probably consumed more energy than those with a low score; high energy intake usually increases the risk of type 2 diabetes, and the lack of adjustment for energy intake might cause a superfluous positive association. However, energy adjustment only strengthens, rather than diminishes, the inverse association between a healthy dietary pattern and the incidence of diabetes, which is the major finding of the present study. Thirdly, we were not able to differentiate foods in detail, because the 16-item food frequency questionnaire was too simple. Therefore, it might be difficult to compare the present findings with previous studies. Finally, diabetes was not diagnosed from the findings of oral glucose tolerance tests. However, we measured levels of blood glucose and of HbA1c, which is a standard clinical method of assessing diabetes.[28]

In conclusion, the healthy dietary pattern determined herein predicted a reduced risk of diabetes, particularly among those who consumed a regular diet, those who exercised habitually and non- and ex-smokers. Intervention to alter dietary patterns might decrease the risk of type 2 diabetes developing.

ACKNOWLEDGMENTS

A part of this work was funded by Research-in-Aid for Cardiovascular Diseases, Ministry of Health, Labor and Welfare.

AUTHOR DISCLOSURES

The authors report no conflicts of interest.

REFERENCES

1. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27:1047-53.
2. Alberti KGMM, Zimmet P, Shaw J. International Diabetes Federation: a consensus on type 2 diabetes prevention. Diabet Med. 2007;24:452-63.
3. Newby PK, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: a review. Nutr Rev. 2004;62:177-203.
4. Hu FB, Rimm EB, Stampfer MJ, Ascherio A, Spiegelman D, Willett WC. Prospective study of major dietary patterns and risk of coronary heart disease in men. Am J Clin Nutr. 2000;72:912-21.
5. Slattery ML, Boucher KM, Caan BJ, Potter JD, Ma KN. Eating patterns and risk of colon cancer. Am J Epidemiol. 1998;148:4-16.
6. 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. 2002;136:201-9.
7. Montonen J, Knekt P, Harkanen T, Jarvincn R, Heliovaara M, Aromaa A, Reunanen A. Dietary patterns and the incidence of type 2 diabetes. Am J Epidemiol. 2005;161:219-27.
8. Morimoto A, Ohno Y, Tatsumi Y, Nishigaki Y, Maejima F, Mizuno S, Watanabe S. Risk of smoking and body mass index for incidence of diabetes mellitus in a rural Japanese population. Prev Med. 2012;54:341-4.
9. Morimoto A, Ohno Y, Tatsumi Y, Nishigaki Y, Maejima F, Mizuno S, Watanabe S. Impact of smoking cessation on incidence of diabetes mellitus among overweight or normal-weight Japanese men. Diabetes Res Clin Pract. 2012;96:407-13..
10. Tatsumi Y, Ohno Y, Morimoto A, Nishigaki Y, Mizuno S, Watanabe S. Lifestyle and the risk of diabetes mellitus in Japanese population. J Behav Med. 2012; doi:10.1007/s10865-012-9427-z.
11. The Committee of Japan Diabetes Society on the diagnostic criteria of diabetes mellitus. Report of the Committee on the classification and diagnostic criteria of diabetes mellitus. J Jpn Diabetes Soc. 2010;53:450-67. (in Japanese)
12. Kim JO, Mueller C. Factor analysis statistical methods and practical issues. Beverly Hills, CA: Sage Publications; 1978.
13. Odegaard AO, Koh W-K, Butler LM, Duval S, Gross MD, Yu MC, Yuan J-M, Pereira MA. Dietary patterns and incident type 2 diabetes in Chinese men and women: the Singapore Chinese Health Study. Diabetes Care. 2011;34:880-5.
14. Cho YA, Kim J, Cho ER, Shin A. Dietary patterns and the prevalence of metabolic syndrome in Korean women. Nutr Metab Cardiovasc Dis. 2011;21:893-900.
15. Feskens EJ, Virtanen SM, Räsänen L, Tuomilehto J, Stengård J, Pekkanen J, Nissinen A, Kromhout D. Dietary factors determining diabetes and impaired glucose tolerance. A 20-year follow-up of the Finnish and Dutch cohorts of the Seven Countries Study. Diabetes Care. 1995;18:1104-12.
16. Ford ES, Mokdad AH. Fruit and vegetable consumption and diabetes mellitus incidence among U.S. adults. Prev Med. 2001;32:33-9.
17. Lee HJ, Kim HC, Vitek L, Nam CM. Algae consumption and risk of type 2 diabetes: Korean National Health and Nutrition Examination Survey in 2005. J Nutr Sci Vitaminol. 2010;56:13-8.
18. Ylonen K, Saloranta C, Kronberg-Kippila C, Groop L, Aro A, Virtanen SM. Botnia Dietary Study. Associations of dietary fiber with glucose metabolism in nondiabetic relatives of subjects with type 2 diabetes: the Botnia Dietary Study. Diabetes Care. 2003;26:1979-85.
19. Ford ES, Will JC, Bowman BA, Narayan KM. Diabetes mellitus and serum carotenoids: findings from the Third National Health and Nutrition Examination Survey. Am J Epidemiol. 1999;149:168-76.
20. Song Y, Manson JE, Buring JE, Liu S. Dietary magnesium intake in relation to plasma insulin levels and risk of type 2 diabetes in women. Diabetes Care. 2004;27:59-65.
21. Reunanen A, Knekt P, Aaran RK, Aromaa A. Serum antioxidants and risk of non-insulin dependent diabetes mellitus. Eur J Clin Nutr. 1998;52:89-93.

22. Bhathena SJ, Velasquez MT. Beneficial role of dietary phytoestrogens in obesity and diabetes. Am J Clin Nutr. 2002; 76:1191-201.
23. Shimazu T, Inoue M, Sasazuki S, Iwasaki M, Sawada N, Yamaji T, Tsugane S. Isoflavone intake and risk of lung cancer: a prospective cohort study in Japan. Am J Clin Nutr. 2010;91:722-8.
24. Kokubo Y, Iso H, Saito I, Yamagishi K, Ishihara J, Inoue M, Tsugane S. Dietary fiber intake and risk of cardiovascular disease in the Japanese population: the Japan Public Health Center-based study cohort. Eur J Clin Nutr. 2011;65:1233-41.
25. Watanabe S, Tsugane S, Sobue T, Konishi M, Baba S. Study design and organization of the JPHC study. Japan Public Health Center-based Prospective Study on Cancer and Cardiovascular Diseases. J Epidemiol. 2001;11:S3-7.
26. Kim MK, Sasaki S, Sasazuki S, Tsugane S. Prospective study of three major dietary patterns and risk of gastric cancer in Japan. Int J Cancer. 2004;110:435-42.
27. 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. 2006;136: 1352-8.
28. American Diabetes Association. Standards of medical care in diabetes-2007. Diabetes Care. 2007;30(Suppl 1):S4-S41.

Original Article

Effects of healthy dietary pattern and other lifestyle factors on incidence of diabetes in a rural Japanese population

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鄉居的日本人健康的飲食模式及其它生活型態對糖尿病發生率的影響

這個研究評估飲食習慣及其它生活型態因子，對鄉居的日本人族群糖尿病盛行率的影響。歷時 10.3 年的世代研究，探討對象包括 1995 名男性及 3670 名女性，年齡介於 40-69 歲。在 1990 年 4 月至 1992 年 3 月進行研究對象的健康檢查，確認在基線時未患糖尿病。追蹤參與者至罹患糖尿病或直到 2006 年底。糖尿病發生率的評估是依據禁食及隨機的血漿葡萄糖量、HbA1c 量或是已接受糖尿病治療。經由主成分分析，確認一個特性為較頻繁攝取蔬菜、馬鈴薯、海菜、水果及大豆製品的飲食模式，將之標示為”健康的”。經過 58151 人年的追蹤，共有 446 名參與者罹患糖尿病。健康的飲食模式與較低的罹患糖尿病風險呈現相關(最高與最低四分位的多變項校正危險比為 0.78[95%信賴區間為 0.61-0.95])。此外，在那些有規律用餐(0.75[0.53-0.96])、運動習慣(0.65[0.44-0.96])及非抽菸或已戒菸的人，其健康飲食的分數與較低的糖尿病風險有相關(0.72[0.53-0.96])。研究結果顯示日本人攝取健康飲食與較低的糖尿病風險有關，尤其是那些用餐規律、習慣地運動及非抽菸或是戒菸者。

關鍵字：糖尿病、前瞻性研究、飲食習慣、生活型態、日本人