Dietary Factors Associated with Adiponectin in Filipino-American Women

Sheila Medina-Torne, MPH; Maria Rosario G. Araneta, PhD; Caroline A. Macera, PhD; Mark Kern, PhD; Ming Ji, PhD

Objective: To explore the cross-sectional association of nutrient intake with adiponectin in Filipino-American women who had completed a validated food frequency questionnaire.

Design: One hundred and sixty-one Filipino women aged 40 to 82 years were recruited from the University of California, San Diego Filipino Women's Health Study. Dietary information was assessed by a validated Harvard-Willet food frequency questionnaire. Plasma adiponectin was measured by radioimmunoassay.

Results: The median adiponectin value of the study population is 5.8 μg/dL (interquartile range, 3.9–8.4). Women in the highest adiponectin tertile had a lower dietary intake of omega-3-fatty acid compared to those with lower adiponectin levels ($P<.005$). In linear models controlling for potential confounders, a significant negative correlation was also observed between adiponectin and dietary intake of monounsaturated fat intake (partial $r=-.12$, $P=.04$), polyunsaturated fat (partial $r=-.17$, $P=.02$), omega-3-fatty acid (partial $r=-.19$, $P=.01$), and omega-6 fatty acids (partial $r=-.14$, $P=.4$),

Conclusion: Our findings suggest that increased nutrient intake of monounsaturated and polyunsaturated fat, as well as omega-3 and omega-6 fatty acids is associated with a decreased demand or requirement for adiponectin. More studies are warranted to evaluate the causal relationship between adiponectin and nutrient intake, including the use of specific food items, to confirm any associations. (*Ethn Dis*. 2011;21(2):190–195)

Key Words: Filipino-American, Women, Adiponectin, Fatty Acids, Diabetes

From the Graduate School of Public Health, San Diego State University (SMT, CAM, MK, MJ) and Department of Family and Preventative Medicine, University of California, San Diego (MRGA).

Address correspondence to Maria Rosario G. Araneta, PhD; University of California, San Diego; Department of Family and Preventive Medicine; 9500 Gilman Dr, MC-0607; La Jolla, CA 92093-0607; 858.822.3559; haraneta@ucsd.edu

Introduction

Adiponectin is a protein secreted by adipose tissue, which affects glucose and lipid metabolism. Low adiponectin concentration is a strong predictor of type 2 diabetes (T2D), while increased blood adiponectin concentrations improve insulin action and sensitivity in the general population.[1,2] Previous studies reveal ethnic differences in adiponectin concentration, independent of obesity, in association with T2D risk factors or outcomes among African-Americans,[3] Pima Indians,[4] Japanese, and Asian Indians.[5,6] Normoglycemic Filipino women have half the adiponectin concentrations compared to Caucasian women, independent of body size or level of insulin resistance.[7] These ethnic differences in adiponectin concentration may account for disparities seen in diabetes risk, especially in Filipinos who have a high prevalence of T2D, even in the absence of obesity, smoking, and physical inactivity.[7]

Modifiable lifestyle factors, notably diet-related elements, have been associated with adiponectin levels. Increased adiponectin levels have been observed with the Mediterranean-style diet, with higher intakes of dietary fiber, magnesium, and moderate alcohol consumption.[8–12] The high consumption of vegetable oils (especially olive oil) in Mediterranean countries contributes to a high intake of polyunsaturated acids (PUFA) and monounsaturated acids (MUFA). The Mediterranean diet also consists of a high consumption of fruits and vegetables, along with high intake of fish, which have been associated with reduction of metabolic risks.[13] The usual Filipino diet also maintains a sufficient amount of protein, fruits and vegetables, but also contains a staple of rice consumption, which contributes to the major part of the carbohydrates in the diet.

While improvements in adiponectin concentrations have been seen with diets rich in polyunsaturated fats in humans[14] and in animal studies,[15,16] there have been other reports of no improvement,[17] as well as decreases in adiponectin.[18] Therefore the role of nutrient intake in the regulation of adiponectin needs further exploration, especially in a cohort with higher T2D risk, like Filipinos. Thus, our aim was to investigate the association between several dietary factors and adiponectin in a sample of Filipino women in San Diego County, California.

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Methods

Self-identified Filipino women aged 40–89 years living in San Diego County were recruited between 1995 and 1999 to a cross-sectional study of multiple chronic conditions, including diabetes, hypertension, and cardiovascular disease.[19] Convenience-based sampling was utilized because Filipinos were not recognized separately from other Asian groups in the 1990 census. Data were analyzed from 161 participants who had completed the validated food frequency questionnaire. All participants provided

written informed consent, and study approval was acquired from the institutional review boards of San Diego State University and the University of California, San Diego (UCSD).

Clinical evaluations and interviews took place at the UCSD Rancho Bernardo Research Clinic. Data on demographics, education, concurrent medical issues, family history of diabetes, and behavioral characteristics of smoking and alcohol intake were collected by nurse-administered structured questionnaires. Participants brought all prescribed medications into the clinic for verification and documentation by research staff. Height, weight, waist, and hip measurements were obtained in a standardized method while participants wore lightweight clothing without shoes. Body mass index was calculated as weight in kilograms divided by height in meters squared. Body composition was measured by dual energy x-ray absorptiometry (DEXA), which determined the percentage of total body fat and truncal body fat (model QRD-2000 X-ray bone densitometers; Hologic, Waltham, Mass).

Blood samples were obtained by venipuncture in the morning after a minimum 8-hour fast, and also after a standard 75g oral glucose tolerance test. Fasting plasma concentrations of total cholesterol, high-density lipoprotein (HDL), and triglycerides were measured by enzymatic techniques at a Lipid Research Clinic Centers for Disease Control and Prevention (CDC) certified research laboratory. Total Low-density lipoprotein (LDL) was calculated using the Friedewald formula (Friedewald, Levy & Fredrickson, D.S., 1972). Fasting insulin was ascertained by radioimmunoassay in a diabetes research laboratory (Fineberg Laboratory, Indiana University). Fasting and post-challenge glucose values were measured by glucose-oxidase method (Fineberg Laboratory, Indiana University). Serum adiponectin levels were measured from archived samples stored at $-70^{\circ}C$ by radioimmunoassay methods (Linco Research, St. Louis, Mo). Hypertension was defined by physician diagnosis, present use of antihypertensive medication, or by systolic blood pressure $\geq$140 mm Hg or diastolic blood pressure $\geq$90 mm Hg. Type 2 diabetes was determined by physician diagnosis, current treatment with oral hypoglycemic agent or insulin, or if the participant fit the 1999 World Health Organizations (WHO) criteria of a fasting plasma glucose level $\geq$126 mg/dL, or a 2-hour post-challenge glucose level $\geq$200 mg/dL.[20]

A validated self-administered Harvard-Willett Diet Assessment Questionnaire was utilized to assess average food intake and determine nutrient values.[21] Portion size information was included as a part of the food item description. This food frequency questionnaire (FFQ) was adapted to a Filipino diet by including foods commonly consumed by Filipino women. Nutrient values were determined by the Harvard-Willett laboratory using the food-composition database of the US Department of Agriculture. Calculations for nutrient intake were estimated via computerized software programs that multiply the reported frequency of each food by the amount of nutrient in a serving of that food item. Quantity of food consumed was estimated using a standard portion size, service, or a predetermined amount, and the respondent was asked about the number of portions consumed. Nutrients used as exposure variables in this study had previous evidence of associations with adiponectin in the literature.

Statistical Analysis

All statistical analyses were performed using the Statistical Analysis Systems (SAS) version 9.1 software (SAS Institute Inc., Cary, NC). Continuous descriptive characteristics were reported as mean $\pm$ standard deviation, and categorical variables were reported as absolute numbers and frequencies. Protein, carbohydrates, saturated fat, monounsaturated fat, and polyunsaturated fat were reported as a percentage of total energy intake. Descriptive statistics utilized general linear models, and X^2 tests. An ANOVA was used for evaluating differences across tertiles of adiponectin; Bonferroni adjustment for multiple comparisons were applied. Adiponectin distribution was log-transformed for linear statistical analysis. Pearson and partial correlation coefficients were also calculated to examine the potential role of dietary factors on adiponectin concentrations. Statistical significance was determined at $P<.05$.

RESULTS

Adiponectin levels were significantly correlated with BMI ($r=-.23$, $P=.003$), waist circumference ($r=-.34$, $P<.0001$), HDL ($r=.5$, $P<.0001$), and triglycerides ($r=-.33$, $P<.0001$). Clinical characteristics of the study participants were examined according to adiponectin tertiles in Table 1. Women in the highest tertile of adiponectin had lower BMI, waist circumference and triglycerides, as well as higher HDL cholesterol. A trend was observed toward lower total energy intake and lower diabetes rates among women in the highest tertile. A trend was also noted toward lower dietary intake of omega-3 fatty acids in the highest adiponectin tertile. The trend remained when investigating linear models even after adjustment for potential confounder of age, overweight status, diabetes, and estrogen use ($P=.04$).

Associations between adiponectin and selected dietary intake were also examined in linear models, before and after adjustment for potential confounders (Table 2). In multivariate analysis, monounsaturated fat was significantly related to adiponectin (partial $r=-.12$, $P=.04$). Significant negative correlations were also observed between

Table 1. Clinical and dietary characteristics according to adiponectin tertiles

Characteristic	Lowest Tertile (*n*=54)	Medium Tertile (*n*=54)	Highest Tertile (*n*=53)	*P* for trend
Adiponectin, μg/mL	3.3 ± 1.0	6.0 ± .8*	11.9 ± 3.8*†	<.001
Age, years	56.4 ± 9.4	56.0 ± 8.7	59.5 ± 9.4	.10
BMI, kg/m^2	25.2 ± 2.7	25.3 ± 3.1	23.8 ± 2.9*†	.02
Overweight, %, BMI±25 kg/m^2	24 (44.4)	27 (51.9)	16 (30.8)	.09
Waist circumference, cm	81.8 + 9.1	80.8 + 7.4	76.1 + 8.5*†	<.001
Waist-to-hip ratio	.85 ± .06	.83 ± .05	.80 ± .06*†	<.001
Total body fat‡, %, by DEXA	31.4 ± 3.8	32.8 ± 3.6	32.0 ± 4.9	.25
Truncal fat‡, %, by DEXA	29.8 ± 4.3	30.4 ± 4.2	28.5 ± 6.1	.14
College graduate, %	28 (51.9)	32 (59.3)	31 (58.5)	.70
Exercise (±3 / wk), %	38 (70.4)	37 (68.5)	42 (79.3)	.41
Ever smoked, %	10 (47.6)	4 (19.1)	7 (33.3)	.23
Estrogen therapy, %	9 (16.7)	9 (16.7)	14 (26.4)	.35
Hypertension, %	40 (74.1)	33 (61.1)	33 (56.6)	.15
Parent with diabetes, %	16 (29.6)	22 (40.7)	9 (17.0)	.03
Type 2 diabetes, %	20 (37.0)	17 (31.5)	9 (17.0)	.06
Fasting glucose, mg/dL	110.0 ± 34.6	103.3 ± 35.8	99.3 ± 29.8	.25
Post challenge glucose, mg/dL	192.7 ± 75.8	171.1 ± 75.8	156.2 ± 80.3	.06
Fasting insulin, mg/dL	.6 ± .4	.6 ± .6	.5 ± .7	.47
Total cholesterol, mg/dL	221.4 ± 49.3	215.0 ± 36.6	216.6 ± 35.5	.65
LDL cholesterol, mg/dL	135.2 ± 36.8	129.4 ± 32.5	130.8 ± 32.7	.64
HDL cholesterol, mg/dL	50.0 ± 11.3	50.8 ± 10.4	63.8 ± 12.6*†	<.001
Triglycerides, mg/dL	172.3 ± 84.2	167.5 ± 115.7	110.3 ± 58.9*†	<.001
Total energy intake, kcal/day	2764 ± 2515	2222 ± 1434	2034. ± 1046	.09
Protein, % total energy	18.8 ± 4.7	17.7 ± 3.7	18.0 ± 3.9	.35
Carbohydrate, % total energy	58.5 ± 8.9	59.6 ± 10.1	60.3 ± 9.0	.60
Saturated fat, % total energy	7.7 ± 2.6	8.0 ± 3.2	7.6 ± 2.7	.71
Monounsaturated fat, % total energy	9.3 ± 2.5	9.0 ± 2.8	8.8 ± 2.4	.64
Polyunsaturated fat, % total energy	5.0 ± 1.2	4.5 ± 1.5	4.6 ± 1.0	.11
Total n-3 fatty acids, % total energy	.73 ± .26	.62 ± .19	.61 ± .17*	<.005
Total n-6 fatty acids, % total energy	4.0 ± 1.1	3.7 ± 1.3	3.8 ± .9	.37
Dietary fiber, g	36.5 ± 32.1	28.2 ± 19.4	28.1 ± 17.8	.12

Data are presented as mean ± standard deviation or *n* (%).
LDL, low-density lipoprotein. HDL, High-density lipoprotein.
Comparisons versus the lowest tertile, Bonferroni corrected, *P<.05
Comparisons verus medium tertile, Bonferroni corrected, †P<.05
‡ Missing data on 11 participants

adiponectin and polyunsaturated fat (partial r=−.17, P=.02), total omega-3 fatty acids (partial r=−.19, P=.01), and total omega-6 fatty acids (partial r=−.14, P=.04).

To rule out possible bias from diabetes influence, diabetes was considered as a potential confounder in the additional multivariate models. Additional analysis restricting the population to non-diabetics found the associations of these dietary factors with adiponectin concentrations remained of similar strength.

DISCUSSION

This cross-sectional investigation is the first to evaluate the association between nutrient intake and adiponectin in Filipino-American women. Data on the prevalence and predictors of adiponectin among Filipinas are lacking. The only study to compare adiponectin levels in Filipinas with other ethnic cohorts found normoglycemic Filipinas and African Americans with a lower concentration compared with Whites after adjusting for age, homeostasis model assessment of insulin resistance (HOMA-IR), and waist-to-hip ratio.[7] This raises the possibility of a generalized phenomenon of inherently low adiponectin concentrations in Filipinas. Marked differences in adiponectin concentration across ethnic groups are likely due to genetic, environmental, and lifestyle factors. Information regarding modulators of adiponectin can provide valuable clues to differences in patterns of disease presentation, and insight into therapeutic or interventional strategies.

We observed Filipinas in the highest adiponectin tertile had lower levels of BMI, waist circumference, and triglycerides, which are all in agreement with previous reports regarding anthropometric and clinical variables.[22–24] In addition, more diabetics were observed with lower adiponectin levels, consistent with earlier cross-sectional and prospective studies.[2,6]

A negative association was observed between monounsaturated as well as polyunsaturated fat with adiponectin concentration. This effect may be

Table 2. Pearson and partial correlation coefficients between adiponectin and select nutrient intake

Variables	Adiponectin			
	r	*P*	r^2	*P*
Total energy intake, kcal/day	−.15	.06	−.16	.05
Protein, % total energy	−.06	.44	−.07	.08
Carbohydrate, % total energy	.11	.17	.11	.06
Saturated Fat, % total energy	−.05	.53	−.04	.12
Monounsaturated Fat , % total energy	−.13	.09	−.12	.04
Polyunsaturated Fat, % total energy	−.18	.03	−.17	.02
Total n-3 fatty acids, % total energy	−.19	.02	−.19	.01
Total n-6 fatty acids, % total energy	−.14	.07	−.14	.04
Dietary Fiber, g	−.14	.07	−.14	.06

r, Pearson correlation coefficients; r^2, partial correlation coefficients controlling for age, overweight status, diabetes, and estrogen use.

attributed to the biological, individual, or synergistic role of these types of fatty acids. In particular, the n-3 and n-6 polyunsaturated fatty acids were associated with decreased adiponectin concentrations. These results are consistent with a previous nutritional intervention trial, which studied the effect of n-3 supplementation vs a control diet among healthy adults.[18] It's speculated that the adiponectin decline was attributed to a reduced demand for anti-inflammatory actions in the presence of high n-3 fatty acids. As n-3 fatty acids themselves produce insulin-sensitizing and anti-inflammatory properties, they compensated for the effects of adiponectin, thus decreasing the demand or requirement for adiponectin. These findings therefore provide a biologically plausible explanation for our findings between low adiponectin concentration and n-3 fatty acid intake seen in this Filipina cohort.

Although other studies considered the effects of n-3 fatty acids on adiponectin and found contrasting results,[15,16,26] their use of animal models may not be representative of outcomes in humans, and the use of gas-liquid chromatography, instead of a validated food frequency questionnaire to measure plasma fatty acid composition may have differing results. Another previous study in humans, utilized a randomized, controlled, dietary intervention model in overweight and obese men and women, which found no significant changes in adiponectin levels in a diet enriched in n-3 PUFA vs a control diet.[17] However, they had a low sample size (n=26) and did not control for sex, as men and women have different adiponectin concentrations.[27]

Adiponectin was also inversely associated with monounsaturated fatty acid. A previous study had found a similar finding, and concluded that this occurrence may be due to the Δ-9 desaturase activity on monounsaturated fatty acids.[25] An association between monounsaturated fatty acids and Δ-9 desaturase was previously discovered with insulin resistant conditions.[28]

Our results should be interpreted while considering some limitations. The cross-sectional design of the study can only establish associations and not temporal relationships between adiponectin and the major dietary intake of the Filipino women. Although dietary intake was based on self-report, measurement error has been shown to be relatively small from self-reported dietary intake data.[29] The method of convenience sampling is another limitation to note, as it may provide results that may not be generalizable to the US Filipino women population. However, the demographic information of our study population was compared to the 2000 US Census and was found to be comparable in regards to socioeconomic status, based on college education. In addition, the low sample size is a limitation to note, which may mask the true outcome in the general population. Previous studies have identified polymorphisms in both the adiponectin gene and the adiponectin receptor.[30] Genetic markers were not measured in the present study, complicating discernment of the influence of genetic factors from environmental factors. Results from this investigation cannot suggest dietary modifications for Filipinas, as the study was cross-sectional and cannot infer causality. In addition, normoglycemic Filipinas, including those in this sample had very low adiponectin levels compared to Caucasians, so the findings might not be generalizable to other populations. Although confounding was appropriately controlled by standard statistical procedures, residual confounding by uncontrolled covariates is still a possibility. Caution should be employed when interpreting the results of the present cross-sectional study as they may have been subject to misclassification or measurement errors. Confirmation of our results by future studies in similar populations is warranted.

There are few studies that have concentrated on the relationship between nutrient intake and adiponectin in an ethnic population, and to our knowledge this is the first one in a Filipina population. Given that higher adiponectin levels may be a cornerstone of diabetes prevention and management, lifestyle factors that potentially influence its levels is of worthwhile exploration. A paradoxical phenomena exists among Filipinos, as they exhibit elevated T2D prevalence, despite frequent exercise, high college attainment, and the absence of obesity. Research is needed to better understand health patterns in this ethnic cohort, in order to develop appropriate interventions or guidelines towards the goal of a healthier Filipino population, and other nonobese populations with similar met-

abolic abnormalities. Although low adiponectin concentrations were observed with more n-3 PUFA consumption, this occurrence may be a secondary reaction to the anti-inflammatory effects of the n-3 PUFA. Further research is necessary to understand the specific pathogenesis of this phenomenon.

In summary, the present study found the highest tertile of adiponectin was independently associated with decreased dietary intake of monounsaturated as well as polyunsaturated fat. This notion supports the idea that in the presence of high n-3 PUFA, adiponectin regulation and expression is reduced. Therefore, assessment of n-3 fatty acid intake may serve as a potential indicator of low adiponectin in Filipinas. Future studies should extend these results by studying the implication of adiponectin and genetic factors.

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AUTHOR CONTRIBUTIONS

Design concept of study: Medina-Torne, Araneta, Macera

Acquisition of data: Medina-Torne, Araneta
Data analysis and interpretation: Medina-Torne, Araneta, Macera, Kern, Ji
Manuscript draft: Medina-Torne, Araneta, Kern, Ji
Statistical expertise: Medina-Torne, Araneta, Ji
Acquisition of funding: Araneta
Administrative: Medina-Torne, Araneta
Supervision: Medina-Torne, Araneta, Macera, Kern, Ji