Journal of
Environmental & Analytical Toxicology

Chobanyan et al., J Environ Anal Toxicol 2016, 6:4
DOI: 10.4172/2161-0525.1000386

Research Article Open Access

Evaluation of Environmental Risk Factors for Type 2 Diabetes in Sint Maarten

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Abstract

A number of environmental risk factors have been reported to be associated with elevated blood glucose and diabetes. However, these associations have primarily been explored in Western populations and few studies have examined diabetic risk factors in novel populations such as the Caribbean. We examined whether exercise and food consumption is associated with blood glucose levels in the Caribbean population of Sint Maarten. Using cross-sectional data from Project HELP (Health, Education, Literacy, and Prevention), a collaboration between the American University of the Caribbean School of Medicine and Sint Maarten Ministry of Health, we estimated two logistic regression models predicting elevated blood glucose. The adjusted model included demographic, biological, and social/behavioral covariates. Unhealthy food consumption was associated with decreased odds of elevated blood glucose in the first model (OR=0.19, *p*=0.04) but not significant in the adjusted model. All other factors were not significantly associated with blood glucose. It seems that the traditional environmental risk factors – such as exercise and diet – associated with blood glucose in most Western populations are not significant in Sint Maarten. Further research must be conducted to determine appropriate risk factors for this population and possibly other Caribbean populations.

Keywords: Risk factors; Blood glucose; Hypertension; Diabetes

Introduction

Type 2 diabetes prevalence has dramatically risen in recent years, with 29 million people in the United States (9.3 percent) having diabetes [1]. The incidence is now at 1.7 million people newly diagnosed in the United States each year [1]. Hispanic Americans, African Americans, and Native Americans are twice as likely to be diagnosed with diabetes as non-Hispanic White Americans [1]. In addition, 86 million people in the United States have prediabetes [1]. With statistics like these, it is clear that diabetes has become a common and devastating problem worldwide.

Some of the well-established risk factors for type 2 diabetes in Western countries are weight, inactivity, family history, race, age, hypertension, high triglycerides, low HDL cholesterol, gestational diabetes, and polycystic ovary syndrome (PCOS) [2]. While we cannot control our race, family history, or age, the rest of these are modifiable risk factors with strong associations to diet.

Statistical information about diabetes in Caribbean populations is much more limited with the majority being extrapolated through self-reporting as well as some voluntary physician reporting. It is estimated that 9.6% of adults have diabetes in Sint Maarten [3]. This goes hand-in-hand with the weight problem in Sint Maarten, with over 70% of the population being overweight, of which 30% is obese [4].

Since the 1950s, the governments of the Caribbean have made meat, fats, oils and refined sugar more available to deal with concerns of malnutrition [5]. While the modern Caribbean diet has curbed the malnutrition, the incidence of diabetes and associated problems of hypertension, coronary heart disease, cancer, and obesity has increased dramatically [5]. This rise cannot be explained by genetic factors alone and must therefore be related to these environmental changes.

Several dietary approaches have been advocated for treatment and prevention of diabetes. Because most patients with diabetes are overweight, weight reduction is an important strategy in improving insulin sensitivity. Four dietary approaches have been recommended: Mediterranean diet, DASH diet, low glycemic index, and high fiber [6-8]. These have each been individually associated with improvements with weight loss, lower blood pressure, and improved insulin sensitivity [6-8]. What all of these approaches has in common is a greater consumption of fruits and vegetables, which is what we used as markers of healthy food consumption in this study.

Our previous research explored some of the genetic and biological risk factors for diabetes [9]. In this study, however, we focused on the role of environmental factors as risk factors for type 2 diabetes. While most research of this type is based on Western populations, there may be some novel differences in risk factors among Caribbean populations where diet, lifestyle, and culture have a unique influence.

Methods

Data

Data analyzed in this study come from Project HELP (Health, Education, Literacy, and Prevention) health clinics from 2013-2014 (n=228). Project HELP is a collaboration between the American University of the Caribbean School of Medicine (AUC) and Sint Maarten Ministry of Public Health, Social Development and Labour. The project was reviewed and approved by AUC's Institutional Review Board, including representation from the Ministry of Health [10]. Project HELP seeks to promote health in Sint Maarten through education and increased awareness about common health problems at regular tri-annual health screening events at local churches and community centers with the help of local community leaders [10]. Participants were seen by AUC medical students, who collected detailed histories and performed physical exams and screenings [10]. The participants were then seen and counseled by AUC faculty members and a Dutch-licensed attending physician. Appropriate follow-up was scheduled and conducted with local physicians [10].

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Received February 03, 2016; **Accepted** July 20, 2016; **Published** July 22, 2016

Citation: Chobanyan N, Allison Kruger K, Nebb S, Jackson G, Asin V, et al. (2016) Evaluation of Environmental Risk Factors for Type 2 Diabetes in Sint Maarten. J Environ Anal Toxicol 6: 386. doi:10.4172/2161-0525.1000386

Measures

The main outcome analyzed is blood glucose level, measured by finger stick and glucometer using appropriate technique. These data were used as a continuous variable with range 53-318 mg/dL. The data were also transformed into a categorical variable by taking into consideration the last time the participant had consumed food or drink and stratifying into normal, pre-diabetic, and diabetic ranges according to American Diabetic Association guidelines [11]. For participants who had not consumed food/drink in the last 8 hours, the cutoffs were: <100 mg/dL, 100-126 mg/dL, and >126 mg/dL. Participants who had consumed food/drink in the last 8 hours were divided as such: <140 mg/dL, 140-199 mg/dL, and ≥ 200 mg/dL.

Our main explanatory variables were self-reported exercise, healthy food consumption, and unhealthy food consumption. Exercise was based on self-reported data. Participants were asked if they engage in physical exercise over the course of an average week and their answer was recorded as a binary variable (0=no exercise, 1=participant exercises). Food consumption variables were also created from participants' self-reports about the food they consume over an average week. Participants were asked how many days per week they consume the following foods: raw vegetables, cooked vegetables, fruits, fried food, sugary food, and sugary beverages. The healthy food consumption variable was created by combining participants' self-report of raw vegetables, cooked vegetables, and fruit consumption over an average week and then organizing the results into three categories based on the number of times per week the participant ate these healthy foods: low (0-7 times/week), medium (8-13 times/week), and high (≥ 14 times/week). The unhealthy food consumption variable was created by combining the combining self-reported data about weekly consumption of fried food, sugary food, and sugary beverages and categorizing the results as follows: low (0-2 times/week), medium (3-7 times/week), and high (≥ 8 times/week) unhealthy food consumption.

We also adjusted for a variety of demographic, biological, and social/behavioral covariates. Demographic covariates included sex and age. Biological covariates included BMI, waist circumference, and blood pressure. Social and behavioral covariates included education and insurance status. Sex (0=female, 1=male) and age (continuous with range 18-90) were self-reported. BMI was calculated from the participant's measured height and weight. Waist circumference was measured using a soft measuring tape and then categorized using increased waist circumference guidelines from the National Institutes of Health [12]. For women, increased waist circumference was defined as ≥ 35 inches and for men, ≥ 40 inches. Blood pressure was measured and categorized using National Institutes of Health guidelines: normal (systolic <120 and diastolic <80), pre-hypertension (systolic 120-139 and/or diastolic 80-89), Stage 1 hypertension (systolic 140-159 and/or diastolic 90-99), and Stage 2 hypertension (systolic ≥ 160 and/or diastolic ≥ 100) [13]. Education level was self-reported and categorized as primary school, secondary school, and vocational and/or college. Participants also self-reported their health insurance status (0=no insurance, 1=has insurance).

Statistical analysis

All statistical tests were conducted using Stata version 13.0 (Stata Corporation, College Station, Texas). We examined the average blood glucose among the various categories of exercise and food consumption. Pearson's chi-squared tests, ANOVA, and t-tests were conducted to test for differences. Linear and logistic regression analyses were used to examine associations between blood glucose and the environmental risk factors. We estimated two nested models. Model 1 examined the association between blood glucose, exercise, and food consumption. Model 2 added in adjustment for biological, demographic, and social/behavioral covariates. We also conducted sensitivity analyses by categorizing food consumption variables in multiple specifications (e.g., as a continuous variable and at various categorical cut-points). Finally, we explored the association of BMI and environmental risk factors using linear regression.

Results

General descriptive statistics of the sample (n=228) can be found in Table 1. The mean age of Project HELP participants was 55 years old and 31.3% were male. The majority of participants were overweight or obese with only 24.2% having a healthy BMI of 18.5-24.9. Most participants also had increased waist circumference and increased blood pressure. More than one-third of participants had not completed their high school education and 30.5% reported having no health insurance. With regard to our main explanatory variables, more than two-thirds of participants reported doing physical activity. Healthy food consumption varied with 34.9% reporting that they eat vegetables and fruit only 0-7 times per week, 41.3% reporting they eat them 8-13 times per week, and the fewest participants (23.8%) reporting they ate vegetables and fruit at least 14 times per week. Unhealthy food consumption also varied with 38.3% reporting that they ate fried food, sugary food, and sugary beverages at least eight times per week.

Results of the t-tests showing average blood glucose by the various measures are also shown in Table 1. None of the t-tests yielded statistically significant differences. Among those who did not exercise (n=36), glucose was 119.4 mg/dL, while those participants who did exercise (n=96) had an average glucose of 116.2 mg/dL. This was not significant (p=0.69). There were no significant differences when stratifying by sex or age. Blood glucose trended in a logical direction with healthy food consumption but was not significant (p=0.20). Those eating healthy foods 0-7 times/week (n=22) had an average glucose of 120.7 mg/dL. Participants eating healthy foods 8-13 times/week (n=26) had an average glucose of 110.7 mg/dL and participants eating healthy foods ≥ 14 times/week (n=15) had the lowest blood glucose at 102.8 mg/dL. Interestingly, results showed that average blood glucose was in fact lower for participants who consumed more unhealthy foods per week, although the results were not significant (p=0.12). Average blood glucose levels were 119.4 mg/dL, 116.5 mg/dL, and 101.8 mg/dL, respectively.

Linear regression of exercise, healthy food consumption, and unhealthy food consumption on blood glucose revealed no significant effects (results not shown). Unhealthy food consumption approached significance (p=0.05) and estimated a decrease of 8.8 mg/dL (95% confidence interval of -17.6 to 0.02 mg/dL) as unhealthy food consumption increased.

The results of the nested logistic regression are shown in Table 2. Model 1, which only included our main explanatory variables, shows that high healthy food consumption (≥ 14 times per week) was significantly associated with decreased odds of having elevated blood glucose as compared to low healthy food consumption (OR=0.19, p=0.04). However, this association is no longer significant in Model 2, which adjusted for demographic, biological, and social/behavioral covariates. In fact, none of the variables significantly predicted odds of having elevated blood glucose in the population.

We also explored the impact of exercise and food consumption

Measure	Total/Mean	Average blood glucose (mg/dL)
Exercise (n=138)		
- No exercise	≥ 27.5%	119.4
- Participant exercises	72.5%	116.1
Healthy food consumption (n=63)		
- Low (0-7 times/week)	34.9%	120.7
- Medium (8-13 times/week)	41.3%	110.7
- High (≥ 14 times/week)	23.8%	102.8
Unhealthy food consumption (n=60)		
- Low (0-2 times/week)	38.3%	119.4
- Medium (3-7 times/week)	23.3%	116.5
- High (≥ 8 times/week)	38.3%	101.8
Age (n=228)	55.1 (mean)	--
Sex (n=227)		
- Female	68.7%	115.0
- Male	31.3%	117.4
BMI (n=220)	28.8 (mean)	
- Normal	24.2%	112.2
- Overweight	34.1%	117.9
- Obese	41.7%	117.1
Waist circumference (n=157)		
- Normal	38.9%	114.3
- Increased	61.2%	118.5
Blood pressure (n=220)		
- Normal	12.3%	130.2
- Pre-hypertension	40.0%	104.5
- Stage 1 hypertension	28.6%	117.3
- Stage 2 hypertension	19.1%	123.7
Education (n=157)		
- Less than high school	33.8%	124.8
- High school/GED	46.5%	107.9
- Some college or more	19.8%	117.3
Insurance (n=210)		
- No insurance	30.5%	120.8
- Has insurance	69.5%	113.1

Table 1: Descriptive statistics of the sample (n=228).

	Odds Ratio (95% CI)	
	Model 1	**Model 2[a]**
Exercise		
- No exercise	REF	REF
- Participant exercises	0.35 (0.10, 1.20)	0.58 (0.11, 2.96)
Healthy food consumption		
- Low (0-7 times/week)	REF	REF
- Medium (8-13 times/week)	0.35 (0.09, 1.32)	0.24 (0.02, 2.45)
- High (≥ 14 times/week)	0.19 (0.04, 0.92)*	0.16 (0.02, 1.57)
Unhealthy food consumption		
- Low (0-2 times/week)	REF	REF
- Medium (3-7 times/week)	0.93 (0.20, 4.30)	1.63 (0.22, 12.35)
- High (≥ 8 times/week)	0.58 (0.16, 2.07)	0.66 (0.10, 4.49)
Age		1.01 (0.93, 1.10)
Sex		
- Female		REF
- Male		3.69 (0.58, 23.37)
BMI		1.02 (0.81, 1.29)
Increased waist circumference		0.96 (0.05, 16.77)
Blood pressure		
- Normal		REF
- Pre-hypertension		0.63 (0.04, 8.92)
- Stage 1 hypertension		0.22 (0.04, 3.32)
- Stage 2 hypertension		0.57 (0.03, 11.22)
Education		
- Less than high school		REF
- High school diploma/GED		2.03 (0.38, 10.85)
- Some college or more		1.94 (0.19, 20.12)
Insurance		
- No insurance		REF
- Has insurance		0.34 (0.05-2.21)

*$p<0.05$
[a]Model 2 adjusts for demographic, biological, and social/behavioral covariates

Table 2: Odds ratios (95% CI) of elevated blood glucose (n=60).

on BMI using linear regression and found that only exercise was significantly associated with BMI (Table 3). Participants who exercised had lower BMI by an average of 3.3 points ($p=0.03$) with 95% confidence interval of -6.2 to -0.4 points.

Discussion and Conclusion

This study failed to find any significant association between environmental factors and blood glucose after controlling for relevant covariates. Risk factors for diabetes previously established in Western populations do not appear to be consequential in this population. We did not find any variables that could explain even a moderate amount of the variation in blood glucose. This could be related to the high percentage of the participants that had cardiovascular risk factors of obesity, hypertension, and high blood glucose.

It was not surprising to find that healthy foods (fruits and vegetables) consumption was trending towards lower blood glucose, although the association was not determined to be significant. Interestingly, unhealthy foods consumption (fried and sugary foods and sugary drinks) actually trended towards lower blood glucose, although again, not significantly. A larger sample size to increase the power of the study would be useful to clarify the effects of these food choices in this population and better elucidate how unhealthy foods impact blood glucose.

The association of exercise with lower BMI is significant in this population. Exercise may play a heightened role as protective factor in this population against obesity and associated conditions as diabetes. One perplexing finding in our analysis among this population is the lack of association between weight and diabetes. This may be due to significant differences between the Caribbean diet consumed in Sint Maarten as compared to the United States and other Western countries. It might also be related to different cultural norms about weight and body shape. Finally, we cannot exclude the possibility that we failed to find any significant associations due to insufficient power and/or poorly collected data.

Our data set was limited to self-reported information about many variables, including exercise and food consumption, and it is possible that this did not accurately capture true environmental factors. For example, in future studies it would be useful to collect information about serving sizes of foods to better estimate relative consumption amongst participants. Some continuous variables were converted into categorical variables in order to illustrate trends from the limited data set. Although data was collected on time spent exercising, frequency per week, and level of physical demand, the small data set limited the ability to use those data in a meaningful way. There were fewer males

Measure	Effect (95% CI)	Significance level
Exercise	-3.3 (-12.6, -0.4)	*p*=0.03

Table 3: Linear regression of exercise estimating BMI.

involved in the study, which may be due to less opportunity for males to attend the H.E.L.P. events. Additionally, females may be more likely to engage in help-seeking behaviors, such as coming to voluntary health fairs for health screening [14].

Another limitation of this study was the lack of data on race/ethnicity. Afro-Caribbean people are not an entirely homogenous group, and which race/ethnicity they identify with may be associated with different dietary qualities and related risks. The uncertainty of ethnic characteristics is due to the majority of participants not identifying themselves by their genetic origins but rather as Sint Maarten residents or by their country of origin. Participants were asked about race in an open-ended manner with the following sampling of the results: African, Antillean, Black, Black Caribbean, Caribbean, Dutch, English, Hispanic, Indian, and Jamaican. When participants were asked to choose from a list of traditional race/ethnicity categories (e.g., Black, Hispanic/Latino/Spanish, Asian, White) the majority responded that they were not sure. Rather than force our notions about race and ethnicity onto the Sint Maarten population, that information was excluded until better and more culturally sensitive questions could be asked.

This type of research of diabetes is scarcely done in the Caribbean in large part due to logistical constraints in obtaining the data. However, Sint Maarten is demonstrating itself to have a unique population with unanticipated findings. This warrants further study to clarify these differences and determine to what extent blood glucose and ultimately diabetes are associated with environmental factors.

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