Published in final edited form as:

Am J Hum Biol. 2009 ; 21(3): 389–391. doi:10.1002/ajhb.20858.

Adiponectin and Type 2 Diabetes in Samoan Adults

Julia R. Dibello¹, Ana Baylin¹, Satupaitea Viali², John Tuitele³, Linda Bausserman⁴, and Stephen T. McGarvey^{*1,*}

¹Department of Community Health, International Health Institute, Brown University, Providence, Rhode Island 02912

²Ministry of Health, Government of Samoa, Apia, Samoa

³Tafuna Family Health Center, American Samoa Department of Health, Pago Pago, American Samoa 96799

⁴Department of Medicine, The Miriam Hospital, Brown University, Providence, Rhode Island 02903

Abstract

Objective—Previous studies have established an association between adiponectin and type 2 diabetes. It is unclear whether adiponectin will be useful among Samoan Islanders, characterized by markedly elevated levels of obesity, in differentiating those at risk of developing type 2 diabetes.

Methods—Cross-sectional, genetic epidemiology study of obesity in American Samoa and Samoa 2002–2003 ($n = 1,599$). Logistic regression provided adjusted odds ratios and 95% confidence intervals for the association between adiponectin, diabetes, and prediabetes (impaired fasting glucose).

Results—There is a significant decreasing trend in the odds of diabetes and prediabetes across increasing quintiles of adiponectin with an OR of 2.8 (95% CI: 1.6, 5.0) and 2.9 (95% CI: 1.5, 5.7), respectively, in the lowest relative to the highest quintile of adiponectin (P -for-trend = 0.004 and 0.001).

Conclusions—Adiponectin is an important correlate, independent of other risk factors, of the pathogenesis of type 2 diabetes among Samoan islanders and may help distinguish those at higher risk of developing this disease.

Adiponectin, a hormone produced exclusively by the adipocyte, is negatively associated with many of the components of the metabolic syndrome, including BMI, triglycerides, and blood pressure (Cnop et al., 2003; Lindsay et al., 2002; Spranger et al., 2003). The majority of obese individuals have hypoadiponectinaemia, but the mechanisms underlying the association are not fully understood (Hattori et al., 2005; Trujillo and Scherer, 2005). Furthermore, low serum adiponectin in obese individuals is associated with decreased hepatic insulin sensitivity characteristic of type 2 diabetes.

Previous studies show an association between low adiponectin and increased incidence of type 2 diabetes across a number of different populations (Lindsay et al., 2002; Nakashima et al., 2006; Snijder et al., 2006; Spranger et al., 2003). This relationship has not been studied in Samoans, a population with a high prevalence of obesity (Ezeamama et al., 2006;

Keighley et al., 2006). Currently, based upon Polynesian obesity definitions, 71% of women and 59% of men in American Samoa are obese. Although the prevalence of obesity has not reached the same epidemic levels in Samoa as in American Samoa, 29% of men and 53% of women are obese (Keighley et al., 2006, 2007). It is unclear whether adiponectin will be useful in differentiating those at higher risk of developing type 2 diabetes in this markedly obese population. In this report, we describe the cross-sectional relationship between adiponectin and type 2 diabetes among adult Samoans.

METHODS

Participants

Participants were 18 years of age and took part in the Samoan Family Study of Overweight and Diabetes in 2002–2003 (Dai et al., 2007, 2008). Recruitment in American Samoa (2002) was based on random selection of individuals seen in the 1990–1994 cohort study in American Samoa, and the presence of at least two adult siblings alive and residing in American Samoa. Initial recruitment in Samoa (2003) was based on finding individuals who were members of American Samoa pedigrees. Later recruitment occurred in villages selected to represent geographic and socioeconomic diversity.

Protocols for this study were approved by the Brown University and American Samoan Institutional Review Board, and the Government of Samoa, Ministry of Health, Health Research Committee. Written informed consent was obtained from all participants.

Measurements

Stature and weight were measured with participants wearing light tropical clothing, without shoes and BMI was calculated. Polynesian BMI criteria for classifying overweight, BMI 26–31.9 kg/m², and obesity, BMI ≥ 32 kg/m², were used based on earlier body composition research (Swinburn et al., 1999). Abdominal circumference was measured twice at the level of the umbilicus with a metal tape, and the average of the two measurements was taken. Serum was collected after a minimum 10-h fast in the field, and the following assays were completed: serum insulin using standard RIA kits from Diagnostic Products, serum glucose using an automatic analyzer, Beckman CX4, and serum adiponectin using RIA kits from Linco. HDL cholesterol was measured after precipitation of very low and low density lipoprotein with heparin-Mn²⁺ reagent (Aberg et al., 2008).

Sociodemographic, health, and nutrition information were obtained by interview including questions about previous diabetes diagnosis, duration, and current treatment. A material lifestyle score was calculated for each participant based upon a 10-point index of household possessions, including possession of a refrigerator and television. This index is a sensitive measure of socioeconomic status (SES) in modernizing societies because it includes the impact of migrant remittances on household income (Ezeamama et al., 2006). Hours per week of physical activity included duration of physical activity in wage labor, recreational sports, farming, and fishing. All physical activities were coded for intensity (low, moderate, high) using CDC guidelines (Keighley et al., 2007).

Statistical analyses

The total study sample consisted of 1,716 adults. Participants were excluded from the sample because of missing data, leaving a sample of 1,599 (251 with type 2 diabetes, 231 with prediabetes, and 1,117 with normal glycemia). Prediabetes or impaired fasting glucose was defined as 100 < fasting plasma glucose (FPG) < 126 with no self-reported treatment or diagnosis of diabetes.

In the study sample, 40% of American Samoan adults <50 years of age and 18% ≥50 years found to have a FPG level ≥126 mg/dl did not have a prior diagnosis of diabetes. In Samoa, slightly less than 50% of adults ≥50 years of age diagnosed with diabetes were unaware of their status (Keighley et al., 2007). It is likely that many individuals with a prior diabetes diagnosis and new cases we detected had diabetes long before diagnosis. This trend is partially attributable to low SES and health literacy in this population leading to low levels of health care seeking (Ezeamama et al., 2006). Therefore, we also examined the relationship between adiponectin and prediabetes as adiponectin likely affects diabetes risk early in the pathogenesis of this condition (Cnop et al., 2003; Trujillo and Scherer, 2005).

Descriptive analyses were performed using ANOVA and *t*-tests for continuous variables and χ^2 tests for categorical variables. Adiponectin, insulin, and glucose were natural log transformed to improve normality. Logistic regression was used to calculate adjusted odds ratios (OR) and 95% CIs for the association between adiponectin, diabetes, and prediabetes with those with normal glycemia as the reference. Because of the family design of the study, a random effects term for household was included to account for clustering among individuals. Individuals were assigned a value for household based upon their residence at the time of the study. Adiponectin was divided into quintiles for use in regression models. Tests for trend across quintiles of adiponectin used the median value for each of the quintiles modeled as a continuous variable. All analyses were conducted using SAS 9.1.

RESULTS

The proportions of adults with diabetes, prediabetes, and normal glycemia are as follows: 11.3% (102/903, 95% CI: 0.09, 0.14), 14.9% (135/903, 95% CI: 0.13, 0.17), and 73.7% (666/903, 95% CI: 0.71, 0.77) in Samoa; and 21.5% (161/750, 95% CI: 0.19, 0.25), 13.9% (104/750, 95% CI: 0.12, 0.17), and 64.7% (485/750, 95% CI: 0.61, 0.68) in American Samoa.

Diabetes risk factors stratified by glycemic status are shown in Table 1. There were significant differences by glycemic group in age, BMI, fat, protein, and carbohydrate intake, moderate activity hours, HDL cholesterol, adiponectin, insulin, and glucose levels. Significant differences were noted between those with prediabetes and diabetes in hours of moderate physical activity ($P = 0.003$), age ($P < 0.0001$), percent calories from fat ($P = 0.002$), and carbohydrate ($P = 0.004$), insulin ($P = 0.0006$), and glucose levels ($P < 0.0001$).

In the adjusted models (Table 2), there was a significant decreasing trend in the odds of diabetes and prediabetes across increasing quintiles of adiponectin with ORs of 2.8 (95% CI: 1.6, 5.0) and 2.9 (95% CI: 1.5, 5.7), respectively, in the lowest relative to the highest quintile of adiponectin (P -for-trend = 0.004 and 0.001). These results were consistent across age and sex strata (data not shown).

DISCUSSION

This report establishes a significant cross-sectional relationship between low serum adiponectin and increased odds of diabetes and prediabetes in adults from throughout the Samoan islands. There was no appreciable change in this relationship after controlling for other risk factors for type 2 diabetes (insulin resistance, abdominal circumference, age, sex, physical activity, and SES). Although these risk factors likely partially mediate the effect of adiponectin on the diabetic state, our results support a direct and independent effect of adiponectin. Our results are consistent with previous studies among Pima Indians (OR: 0.63, 95% CI: 0.43, 0.92 high versus low adiponectin) (Lindsay et al., 2002), Japanese Americans (Hazard ratio: 1.79, 95% CI: 1.01, 3.17 lowest versus highest tertile of adiponectin)

(Nakashima et al., 2006), and European populations (Relative risk: 0.3, 95% CI: 0.2, 0.7 fourth versus first quartile of adiponectin) that found low adiponectin levels to be related to the occurrence of type 2 diabetes. The consistency of the inverse relationship between adiponectin and type 2 diabetes across study populations with varying obesity and adiponectin levels is noteworthy. Adiponectin appears to be an important predictor early in the pathogenesis of type 2 diabetes even among Samoan islanders, characterized by high obesity levels and may help distinguish those at higher risk of developing this disease.

Acknowledgments

Contract grant sponsor: NIH; Contract grant number: DK59642.

LITERATURE CITED

- Åberg K, Dai F, Sun G, Keighley ED, Indugula SR, Bausserman L, Viali S, Tuitele J, Deka R, Weeks DE, McGarvey ST. A genome-wide linkage scan identifies multiple chromosomal regions influencing serum lipid levels in the population on the Samoan Islands. *J Lipid Res.* 2008; 49:2169–2178. [PubMed: 18594117]
- Cnop M, Havel PJ, Utzschneider KM, Carr DB, Sinha MK, Boyko EJ, Retzlaff BM, Knopp RH, Brunzell JD, Kahn SE. Relationship of adiponectin to body fat distribution, insulin sensitivity and plasma lipoproteins: Evidence for independent roles of age and sex. *Diabetologia.* 2003; 46:459–469. [PubMed: 12687327]
- Dai F, Keighley ED, Sun G, Indugula SR, Roberts ST, Åberg K, Smelser D, Tuitele J, Jin L, Deka R, Weeks DE, McGarvey ST. Genome-wide scan for adiposity-related phenotypes in adults from American Samoa. *Int J Obes (Lond).* 2007; 31:1832–1842. [PubMed: 17621312]
- Dai F, Sun G, Åberg K, Keighley ED, Indugula SR, Roberts ST, Smelser D, Viali S, Jin L, Deka R, Weeks DE, McGarvey ST. A whole genome linkage scan identifies multiple chromosomal regions influencing adiposity-related traits among Samoans. *Ann Hum Genet.* 2008; 72(Part 6):780–792. [PubMed: 18616661]
- Ezeamama AE, Viali S, Tuitele J, McGarvey ST. The influence of socioeconomic factors on cardiovascular disease risk factors in the context of economic development in the Samoan archipelago. *Soc Sci Med.* 2006; 63:2533–2545. [PubMed: 16876925]
- Hattori S, Hattori Y, Kasai K. Hypoadiponectinemia is caused by chronic blockade of nitric oxide synthesis in rats. *Metabolism.* 2005; 54:482–487. [PubMed: 15798955]
- Keighley, ED.; McGarvey, ST.; Quested, C.; McCuddin, C.; Viali, S.; Maga, U. Nutrition and health in modernizing Samoans: temporal trends and adaptive perspectives. In: Ohtsuka, R.; Ulijaszek, SJ., editors. *Health change in the Asia-Pacific region: biocultural and epidemiological approaches.* Cambridge: Cambridge University Press; 2007. p. 147-191.
- Keighley ED, McGarvey ST, Turituri P, Viali S. Farming and adiposity in Samoan adults. *Am J Hum Biol.* 2006; 18:112–122. [PubMed: 16378333]
- Lindsay RS, Funahashi T, Hanson RL, Matsuzawa Y, Tanaka S, Tataranni PA, Knowler WC, Krakoff J. Adiponectin and development of type 2 diabetes in the Pima Indian population. *Lancet.* 2002; 360:57–58. [PubMed: 12114044]
- Nakashima R, Kamei N, Yamane K, Nakanishi S, Nakashima A, Kohno N. Decreased total and high molecular weight adiponectin are independent risk factors for the development of type 2 diabetes in Japanese-Americans. *J Clin Endocrinol Metab.* 2006; 91:3873–3877. [PubMed: 16882743]
- Snijder MB, Heine RJ, Seidell JC, Bouter LM, Stehouwer CD, Nijpels G, Funahashi T, Matsuzawa Y, Shimomura I, Dekker JM. Associations of adiponectin levels with incident impaired glucose metabolism and type 2 diabetes in older men and women: The Hoorn Study. *Diabetes Care.* 2006; 29:2498–2503. [PubMed: 17065691]
- Spranger J, Kroke A, Mohlig M, Bergmann MM, Ristow M, Boeing H, Pfeiffer AF. Adiponectin and protection against type 2 diabetes mellitus. *Lancet.* 2003; 361:226–228. [PubMed: 12547549]
- Swinburn BA, Ley SJ, Carmichael HE, Plank LD. Body size and composition in Polynesians. *Int J Obes Relat Metab Disord.* 1999; 23:1178–1183. [PubMed: 10578208]

Trujillo ME, Scherer PE. Adiponectin—Journey from an adipocyte secretory protein to biomarker of the metabolic syndrome. *J Intern Med.* 2005; 257:167–175. [PubMed: 15656875]

TABLE 1

Characteristics of the cross-sectional Samoan Island study population by glycemic status, 2002–2003 ($n = 1,599$)

	Diabetes ^a ($n = 251$) % (n)	Prediabetes ^a ($n = 231$) % (n)	Normoglycemia ^a ($n = 1,117$) % (n)
Age ^b			
18–39	17.5 (44)	34.2 (79)	59.4 (664)
40–59	49.4 (124)	49.8 (115)	27.9 (312)
60+	33.1 (83)	16.0 (37)	12.6 (141)
Female	43.8 (110)	49.4 (114)	43.4 (485)
Moderate activity hours ^{b,c}	0.59 (0.12), 0	1.4 (0.27), 0	2.3 (0.21), 0
MLS score ^{c,d}	7.38 (0.12), 8.0	7.24 (0.12), 8.0	6.98 (0.06), 7.0
Fat intake (%) ^{d,e}	42.9 (0.55)	45.4 (0.60)	45.4 (0.29)
Protein intake (%) ^d	14.9 (0.31)	14.9 (0.31)	14.1 (0.13)
Carbohydrate intake (%) ^d	43.1 (0.58)	40.6 (0.61)	41.6 (0.28)
BMI (kg/m ²) ^{b,f}			
25.9	6.8 (17)	7.8 (18)	22.8 (255)
26–32	27.5 (69)	22.1 (51)	32.9 (367)
>32	65.7 (165)	70.1 (162)	44.3 (495)
Abdominal circumference (cm) ^{b,c}	114.2 (0.91), 113.5	111.4 (0.98), 112.1	102.1 (0.48), 102.0
HDL cholesterol (mg/dl) ^{b,c}	41.0 (0.67), 39.3	41.2 (0.67), 40.2	46.3 (0.33), 44.8
Glucose (mg/dl) ^{b,c}	180.8 (5.23), 155.0	108.1 (0.47), 106.0	83.3 (0.32), 86.0
Insulin (μU/ml) ^{b,c}	16.3 (1.10), 11.1	20.1 (1.44), 14.2	8.8 (0.27), 6.0
Adiponectin (μg/ml) ^{b,c}	10.1 (0.64), 8.4	8.6 (0.37), 7.3	11.0 (0.29), 9.1

^aDiabetes is defined as fasting glucose ≥ 126 or a self-reported history of this condition. Prediabetes is defined as $100 < \text{fasting glucose} < 126$ with no history of self-reported treatment or diagnosis of diabetes. Normoglycemia is defined as fasting glucose < 100 mg/dl with no history of diabetes.

^bSignificantly different at: $P < 0.0001$.

^cMean, SE, and median reported for these variables.

^dSignificantly different at: $P < 0.004$.

^eDietary variable expressed as a percentage of total caloric intake.

^fPolynesian obesity categorization was used to define BMI.

Odds ratios and 95% confidence intervals for diabetes and prediabetes by quintile of adiponectin in the cross-sectional Samoan Island study population 2002–2003 ($n = 1,599$)

TABLE 2

	Quintiles of adiponectin					<i>P</i> -for-trend
	1 (lowest) (0.8–5.9 µg/ml)	2 (5.9–8.0 µg/ml)	3 (8.0–10.3 µg/ml)	4 (10.3–14.2 µg/ml)	5 (highest) (14.2–73.9 µg/ml)	
Diabetes						
Model 1 ^a	1.9 (1.3, 2.9)	1.1 (0.7, 1.7)	1.3 (0.8, 1.9)	0.98 (0.6, 1.5)	1.0	0.02
Model 2 ^b	3.3 (1.9, 5.8)	1.6 (0.9, 2.9)	2.0 (1.1, 3.5)	1.2 (0.7, 2.0)	1.0	0.0002
Model 3 ^c	2.8 (1.6, 5.0)	1.3 (0.7, 2.5)	1.9 (1.1, 3.4)	1.2 (0.7, 2.0)	1.0	0.004
	1 (lowest) (1.0–5.8 µg/ml)	2 (5.8–7.9 µg/ml)	3 (7.9–10.1 µg/ml)	4 (10.1–14.0 µg/ml)	5 (14.0–73.9 µg/ml)	<i>P</i> -for-trend
Prediabetes						
Model 1 ^a	3.8 (2.3, 6.3)	2.2 (1.3, 3.6)	1.8 (1.0, 3.0)	1.3 (0.7, 2.3)	1.0	0.0001
Model 2 ^b	3.9 (2.2, 7.1)	2.3 (1.3, 4.3)	1.9 (1.1, 3.5)	1.3 (0.7, 2.4)	1.0	0.0001
Model 3 ^c	2.9 (1.5, 5.7)	1.8 (0.9, 3.6)	2.0 (1.1, 3.7)	1.3 (0.7, 2.5)	1.0	0.001

^a Adjusted for household of residence.

^b Adjusted for household, age, sex, abdominal circumference, material lifestyle score, and moderate activity levels.

^c Adjusted for household, age, sex, abdominal circumference, material lifestyle score, moderate activity levels, and insulin. The addition of BMI, HDL cholesterol, and macronutrient variables to the model did not appreciably change the results.