Original Research

Type 2 Diabetes Mellitus in Navajo Adolescents

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Diabetes mellitus afflicts over one-fifth of the Navajo population aged over 20 years, but the prevalence of diabetes in Navajo adolescents is unclear. We conducted voluntary testing for diabetes mellitus at two high schools on the Navajo reservation to clarify the prevalence as well as to assess the utility of a high-school based screening program. Body mass index measurements (BMI), oral glucose tolerance tests, and hemoglobin A1C measurements were obtained in consenting high school students. Of the 276 students that participated, 234 were Navajo. Only one Navajo student (0.4%) had diabetes mellitus, although eight (3%) had impaired glucose tolerance or impaired fasting glucose. Participant BMI did not differ significantly from nonparticipant BMI. No correlation existed between BMI or impaired glucose handling, and significant overlap existed between the hemoglobin A1C values of students with impaired glucose handling and students without impaired glucose handling. Increased participation in screening programs may reveal higher disease prevalence, but high school–based screening is not justified by this study, despite the high rates of diabetes mellitus in the Navajo population.

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Type 2 diabetes mellitus, or non-insulin dependent diabetes mellitus, is a common chronic health problem among the Navajo tribe. According to the Navajo Health and Nutrition Survey (NHNS), a population-based reservation-wide study, type 2 diabetes afflicts 22.9% of Navajo aged 20 years and older. This is markedly higher than the age-standardized estimates for the general United States population.[1]

The link between obesity and type 2 diabetes mellitus in the Navajo has not been clarified; the degree and prevalence of obesity varies among different racial groups. While obesity is apparent in no more than 30% of Chinese and Japanese patients with type 2 diabetes mellitus, it is found in 75%–80% of North Americans, Europeans, or Africans with type 2 diabetes and approaches 100% of patients with type 2 among Pima Indians or Pacific Islanders from Nauru or Samoa.[2] Navajo adolescents have a 35%–40% prevalence of obesity and are roughly 2 kg/m^2 heavier than adolescents in the general United States population; therefore they may be at increased risk for diabetes.[3] In Navajo aged 12–19 years, the NHNS survey estimated a combined 8% prevalence of impaired glucose tolerance and diabetes mellitus, which is comparable to that seen among young and middle-aged adults in the general United States population. This age group, however, had a relatively small representation of 160 participants in the survey, and therefore it is possible that the survey could have underestimated the prevalence of diabetes.

Substantial evidence exists that improved glucose control in diabetes mellitus reduces the incidence of microvascular and perhaps macrovascular complications.[4,5] Theoretically, diagnosing diabetes mellitus earlier in its course could lead to earlier improved glucose control over a longer period of time.

In an attempt to further clarify the prevalence of diabetes mellitus in Navajo adolescents and to test the feasibility of a school screening program, we offered testing at two high schools on the Navajo reservation using the oral glucose tolerance test (OGTT).

Methods

Study Design

The target population was students aged 13–20 at two high schools on the Navajo reservation. Several weeks before screening, students and parents were informed of screening for diabetes through fliers and announcements at the high schools; participants were offered T-shirts, water bottles, gift certificates, food, and education. In order to participate, students, unless they were 18 years of age or older, had to submit an informed consent signed by their parents and themselves. Students were excluded if they

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TABLE 1.—*Body Mass Indices of Participants and Non-Participants by Age and Sex*

	Participants Median BMI (kg/m²)	*>95th percentile BMI*	*Non-Participants BMI (kg/m²)*	*>95th percentile BMI*	*P-value*
Age 13–14 y					
	Boys (n = 11) 22.96	(n = 4) 25.5	Boys (n = 23) 22.91	(n = 6) 25.5	0.796
	Girls (n = 23) 25.43	(n = 7) 27.0	Girls (n = 34) 22.32	(n = 5) 27.5	0.094
Age 15 y					
	Boys (n = 30) 25.04	(n = 9) 27.5	Boys (n = 30) 20.96	(n = 9) 27.5	0.326
	Girls (n = 50) 25.42	(n = 11) 28.5	Girls (n = 47) 24.11	(n = 8) 29.0	0.655
Age 16 y					
	Boys (n = 22) 22.92	(n = 4) 28.0	Boys (n = 43) 23.40	(n = 8) 28.0	0.624
	Girls (n = 43) 23.45	(n = 10) 29.0	Girls (n = 38) 24.37	(n = 10) 29.0	0.579
Age 17 y					
	Boys (n = 11) 25.90	(n = 5) 29.0	Boys (n = 41) 23.21	(n = 8) 29.0	0.178
	Girls (n = 33) 24.77	(n = 8) 29.0	Girls (n = 48) 26.13	(n = 16) 29.0	0.453
Ages 18–21 y					
	Boys (n = 18) 24.80	(n = 3) 30.0	Boys (n = 30) 25.28	(n = 8) 30.0	0.884
	Girls (n = 35) 24.39	(n = 5) 30.0	Girls (n = 38) 24.89	(n = 8) 30.0	0.503
Total	276	66	372	86	

BMI = body mass index

were pregnant, reported a medical history of diabetes mellitus or impaired glucose tolerance, were not fasting, or were acutely ill on the day of screening. High school students with chronic disease are tracked through the Indian Health Service school-based clinic registry, and only one student in the high schools had a history of diabetes mellitus and was excluded from screening for this reason.

The OGTT was administered according to World Health Organization (WHO) criteria.[6] A fasting blood sample was drawn after which students drank a solution of 75 grams of glucose. A second blood sample was drawn 2 hours later. Venous samples were collected in gray-top vacutainer tubes containing sodium fluoride. According to the requirements of the Navajo Nation Health Research Board, fasting plasma glucose and 2-hour postprandial glucose analysis were performed at the laboratory of the Crownpoint Healthcare Facility and the hemoglobin A1C analysis was performed at a reference laboratory (Quest Clinical Laboratories, El Paso, Texas). While awaiting their second blood draw, students participated in four teaching sessions given by a nutritionist, a physical therapist, a physician, and a physician's assistant on healthy diet and exercise plans and the pathophysiology and sequelae of type 2 diabetes mellitus.

Students were diagnosed as having type 2 diabetes mellitus if they met the criteria set by the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus: fasting plasma glucose ≥7.0 mmol/liter (126 mg/dl) or 2-hour postprandial glucose ≥11.1 mmol/liter (200 mg/dl).[7] They were diagnosed with impaired glucose tolerance if their two-hour glucose was ≥7.8 mmol/liter (140 mg/dl) and <11.1 mmol/liter (200 mg/dl), and they were diagnosed with impaired fasting glucose if their fasting plasma glucose was ≥6.1 mmol/liter (110 mg/dl) and <7.0 mmol/liter (126 mg/dl).

Students' heights and weights were obtained from either the school record or the hospital record; all values were measured within the past year by either the school nurses or the hospital staff. For comparison, we obtained the heights and weights of the nonparticipants from the school record when available. The body mass index (BMI) was compared to the national averages adjusted for age and sex.[8] The ethnicity of the students was elicited by asking the students at the time of screening.

Subjects and their parents were informed of the results of their tests, and clinical care was arranged for subjects with newly diagnosed diabetes mellitus. Students diagnosed with impaired glucose tolerance or impaired fasting glucose were given monthly educational sessions with their parents by a nutritionist and physician, and were placed in the hospital's chronic disease registry for tracking purposes.

We used STATA (1997, College Station, Texas), a statistics software package, to perform statistical analysis.[9] Unless otherwise indicated, analyses were done separately in groups stratified by age and sex. Descriptive and bivariate associations were assessed by using the t test for continuous variables and the chi-square test for dichotomous variables. Continuous associations were assessed by using the Spearman's correlation test for continuous variables. A two-sided P value of 0.05 or less was considered significant for all statistical models.

Results

Body Mass Index

Of 970 eligible high school students, 276 participated in diabetes screening (Table 1). Of the participants, 234 were Navajo. The non-Navajo participants were

TABLE 2.—*Median Age and BMI of Students with Diabetes Mellitus and Impaired Glucose Tolerance**

	Age (y)	BMI (kg/m²)	Fasting Plasma Glucose (mmol/liter)	Hemoglobin A1C (% of control)	2-hour Plasma Glucose (mmol/liter)
Impaired glucose handling (n = 8)	16.01 (15.0–19.6)	26.7 (21.6–35.8)	4.9 (3.8–6.4)	5.1 (4.4–5.2) 88 (69-116)†	8.1 (4.7–8.8) 146 (85–159)†
Diabetes mellitus (n = 2)	17.0 (15.5–18.5)	25.0 (24.8–25.3)	15.4 (13.8–17.0)	14.9 (14.3–15.5) 277 (248-306)†	25.7 (24.8–26.6) 462.5 (446–479)†
Participants	16.41 (12.6–20.3)	24.8 (15.8–48.5)	4.4 (2.6–5.9)	4.9 (4.1–5.6)	4.8 (2.0–8.8)
Normal glucose handling				79 (47–106)†	86 (37–159)†
Nonparticipants	16.81 (13.2–21.7)	23.5 (14.2–55.6)			

*Median values given. Numbers in parentheses indicate range of values; if no parentheses are present, only one value is available.
†Median values given in mg/dl.

primarily white (n = 29) or Hispanic (n = 7). Heights and weights were available on 372 nonparticipants and used for comparison; race was not available on the nonparticipants, although the majority were Navajo. A higher percentage of females were represented among the participants (67%) versus the nonparticipants (56%) (P = .004).

The BMIs as measured in kg/m² of the participants and nonparticipants by sex and age are presented in Table 1. Height and weight were not available for one participant. Twenty-four percent of participants were overweight as defined by having a BMI exceeding the 95th percentile for their sex and age; 23% of nonparticipants were overweight (Table 1).[8] After adjustment for age and sex, participants and nonparticipants did not have significantly different BMIs, and the participants who were non-Navajo did not have a significantly different BMI from participants who were Navajo.

Diabetes Prevalence

Ten students were found to have impaired glucose handling: either diabetes mellitus, impaired glucose tolerance, or impaired fasting glucose. One student diagnosed with diabetes mellitus was white; the nine other students were Navajo. Fasting blood glucose values, 2-hour glucose values, BMI, and hemoglobin A1C values for these students are listed in Table 2; for comparison, Table 2 also lists these values for students with normal glucose handling as well as the age and BMI of nonparticipants.

Hemoglobin A1C values were highly correlated with fasting blood glucose values (r = 0.885) and 2 hour glucose values (r = 0.811). However, significant overlap existed in the hemoglobin A1C values of students with abnormal fasting blood glucose or 2-hour glucose values and the hemoglobin A1C values of normals. When the children with diabetes mellitus were excluded, the hemoglobin A1C values were indistinguishable (P = 0.468). No significant correlation between impaired glucose tolerance, impaired fasting glucose, diabetes mellitus, and BMI was found.

Comment

The high prevalence of diabetes mellitus among Navajo Indians is of concern, as it is one of the largest tribes in the United States, with membership exceeding 200,000, and therefore diabetes consumes a significant amount of health care resources.[10]

Screening for diabetes mellitus with the glucose tolerance test automatically tests patients for both impaired glucose tolerance as well as diabetes mellitus. Evidence supporting early intervention in impaired glucose tolerance (IGT) is controversial; while progression to diabetes is high in Pima Indians,[11] prospective studies of interventions to prevent progression to frank diabetes in patients with IGT have produced conflicting results,[12–14] and there is little evidence of benefit in treating IGT itself.[15,16] For patients with type 2 diabetes mellitus, however, early intervention and improved glucose control can decrease end-organ damage.[4,5]

Screening for diabetes in youth, however, is problematic. The Navajo adolescents would appear to be at high risk given the rates of diabetes mellitus in older age groups, but the exact prevalence of diabetes mellitus remains unclear due to adolescents' small representation in the NHNS population-based survey.[3] In addition, population-based screening programs are difficult to conduct on a regular basis.

To try to address these issues, we offered screening at two reservation high schools in order to evaluate a large number of adolescent participants. We found two students had diabetes mellitus, one of whom was non-Navajo, and eight had glucose intolerance, a rate of impaired glucose handling that was lower than previously found in the population-based survey NHNS. Also, we did not find a correlation between BMI and impaired glucose handling.

As previously reported in the literature, the hemoglobin A1C values did not serve as a good screening tool for impaired glucose tolerance.[17–19] The A1C of students with normal glucose tolerance test values did not differ significantly from the hemoglobin A1C values of students with abnormal glucose tolerance test values. In the two students with diabetes mellitus, the hemoglobin A1C was significantly elevated, but the number of students we found with diabetes is too low to determine the hemoglobin A1C's efficacy as a screening tool for diabetes mellitus. In order to evaluate the sensitivity of the A1C within ±5%, and assuming the prevalence of diabetes in the population is at least 5% and the sensitivity is 50%, we would need to test 8000 students. If we assumed the prevalence is 5% and the sensitivity is 90%, we would need to test 4000 students.

There may be several reasons for the difference between our study and the NHNS. Our population consisted of volunteers, girls being better represented than boys, and participants may have been more health conscious. Students who had a family history of diabetes may have been afraid to participate for fear of confirmation of the diagnosis of diabetes.

The BMIs of students who participated and students who did not participate were not significantly different, but we did not have height and weight measurements for the entire eligible student population, and the students whose height and weight were available may represent a healthier population than those who were not measured; this would minimize the differences in body mass indices between participants and nonparticipants. Of note, the percent of overweight students in each group, or the students who exceeded the 95th percentile BMI for age and sex, was sometimes as high as 30% (Table 1). Finally, the majority of our students were 15 or 16 years of age and presumably would be at lower risk than older students, who were underrepresented.

With increased participation in a diabetes screening program, it is possible that there would be more students identified with impaired glucose handling. In this study, the students were given multiple incentives including T-shirts, water bottles, and gift certificates, but possibly other incentives such as a financial reward would be more successful. The screening program was held in the late spring, and perhaps holding the program at a different time of year would increase participation, although other constraints on resources make this difficult. The program was conducted at a small rural health care facility and required diversion of physician, physical therapy, nursing, nutrition, and laboratory personnel to the high school; this would not be feasible during the busy winter months or late fall when school sports physicals need to be conducted. Finally, the OGTT is a cumbersome tool for assessing the presence of diabetes mellitus, and the development of a test that would not involve ingesting sugar and having blood drawn twice would probably improve participation.

Given the low rate of diabetes mellitus and the questionable value of addressing IGT, we conclude that a high-school based screening program with a similar structure to the one outlined in this paper does not appear justified at this time. If the problem of low participation of students could be successfully addressed, however, a screening program might yield higher rates of diabetes mellitus and impaired glucose tolerance.

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