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Major dietary patterns, ethnicity and prevalence of type 2 diabetes in rural Hawaii[a,,b]

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Abstract

Objective—The association of type 2 diabetes (T2DM) with the overall dietary pattern and its relation with ethnicity were examined.

Methods—A cross-sectional study with 1257 participants with four ethnicities (Caucasian, Filipino, Native Hawaiian and Japanese) in the North Kohala region of Hawaii was conducted. Participants aged 18-95 years were surveyed for their ethnic and demographic backgrounds, dietary intakes and biochemical indexes of glucose intolerance between 1997 and 2000.

Results—Three dietary patterns from the food frequency questionnaire were identified by factor analysis. Factor 1 was characterized by a healthy diet with a frequent intake of vegetables and fruits, and factor 2 was dominated by animal foods and local ethnic dishes. Factor 3 was characterized by a Western diet, which was dominated by French fries, fast-food hamburgers, pizza, and chips. Multivariate logistic regression model for the T2DM prevalence included ethnicity and 3 dietary factors after adjustment for age, sex, BMI, income, physical activity, smoking status and energy intake. Ethnicity was significantly associated with T2DM showing odds ratios (OR's) for Native Hawaiians and Filipinos compared to Caucasians are 1.83 (95% CI 1.12-3.00) and 1.92 (95% CI 1.12-3.29), respectively. Among the three dietary factors, factor 2

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was positively associated with T2DM (OR=1.30, 95% CI of 1.03-1.68), but the significance disappeared after adjustment for energy intake.

Conclusions—The findings show that ethnicity is a stronger risk factor for T2DM than dietary patterns when energy intake is adjusted for. Reducing energy intake to prevent T2DM deserves more attention during health promotion for the multiethnic population of Hawaii.

Keywords

Dietary patterns; ethnicity; type 2 diabetes; Hawaii; factor analysis

Introduction

Previous population studies addressing the relationship between diet and type 2 diabetes (T2DM) have investigated the intake of specific nutrients or food groups of individuals (1). However, it is uncertain whether the observed association is a singular effect of a food or nutrient, or if the food or nutrient acts as a marker for an overall lifestyle and dietary pattern. This distinction is important as the intake of one food or nutrient is often correlated with the intake of another (2,3) or with other lifestyle factors (4), which may have a relationship to the risk status of the individual. Although the role of individual dietary components has been a focus of considerable research, foods are consumed in many complex combinations. Therefore, dietary pattern analysis, which reflects the complexity of dietary intake, has recently received greater attention from nutritional epidemiologists (5-7).

Ethnic groups in the United States have different dietary cultures and distinct rates of chronic disease (8). However, ethnic differences have rarely been the focus of diet-disease studies using dietary pattern analysis. Dietary changes observed in Asian Americans, due to a substantial shift to a Western lifestyle including increased intakes of total energy and fat, have been hypothesized to be risk factors for various chronic diseases (9). Therefore, how people retain or modify their own dietary patterns as they assimilate into a different culture may have either positive or negative consequences on the nutritional quality of their diets and chronic disease risk. It is clear that T2DM is due to genetic, environmental, and behavioral determinants, and recent studies of ethnic groups have contributed to this understanding (10-12). Indeed, different ethnic groups show prominent differences in their genetic predisposition towards T2DM and glucose intolerance (13,14). Kosaka (13), therefore, proposed two types of T2DM that progress differently among different ethnicities. One type is obesity-associated insulin resistance, in which insulin resistance due to obesity precedes the development of diabetes (14); the other is non-obesity type with impaired insulin secretion, in which reduction of insulin secretion among the non-obese population precedes development of the disease (10,13, 15). Not only are there genetic differences in diabetes etiology, but also different dietary patterns among ethnic groups may interact with both types at T2DM, leading to a varying disease prevalence in ethnic groups.

The aims of this study are to describe the dietary patterns among different ethnic groups in a rural Hawaiian population and to relate these patterns to the prevalence of T2DM.

Materials and Methods

Study population and sampling methods

The Kohala Health Research Project is an ongoing multiethnic, epidemiological study of diabetes and cardiovascular risk factors in North Kohala, Hawaii. The study was approved by the Institute of Research Board of University of Hawaii, and the details of this study have been published elsewhere (16). Data for the cross-sectional analysis were from the baseline survey conducted from 1997 to 2000. Out of 1451 subjects (665 men and 786 women) aged 18-95 years, 344 participants reported Caucasian as their strongest ethnic association (24%), 261 Filipino (18%), 434 Hawaiian (30%) and 218 Japanese (15%) were included for the analysis (n=1257). Those who reported Chinese (n=27), Hispanic (n=45), Portuguese (n=42), or other (n=80) as their strongest ethnic association were excluded (n=194) due to their small numbers.

The health screening examination was described previously (16). In brief, blood was drawn in the fasting state and after a standard 75g oral glucose-tolerance test, according to the 1998 WHO criteria for T2DM (17). Blood samples were separated and divided into two aliquots; one aliquot was stored at 4°C for glucose analyses, and the other aliquot was frozen at −80°C for insulin analyses. Plasma glucose was measured colorimetrically by using a Beckman Synchron CX4 Analyzer (Beckman Coulter, Brea, CA). Insulin was analyzed by using kits from Linco Research Inc. (St. Charles, MO). All measurements were performed with quality control procedures in place. Intraassay and interassay coefficient of variances were all less than 10 %. Height and weight were measured with participants wearing lightweight clothing without shoes and used to calculate body mass index (BMI). Waist and hip circumferences were measured at the level of the umbilicus and the widest area around the buttocks, respectively, and the waist to hip ratio (WHR) was also calculated. Food consumption was assessed with a food frequency questionnaire (FFQ) that included 166 foods and beverages commonly consumed by the multiethnic residents of the Hawaiian Islands. The FFQ was designed to assess the average food intake for the week prior to the survey. For the food list, the participants were asked to grade their frequency of consumption of each food item as ‘never’, ‘once a week’, ‘2-3 times a week’, ‘4-6 times a week’, ‘once a day’ and ‘2 times a day or more’. Using natural size photographs of one serving of each food item, usual serving sizes were also recorded as 1, 2 and 3 grading (1/2 serving for grade 1, one serving for grade 2 and twice or more than one serving for grade 3). The FFQ was validated by a pilot study with a small group within the same population by comparison with three 24-hour dietary recalls prior to the study. The FFQ and information on education, annual household income levels and smoking status were assessed by an interviewer-administered questionnaire. The average energy expenditure from leisure and occupational activities for the past month and past year were estimated using the Pima Indian Physical Activity Questionnaire (18), adapted to include activities unique to Hawaii customs. Metabolic equivalents (METS) were calculated using standardized estimates of energy expenditure as recommended by the American Colleges of Sports Medicine Compendium for Physical Activity (19). The 1998 World Health Organization criteria for diabetes were used to classify participants with disease status (17).

Statistical analysis

The data were analyzed using SAS version 9.1 software (SAS Institute, Cary, NC, USA). Data on frequency of food consumption and serving size in the list were recorded as relative quantity by multiplying frequency by serving size grade. Principal component factor analysis was conducted with varimax rotation using the 166 food items. Factors were retained based on the eigenvalue greater than 0.300, a scree plot and the interpretability of the factors (20). The factor loading matrix for the three retained dietary patterns is shown in table 1. Factor 1 was dominated by frequent intakes of fruits, vegetables and bean products. Factor 2 included frequent intake of corned beef and cabbage, rice, steamed shell fish, Filipino ethnic foods (Pinacbet, Sinigang and Dinengdeng) and local Hawaiian foods (Laulau, Kalua pig, Poi and Portuguese sausage). Factor 3 included frequent intakes of French fries, fast food hamburgers, pizza, chips, soda, pasta and salad dressings. The factor scores for each pattern computed for each individual based on their responses were used as new variables for further analyses. A higher factor score indicated that the individual ate the food pattern described by that factor more frequently than a person with a lower score. The relationship between the general characteristics of the participants and ethnic groups or diabetes status was assessed using ANOVA with Tukey's post-hoc analysis, Student's t-test and Pearson's Chi-square test to compare the arithmetic means and proportions of the characteristics in different ethnicities. Partial correlation was used to assess the relationship between the dietary factors and social economic status, smoking and physical activity scores, BMI, WHR and biochemical indexes of glucose intolerance after adjustment for age, sex and energy intake. The prevalence of T2DM was also compared among ethnic associations and logistic regression was used to investigate the relationship between the dietary factors and diabetes by ethnicity. The effects of potential confounders such as age, sex, BMI, income, physical activity levels, smoking status and energy intake on the relationship between dietary factors and diabetes were assessed in a series of multivariate logistic regression models.

Results

The general characteristics of the four ethnicities are shown in Table 2. The mean age and BMI of the total study population was 49.2 years and 28.0 kg/m^2, respectively. Those who identified themselves as Hawaiian were younger and those identified as Japanese were older than the other ethnic associations. Hawaiians showed significantly higher BMI and WHR than Caucasians and Japanese. Filipinos showed no difference in BMI with Caucasians, but their WHR was significantly higher. Filipino women showed the highest WHR among all groups. Of the lifestyle variables, physical activity scores were not significantly different across ethnicities, and the highest rate for current smoking was reported by Filipinos and Hawaiians. Income and education status were higher in Caucasians than in other ethnicities.

Two hundred and eight participants (16.5%) were categorized as having T2DM (Table 3). Prevalence of T2DM was lowest for Caucasians and highest for Japanese in the study population ($p<0.001$). However, since mean age was highest for Japanese, age stratified prevalence was also assessed. When diabetes prevalence was compared within an age-specific stratum, the order of most prevalence was Hawaiian, Filipino, Japanese and

Caucasian for both strata ($p<0.001$ for age ≥50 years and $p<0.05$ for age<50 years). Fasting glucose was significantly lower for Caucasians without diabetes, but no difference was observed by ethnicity for those with diabetes. A standard 75g oral two-hour glucose tolerance test (2-hour glucose) was only undertaken by participants without previously diagnosed diabetes at the time of survey. Among those without diabetes, Caucasians showed the lowest and Japanese showed the highest 2-hour glucose levels compared to Filipinos and Hawaiians ($p<0.001$). For those with newly diagnosed diabetes, there was no difference among groups in 2-hour glucose levels. Fasting insulin was significantly higher in Hawaiians than other ethnicities for both with and without diabetic participants.

Dietary patterns described by generated factor scores among the ethnicities by diabetes status showed ethnic differences in dietary patterns. Higher scores for factor 1, dominated mainly by fruits and vegetables, were observed in Caucasian relative to other ethnicities in non-diabetics, while diabetic patients did not show any differences by ethnicity. For factor 2, Caucasians and Japanese showed significant negative scores, while Filipinos and Hawaiians showed significant positive scores. Differences among ethnicities were observed both in diabetic and non-diabetic cases. The mean factor 2 score of diabetic cases was significantly higher than that of non-diabetic cases for Filipinos by Student's t-test ($p<0.001$). Factor 3 score was highest among Caucasians and lowest among Filipinos and Japanese for non-diabetics, while negative scores were observed among Filipino, Hawaiian and Japanese diabetics. The tendency of these results on dietary pattern scores among different ethnicities did not differ when energy adjusted ANCOVA analysis was conducted (data not shown).

Factor 1 was negatively correlated with BMI, smoking, WHR, fasting glucose, 2-hour glucose and fasting insulin, and positively correlated with years of education and physical activity ($p<0.001$) when age, sex and energy intake were controlled in partial correlation analysis (Table 4). Factor 2 was positively correlated with BMI, smoking, WHR, fasting glucose and 2-hr glucose, and negatively correlated with income level, years of education, physical activity and fasting insulin. Factor 3 was positively correlated with income and education and negatively correlated with BMI, WHR, fasting glucose and 2-hr glucose.

The odds ratios (OR) for having diabetes were significantly higher for Filipinos (2.24, 95% CI 1.43-3.52) and Hawaiians (2.85, 95% CI 1.90-4.28) when compared to Caucasians after adjustment for age, sex, BMI, income, physical activity and smoking status (Table 5, model 1). After further adjustment for dietary factors and interactions of smoking and dietary factors (model 2), the OR remained significantly different from that of Caucasians for Filipinos and Hawaiians, albeit slightly attenuated. When examined from an alternate view, we find that dietary factor 2 showed a significant OR when ethnicity was adjusted. The OR for having diabetes per unit change of factor 2 was 1.30 (95% CI 1.03-1.68) after adjustment for age, sex, income, physical activity, smoking and ethnicities (model 2). When energy intake was further adjusted in addition to the confounding factors added in model 2, the significant OR of dietary factor 2 became insignificant (model 3). In model 3, unlike in models 1 and 2, Filipinos showed a higher OR of 1.92 (95% CI 1.12-3.29) than Hawaiians (1.83, 95% CI 1.12-3.00) when compared with Caucasians after an adjustment for energy intake.

Because smoking status likely confounded the effect of dietary factors on diabetes, we compared the OR's across the smoking status strata (Figure 1). We noted that the association of T2DM and dietary factor 2 was only significant among never smokers while dietary factors were not significantly associated with T2DM among former or current smokers.

Discussion

By using the factor analysis, three dietary patterns were identified and showed an association with social economic status, lifestyle factors and diabetes. Factor 1, dominated by fruits, vegetables and bean products, positively correlated with lower BMI and WHR, non-smoking, increased education and income, lower fasting and 2-hr glucose after adjustment for age, sex and energy intake. The correlation direction for these health indicators was opposite for factor 2, which was dominated by local Hawaiian or ethnic foods. The tendency shown by factor 2 scores reflected ethnic food preferences very well, as shown in table 3, with significantly higher factor 2 scores in Filipinos and Hawaiians. Factor 3 positively correlated with income and education and negatively correlated with BMI, fasting, and 2-hr glucose. Two out of three dietary patterns identified by the current study were similar to previously reported patterns labeled as “Prudent” (factor 1) and “Western” (factor 3) patterns in Native Canadian (21), British (22), US (23) and Finnish studies (24). However, unlike the association of these dietary patterns with T2DM in other studies, our results did not show any association between factor 1 or factor 3 and T2DM prevalence.

The difference found in the present study may be attributable to the multi-ethnicity of our study population. Genetic backgrounds among different ethnicities might be a much stronger predictor of diabetes than dietary pattern factors 1 or 3. Moreover, since this study is a cross sectional study and 58% of diabetes cases were diagnosed before the study was conducted, some dietary behavior modification may have occurred in previously diagnosed diabetes cases leading the estimate measures toward null. This can be supported by table 3, which shows higher factor 1 scores in diabetics than in non-diabetics among Filipino, Hawaiian and Japanese, and lower factor 3 scores for diabetics than for non-diabetics in all ethnicities. Native Canadians also showed a similar dietary behavior modification in previously diagnosed diabetics (21). Further confirmation on dietary behavior modification of previously diagnosed diabetics could be made when we compared dietary pattern scores by new and old cases of diabetes (data not shown), but the regression model did not show any significance with only newly diagnosed T2DM cases due to low statistical power.

On the other hand, the dietary pattern described as factor 2, mostly dominated by local ethnic foods, represented the unique multicultural environment of Hawaii. It was positively associated with diabetes prevalence after adjustment for potential confounders except energy intake and ethnicity. However, the significance disappeared as energy intake was added in the logistic model. A local or ethnic food intake pattern, especially for Filipinos and Hawaiians in this study population, was stronger than other healthy lifestyle factors and other dietary patterns, but it was attenuated when total energy intake was adjusted. Hawaiians showed the highest energy intake compared to other ethnic groups. This is especially true for non-diabetics, who may not modify their diet due to T2DM. Our results show that total energy intake could be a more significant risk factor for T2DM than a specific dietary pattern in a very distinct multiethnic population. Ethnic background, explained not only by genetic factors but also by cultural dietary habits and a life style, seems to have the strongest association with T2DM. However, due to the cross-sectional nature of the present study, we can not conclude this association is a causal effect. Clearly, more investigation into this relationship is needed, but the relationship found in the present study seemed more likely to be caused by the dietary behavior modification after diagnosis of T2DM rather than the other way around.

Filipinos with diabetes showed the highest factor 2 scores probably due to the highly loaded Filipino dishes. However, other foods dominating factor 2 consisted of dishes made with canned beef and processed meat, which were supplied by commodity food distribution programs during the era of Western cultural introduction to the history of Hawaii. These foods may have contributed to the dietary evolution of Hawaii toward the Western diet with a high fat intake. Similar dietary cultural modification was observed among Pima Indians (25). On the Island of Hawaii, especially in the region of North Kohala, those with native Hawaiian ancestry seemed to retain their traditional Hawaiian foods such as Laulau (steamed pork and fish wrapped by spinach and tee leaves), Kalua pig and Poi, as well as other ethnic foods such as Pinacbet, Tinola and Sinigang. These ethnic dishes are mixed with various vegetables and pork or chicken. Due to their mixed vegetable ingredients, these dishes may be perceived as healthy foods. However, the ethnic foods identified as factor 2 may contain substantially high amounts of animal fat depending on cooking methods. Since these foods are made with chicken, pork, or canned processed meat, they may turn out to be high animal fat dishes, without removal of chicken skin or pork fats. As observed in Native Canadians, choice of cooking method and the addition of fat during the preparation of foods could be a great risk for diabetes (21). Therefore, appropriately tailored nutrition education including proper food preparation methods for people with different ethnic backgrounds seem to be very important, especially for the multiethnic population of Hawaii.

Japanese dietary patterns, however, did not appear as a distinct dietary pattern factor despite the fact that a similar number of Japanese food items were included in the FFQ and a large number of participants with Japanese ancestry were included in the study. A plausible explanation for this could be the longer immigration history of Japanese relative to that of Filipinos in Hawaii. Acculturation is a long-term process in which individuals modify or abandon certain aspects of their original culture as they adopt patterns of the new culture (26). Within the unique cultural environment of Hawaii, in addition to a long Japanese immigration history, Japanese might have more bidimensionally and multiple cultural identities differing in strength form those of Filipinos. The uniqueness of Japanese ancestry in Hawaii can be compared with the recent study on Japanese men in Japan, in which three dietary factors including Japanese patterns were generated (27). However, it is also possible that those with Japanese ethnicity did not show any distinct dietary factors because their genetic background is more strongly associated with T2DM for them than for the other ethnicities.

Caution must be used when interpreting the results of this current cross-sectional study, because they may have been subject to the following possible misclassification or measurement errors. First, the exposure measure of dietary intake could be biased by a recall bias of the FFQ. Another potential measurement error might be expected in quantifying food intakes. Since we used only 3 grades in determining the amount of intake (1/2 serving size as grade 1, one serving size as grade 2 and more than one serving size as grade 3), those who ate more than twice of the serving size would be underestimated. The weaker association observed with factor 1 compared to the previously reported studies (21-24) could also be attributable to the underestimated measurement error of dietary intakes. Second, the ethnic associations in this study were determined based on the self-reported ethnic identity. A major proportion of the participants in this study have a diverse mixed ancestry background, as do most local residents in the state of Hawaii. Therefore, the ethnic identity of the study population could reflect the strongest perceived cultural background of the individual, but it is possible that the strongest influence on dietary pattern is not the ethnicity with which people choose to associate. However, it is unlikely that the association we observed is fully attributable to the possible measurement errors, because these measurement errors would bias the association toward the null. Third, BMI was not controlled for as confounder in our models since it is an intermediate in causal pathway and we would like to examine the association of BMI as part of the diet's or ethnicity effect on T2DM (28,29).

Conclusion

Our results suggest that the existence of genetic, socioeconomic and lifestyle factors, as well as differences in food choices and total energy intake may account for the different prevalence of T2DM in this multiethnic population. Since genetic susceptibility and socioeconomic factors are more immutable factors, dietary behavior modification in efforts to prevent diabetes deserves more attention for promoting health in the multiethnic population of Hawaii.

References

1. Hamman RF. Genetic and environmental determinants of non-insulin-dependent diabetes mellitus (NIDDM). Diab Metab Rev. 1992; 8:287–338.
2. Barker ME, McClean SI, Thompson KA, Reid NG. Dietary behaviors and sociocultural demographics in Northern Ireland. Br J Nutr. 1990; 64:151–156.
3. Kant AK, Schatzkin A, Ziegler RG. Dieatry diversity and subsequent cause-specific mortality in the NHANES I epidemiologic follow-up study. J Am Coll Nutr. 1995; 14:233–238. [PubMed: 8586771]
4. Margetts BM, Jackson AA. Interactions between people's diet and their smoking habits: The dietary and nutritional survey of British adults. Br Med J. 1993; 307:1381–1384. [PubMed: 8274889]
5. Kant AK. Dietary patterns and health outcomes. J Am Diet Assoc. 2004; 104:615–635. [PubMed: 15054348]
6. Newby PK, Tucker KL. Empirically driven eating patterns using factor or cluster analysis: a review. Nutr Rev. 2004; 62:177–203. [PubMed: 15212319]
7. Park SY, Murphy SP, Wilkens LR, Yamamoto JF, Sharma S, Hankin JH, et al. Dietary patterns using the food guide pyramid groups are associated with sociodemographic and lifestyle factors: The Multiethnic Cohort Study. J Nutr. 2005; 135:843–849. [PubMed: 15795445]
8. National Center for Health Statistics. Vital and Health Statistics, Series 10, No 222. Department of Health and Human Services Publication no. (PHS) 2004-1550; 2004. Summary Health Statistics for US Adults: National Health Interview Survey, 2002.
9. Huang B, Rodriguez BL, Burchfiel CM, Chyou PH, Curb JD, Yano K. Acculturation and prevalence of diabetes among Japanese-American men in Hawaii. Am J Epi. 1996; 144:674–681.

10. Simon D, Bourgeon M, Balkau B, Eschwege E, Charles MA. Insulin sensitivity and ethnic groups. Diabetes Met. 2001; 27:215–221.
11. Ferreira SR, Lerario DD, Gimeno SG, Sanudo A, Franco LJ. Japanese-Brazilian Diabetes study group. Obesity and central adiposity in Japanese immigrants: role of the Western dietary pattern. J Epi. 2002; 12:431–438.
12. Tusie Luna MT. Genes and type 2 diabetes mellitus. Arch Med Res. 2005; 36:210–222. [PubMed: 15925011]
13. Kosaka K, Kuzuya T, Yoshinaga H, Hagura R. A prospective study of health check examinees for the development of non-insulin-dependent diabetes mellitus: relationship of the incidence of diabetes with the initial insulinogenic index and degree of obesity. Diabet Med. 1996; 13:S120–126. [PubMed: 8894495]
14. Fukushima M, Suzuki H, Seino Y. Insulin secretion capacity in the development from normal glucose tolerance to type 2 diabetes. Diabetes Res Clin Pract. 2004; 66:S37–S43. [PubMed: 15563978]
15. Grandinetti A, Kaholokula KJ, Chang HK, Chen R, Rodriguez BL, Melish JS, et al. Relationship between plasma glucose concentrations and Native Hawaiian Ancestry: The Native Hawaiian Health Research Project. Int J Obese Related Met Disorders. 2002; 26:778–782.
16. Grandinetti A, Chang HK, Theriault A, Mor J. Metabolic syndrome in a multiethnic population in rural Hawaii. Ethn Dis. 2005; 15:233–237. [PubMed: 15825969]
17. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Diabetes Care. 1997; 20(7):1183–1197. [PubMed: 9203460]
18. Kriska AM, Knowler WC, LaPorte RE, Drash AL, Wing RR, Blair SN, et al. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. Diabetes Care. 1990; 13:401–411. [PubMed: 2318100]
19. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc. 2000; 32(9 Suppl):S498–504. [PubMed: 10993420]
20. Hu FB, Rimm E, Smith-Warner SA, Feskanich D, Stampfer MJ, Ascherio A, et al. Reproducibility and validity of dietary patterns assessed with a food frequency questionnaire. Am J Clin Nutr. 1999; 69:243–249. [PubMed: 9989687]
21. Gittelsohn J, Wolever TMS, Harris SB, Harris-Giraldo R, Hanley AJG, Zinman B. Specific patterns of food consumption and preparation are associated with diabetes and obesity in a Native Canadian Community. J Nutr. 1998; 128:541–547. [PubMed: 9482761]
22. Williams DEM, Prevost AT, Wichelow MJ, Cox BD, Day NE, Wareham NJ. A cross-sectional study of dietary patterns with glucose intolerance and other features of the metabolic syndrome. Br J Nutr. 2000; 83:257–266. [PubMed: 10884714]
23. Van Dam R, Rimm EB, Willett WC, Stampfer MJ, Hu FB. Dietary patterns and risk for type 2 diabetes mellitus in US men. Ann Intern Med. 2002; 136:201–209. [PubMed: 11827496]
24. Montonen J, Knerkt P, Harkanen T, Jarvinen R, Hellovaara M, Aromaa A, Reunanen A. Dietary patterns and the incidence of Type 2 Diabetes. Am J Epi. 2005; 161:219–227.
25. Williams DEM, Saremi A, Knowler WC, Kriska AM, Smith CJ, Bennett PH, et al. The effect of Indian or Anglo dietary preference on the incidence of diabetes in Pima Indians. Diabetes Care. 2001; 24:811–816. [PubMed: 11347735]
26. Gibson MA. Immigrant adaptation and patterns of acculturation. Hum Dev. 2001; 44:19–23.
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; 136:1352–1358. [PubMed: 16614429]
28. Rothman, KJ. Epidemiology: an Introduction. New York: Oxford University Press; 2002. p. 108
29. Jewell, NP. Statistics for Epidemiology. Boca Raton: Chapman & Hall/CRC; 2004. p. 107-109.

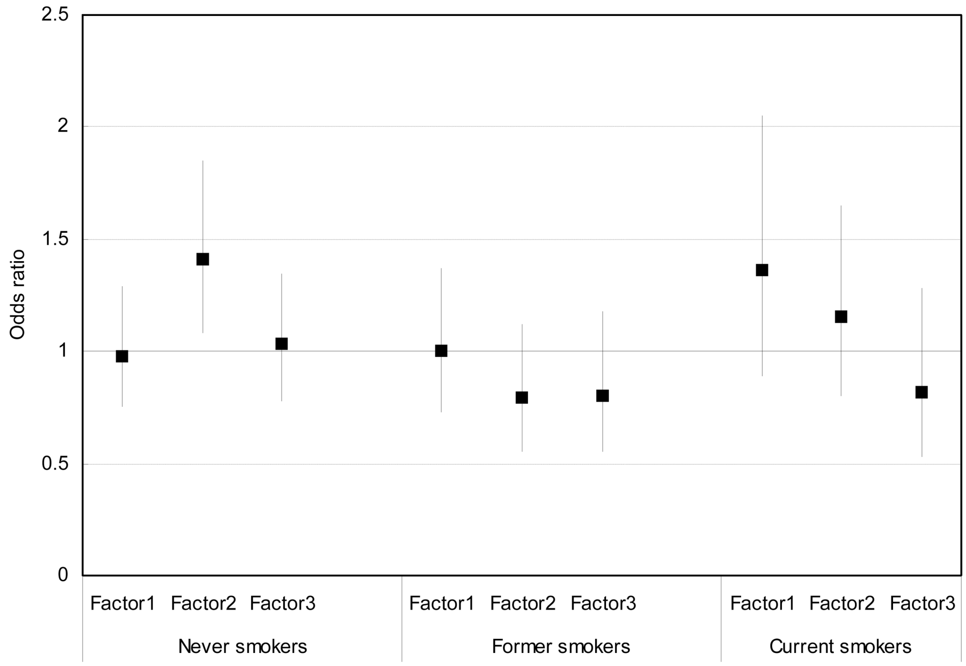

Figure 1.

Association of dietary patterns with prevalence of type 2 diabetes after adjusted for age, sex, BMI, physical activity and income levels by smoking status strata. Vertical lines are 95% confidence intervals.

Table 1

Factor loadings of the food items in the three dietary factors identified

	Dietary factors		
	1	2	3
Papaya	0.472	0.021	-0.101
Banana	0.467	0.009	0.035
Carrots	0.420	-0.109	0.047
Salad	0.407	-0.248	0.228
Tomatoes	0.389	-0.009	0.115
Zucchini	0.369	0.008	0.102
Tofu	0.360	-0.090	-0.064
Stir-fried vegetables	0.353	-0.006	-0.110
Other vegetables	0.344	0.105	-0.044
Apple	0.332	-0.100	0.018
Avocado	0.329	-0.053	0.074
Broccoli	0.324	-0.082	0.094
Dark green leaves	0.308	0.094	0.011
Orange	0.306	0.024	0.022
Corned beef and cabbage	-0.038	0.476	-0.024
Rice	-0.157	0.429	-0.003
Steamed shell fish	0.132	0.407	-0.023
Ribs	-0.030	0.383	0.046
Tinola	0.129	0.383	-0.098
Pinacbet	0.098	0.378	-0.182
Sinigang	0.164	0.367	-0.178
Beef stew	-0.015	0.363	0.008
Laulau	-0.081	0.347	0.191
Kalua pig	-0.108	0.341	0.096
Portuguese sausage	-0.060	0.329	0.158
Poi	0.016	0.325	-0.043
French fries	-0.146	0.153	0.434
Fast food cheese burger	-0.115	0.142	0.378
Pizza	-0.036	0.048	0.362
Potato chips	0.075	-0.100	0.334
Soda	-0.188	0.196	0.321
Pasta with red meat	0.078	-0.008	0.319
Pasta with fish	0.082	-0.042	0.318
Dressings	0.061	-0.094	0.316
Other chips	0.170	-0.177	0.302
Fast food hamburger	-0.080	0.242	0.301

Table 2

Anthropometric and lifestyle characteristics by different ethnicities

	Caucasian	Filipino	Hawaiian	Japanese
N (%)	344 (27)	261 (21)	434 (35)	218 (17)
Men	163 (47)	103 (39)	198 (46)	106 (49)
Women	181 (53)	158 (61)	236 (54)	112 (51)
		Mean±SD		
Age (y)	48.7±13.2[a]	50.0±16.3[a]	45.2±14.5[b]	56.3±17.5[c]
BMI (kg/m^2)	25.9±5.2[a]	26.8±5.7[a]	31.0±7.3[b]	26.2±4.7[a]
Waist to hip ratio				
Men	0.970±0.061[a]	0.991±0.043[bc]	0.997±0.056[c]	0.984±0.039[b]
Women	0.879±0.056[a]	0.914±0.059[b]	0.901±0.057 [c]	0.906±0.055[bc]
Physical activity		%		
Quartile 1	20.7	29.2	24.8	28.0
Quartile 2	26.1	26.0	25.1	20.9
Quartile 3	24.0	24.0	23.4	30.8
Quartile 4	29.1	20.8	26.8	20.4
Smoking status***		%		
Never	47.1	52.1	44.3	53.6
Quit	39.2	25.4	32.8	36.2
Current	13.7	22.5	22.9	10.1
Income***		%		
< $25,000	33.4	40.6	34.1	41.9
$25,000-$49,999	34.6	39.1	45.2	33.2
>=$50,000	32.0	20.3	20.7	24.9
Education***		%		
High school or less	43.2	65.1	71.6	60.5
More than high school	56.8	34.9	28.4	39.5

Mean values within a row with unlike superscript letters were significantly different with ANOVA and Tukey's post-hoc test ($p<0.05$).

*** $p<0.001$ with Chi-square test.

Table 3

Prevalence of type 2 diabetes, biochemical indices of glucose intolerance features and dietary pattern factor scores by different ethnicities[1]

	Caucasian (n=344)	Filipino (n=261)	Hawaiian (n=434)	Japanese (n=218)
Diabetes prevalence		N (%)		
Diabetics (16%)	23 (6.7)	53 (20.3)	86 (19.8)	46 (21.1)
Non-diabetics(84%)	321 (93.3)	208 (79.7)	348 (80.2)	172 (78.9)
Age ≥50 years***				
Diabetes (27%)	17 (11.3)	43 (30.9)	57 (36.8)	39 (29.5)
Non-diabetics (73%)	133 (88.7)	96 (69.1)	98 (63.2)	93 (70.5)
Age<50 years*				
Diabetes (8%)	6 (3.1)	10 (8.3)	29 (10.4)	7 (8.1)
Non-diabetics(92%)	188 (96.9)	111 (91.7)	249 (89.6)	79 (91.9)
Biochemical indexes		Mean±SD		
Fasting glucose (mg/dl)				
Diabetics (n=208)	156.5±73.7	157.3±59.4	165.3±55.7	144.2±40.2
Non-diabetics (n=1049)	95.2±8.1[a]	98.5±9.3[b]	98.2±9.1[b]	99.0±7.8[b]
Two-hour glucose[2] (mg/dl)				
New diabetics (n=87)	226.4±39.6	234.2±33.6	224.1±71.1	223.0±44.9
Non-diabetics (n=1049)	93.7±29.1[a]	109.9±32.3[b]	105.6±31.7[b]	120.3±34.1[c]
Fasting insulin (μU/ml)				
Diabetics (n=208)	18.9±7.5[a]	21.8±9.7[a]	26.8±19.1[b]	21.3±9.0[a]
Non-diabetics (n=1049)	15.2±9.9[a]	16.7±9.9[a]	19.5±10.2[b]	16.2±8.9[a]
Energy intake		Mean±SD		
Diabetics (n=208)	2002.9±785.6[a]	2410.1±1002.9[ab]	2672.5±1239.7[b]	2156.2±688.2[ab]
Non-diabetics (n=1049)	2316.5±892.4[ab]	2381.3±1003.9[b]	2765.4±1236.6[c]	2131.4±782.7[a]
Dietary patterns		Mean±SD		
Factor 1				
Diabetics (n=208)	0.27±1.01	0.16±1.17	0.09±1.07	-0.03±1.01
Non-diabetics (n=1049)	0.36±0.99[a]	-0.13±0.91[b]	-0.25±0.92[b]	-0.13±0.79[b]
Factor 2				
Diabetics (n=208)	-0.52±0.45[a]	0.61±1.45[b]	0.35±0.85[b]	-0.07±0.49[a]
Non-diabetics (n=1049)	-0.68±0.60[a]	0.39±1.06[c]	0.34±1.05[c]	-0.14±0.56[b]
Factor 3				
Diabetics (n=208)	0.14±0.68[a]	-0.61±0.79[b]	-0.18±1.13[ab]	-0.44±0.54[ab]
Non-diabetics (n=1049)	0.52±1.06[a]	-0.39±0.81[c]	0.05±0.81[b]	-0.31±0.64[c]

[1] Mean values within a row with unlike superscript letters were significantly different with ANOVA and Tukey's post-hoc test ($p<0.05$)

[2] Not measured for those who were previously diagnosed as diabetics

* $p<0.05$,

*** p<0.001 with Chi-square test.

Table 4

Partial correlation coefficients of the dietary factors with lifestyle, anthropometric and glucose intolerance variables adjusted for age, sex and energy intake.

	Factor 1	Factor 2	Factor 3
BMI	-0.127**	0.124***	-0.099**
Income	0.032	-0.147***	0.129**
Years of education	0.131***	-0.155***	0.107***
Smoking status	-0.102**	0.095**	0.048
Waist to hip ratio	-0.152***	0.100**	-0.078**
Physical activity score	0.205***	-0.060*	-0.007
Fasting glucose	-0.106***	0.134***	-0.087**
Two hour glucose	-0.062*	0.154***	-0.105***
Fasting insulin	-0.071*	-0.088**	-0.088**

* p<0.05,

** p<0.01,

*** p<0.001.

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Table 5

Association of ethnicity and dietary factor scores with prevalence of type 2 diabetes after adjusted for age, sex, BMI, physical activity, income and smoking status

	Coefficients (Std. Error)	Odds ratio	95% Confidence interval
Model 1			
Caucasian	-	1.00	
Filipino	0.81 (0.25)***	2.24	1.43-3.52
Hawaiian	1.05 (0.21)***	2.85	1.90-4.28
Japanese	0.45 (0.24)	1.57	0.98-2.52
Model 2[1]			
Caucasian	-	1.00	
Filipino	0.56 (0.27)*	1.75	1.03-2.95
Hawaiian	0.86 (0.23)***	2.36	1.49-3.73
Japanese	0.32 (0.26)	1.38	0.83-2.29
Dietary factor 1	-0.07 (0.14)	0.93	0.71-1.25
Dietary factor 2	0.27 (0.13)*	1.30	1.03-1.68
Dietary factor 3	0.05 (0.13)	1.05	0.81-1.35
Model 3[2]			
Caucasian	-	1.00	
Filipino	0.65 (0.28)*	1.92	1.12-3.29
Hawaiian	0.60 (0.25)*	1.83	1.12-3.00
Japanese	0.46 (0.26)	1.58	0.94-2.65
Dietary factor 1	-0.04 (0.15)	0.99	0.74-1.34
Dietary factor 2	0.29 (0.16)	1.34	0.93-1.83
Dietary factor 3	0.89 (0.16)	1.09	0.80-1.49

* $p<0.05$,

*** $p<0.001$.

[1] Further adjustment included covariates for the interaction of smoking status and dietary factors.

[2] Energy intake was adjusted by adding energy intake levels as an additional covariate in Model 2.