Type 2 Diabetes Mellitus Among Florida Children and Adolescents, 1994 through 1998

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SYNOPSIS

Objectives. This study was undertaken to examine the trends in the diagnosis of Type 2 diabetes mellitus among children and adolescents with new-onset diabetes seen from 1994 through 1998 at the three university-based diabetes centers in Florida.

Methods. Data were abstracted from medical records and patients were categorized as having Type 1 or Type 2 diabetes.

Results. There were 569 patients classified with Type 1 diabetes and 92 with Type 2 diabetes. The proportion of patients diagnosed with Type 2 diabetes increased over the five years from 9.4% in 1994 to 20.0% in 1998 (chi-square test for trend = 8.2; p=0.004). There was not an associated net increase in the total number of new diabetes patients referred over time (chi-square test for trend = 0.6, p=0.4). Those with Type 2 diabetes were more likely to have a body mass index in the 85th–94th percentile [odds ratio (OR) = 8.5; 95% confidence interval (CI) 2.5, 28.8], have a body mass index ≥95th percentile (OR = 6.8; 95% CI 2.6, 17.7), Hispanic ethnicity (OR = 6.2; 95% CI 2.2, 17.9), black race (OR = 2.8; 95% CI 1.3, 6.2), female gender (OR = 2.2; 95% CI 1.2, 4.3), and older age (OR = 1.4 for each one-year increment in age; 95% CI 1.3, 1.6), compared with those having Type 1 diabetes.

Conclusions. From 1994 through 1998, there was a significant overall increase in the percentage of children referred with new-onset diabetes who were considered to have Type 2 diabetes. Factors associated with the diagnosis of Type 2 diabetes relative to Type 1 diabetes include body mass index ≥85th percentile, Hispanic ethnicity, black race, female gender, and older age.

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Numerous reports have recently documented an increase in the frequency of Type 2 diabetes among children and adolescents.[1–8] The proportion of Type 2 diabetes among all children and adolescents with new-onset diabetes is now estimated to be between 8% and 45%, depending on "race/ethnicity" and socioeconomic case mix.[7,8] The increasing prevalence of Type 2 diabetes in children and adolescents is a growing public health concern. The American Diabetes Association and the American Academy of Pediatrics recently emphasized the public health importance of the increase in the prevalence of Type 2 diabetes in children and adolescents by releasing a consensus statement addressing this issue.[8,9]

The prevalence of Type 2 diabetes varies by "race/ethnicity" among pediatric and adult populations.[4,6] Pima Indians, First Nation Canadians, African Americans, Mexican Americans, and Japanese all display high rates of Type 2 diabetes in both adults and children.[2–6,7] Although not yet demonstrated, the modifiable risk factors for Type 2 diabetes in adolescents are believed to be similar to those in adults: obesity, a diet high in fat and calories, and physical inactivity. Since the end of the 1970s, the prevalence of obesity among children and adolescents has doubled.[10] This increase is paralleled by an increase in the prevalence of Type 2 diabetes among children and adolescents.[4,7]

This study sought to determine whether Type 2 diabetes was increasing among Florida children and adolescents diagnosed with diabetes, and to describe the risk factors associated with a diagnosis of Type 2 diabetes relative to Type 1 diabetes. We reviewed the medical records of children and adolescents newly diagnosed with diabetes by diabetologists at the three university health centers during the study period. The research hypotheses were that among children and adolescents ages 5–19 years referred with new-onset diabetes from 1994 through 1998: (*a*) those seen in later years were more likely than those seen in earlier years to have Type 2 diabetes, and (*b*) those considered to have Type 2 diabetes were more likely to be black or Hispanic, older, and have a body mass index (BMI) ≥85th percentile, compared with those classified as having Type 1 diabetes.

METHODS

We conducted a medical record review of patients seen at the three university-based pediatric diabetes centers in Florida (University of South Florida, University of Florida, and University of Miami). Patients referred at the onset of diabetes between January 1, 1994, and December 31, 1998, and who were 5–19 years of age at the time of diagnosis were included. We excluded those younger than five years of age, because Type 2 diabetes occurs only rarely in children this young.[1,2,8] We also excluded those older than 19 years of age, because few patients older than this are seen in the participating pediatric programs.

We used a standard medical record abstraction form to collect data from the medical records, which included: demographics, height, weight, type of diabetes (diagnosis at first and most recent visit), date of diagnosis, laboratory data, presenting signs and symptoms, and diabetes medications. We did not collect information on family history of diabetes, history of gestational diabetes in the mother, or birthweight, because this information was not consistently noted in the medical record.

Diabetes was classified as Type 1 or Type 2, based on the most recent impression of the treating pediatric endocrinologist. A standard case definition was not used because there was not consistent availability of data, such as diabetes-related autoimmunity studies or C-peptide concentrations—studies that would have been done only if there was a question of diagnosis.

We calculated BMI at diagnosis for each patient by dividing weight in kilograms by height in meters squared; overweight and obesity status were defined as the age- and sex-specific 85th and 95th percentile BMI cutpoints from the National Health and Nutrition Examination Survey-I, conducted in 1960.[11]

The study was reviewed and considered to be exempt from the need for informed consent by the institutional review boards of the three university health centers.

RESULTS

From 1994 through 1998, 699 children and adolescents ages 5–19 years with newly diagnosed diabetes were referred to the pediatric clinics of the three university-based diabetes centers in Florida. Based on the diagnosis at the most recent visit, 569 (86.1%) patients had Type 1 diabetes, and 92 (13.9%) patients had Type 2 diabetes. Ten patients were diagnosed with atypical diabetes, and the type of diabetes was not specified in the medical records of 28 patients. We excluded these 38 patients from the analysis. Among those with a diagnosis of Type 2 diabetes at the most recent visit, 15 (19.5%) had been initially thought to have Type 1 diabetes. Table 1 describes the demographic differences and differences in presenting symptoms between patients diagnosed with Type 1 and Type 2 diabetes.

The body weight profile and presenting symptoms

Table 1. Demographic profile of study population: Florida diabetes study, 1994 through 1998

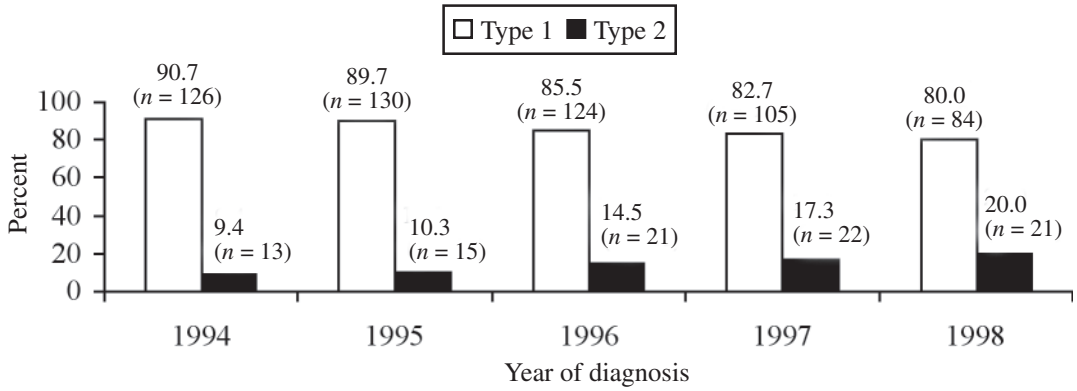
	Whole population n = *661*	*Type 1* n = *569*	*Type 2* n = *92*
Gender			
Female	50.8%	47.1%	62.2%
Male	49.2%	52.9%	37.8%
Race/ethnicity			
White	49.2%	53.4%	22.8%
Black	17.4%	12.8%	45.7%
Hispanic	10.9%	10.4%	14.1%
Other	1.2%	1.1%	2.2%
Not specified	21.3%	22.3%	15.2%
Age			
Mean age	11.1	10.6	13.4
Median age	11.0	11.0	13.5

varied by type of diabetes. At diagnosis, the 569 children and adolescents classified as having Type 1 diabetes had a mean BMI of 19.9 kg/m^2 (median 18.0 kg/m^2). Twelve percent of these patients had a BMI in the 85th–94th percentile, and 19.1% had a BMI ≥95th percentile. Of those with Type 1 diabetes who had symptoms documented in the medical record, 82.0% (204 of 249) had ketonuria and 54.7% (111 of 203) were in ketoacidosis. Among the 92 diagnosed with Type 2 diabetes, the mean BMI was 32.6 kg/m^2 (median 32.4 kg/m^2); 9.6% had a BMI in the 85th–94th percentile, and 84.3% had a BMI ≥95th percentile. Of those with Type 2 diabetes with specific notations in the medical record at the time of initial referral, 24.4% (11 of 45) had ketonuria, 4.7% (2 of 43) were in ketoacidosis, and 88.6% (31 of 35) had acanthosis nigricans.

The proportion of children and adolescents with diabetes classified as Type 2 increased each year from 1994 through 1998 (see Figure; chi-square test for trend = 8.2; p=0.004). As the proportion of Type 2 diabetes increased, there was not an associated net increase in the total number of patients in this age group with new-onset diabetes referred to the centers (chi-square test for trend = 0.6; p=0.4).

The analysis suggested that children and adolescents with Type 2 diabetes were more likely than those with Type 1 diabetes to have a BMI ≥85th percentile, to be Hispanic or black, to be female, and to be older at the time of diagnosis. We tested the associations

Figure. Percent of patients with diabetes who were diagnosed with Type 1 and Type 2 diabetes: Florida diabetes study, 1994 through 1998, *n* = 661



between these variables and the likelihood of being diagnosed with Type 2 diabetes relative to Type 1 diabetes in a multivariate setting to assess the effect of each variable, controlling for each of the other variables. We fitted a logistic regression model predicting the type of diabetes (Type 2 vs. Type 1) to assess the relative contributions of gender, race/ethnicity, age, and body weight to the diagnosis. Odds ratios (ORs) and 95% confidence intervals (CIs) for each of these variables are shown in Table 2. Each variable was significantly associated with a diagnosis of Type 2 diabetes relative to Type 1 diabetes, adjusting for each of the other variables. The odds of being diagnosed with Type 2 diabetes relative to Type 1 diabetes were 8.5 times greater for those who had a BMI in the 85th–94th percentile, and 6.8 times greater for those whose BMI was ≥95th percentile, compared with those whose BMI was <85th percentile. The ORs for those with a BMI in the 85th–94th percentile range and those with a BMI ≥95th percentile were not significantly differ-

Table 2. Odds ratios and confidence intervals for diagnosis of Type 2 vs. Type 1 diabetes: Florida diabetes study, 1994 through 1998

Stratified by	*Variable*	*OR*	*95% CI*
All patients	Weight in the 85th–94th percentile	8.5	2.5, 28.8
	Weight ≥ 95th percentile	6.8	2.6, 17.7
	Hispanic ethnicity	6.2	2.2, 17.9
	Black race	2.8	1.3, 6.2
	Gender (female)	2.2	1.2, 4.3
	Age at diagnosis	1.4	1.3, 1.6
	Missing race/ethnicity	1.4	0.6, 3.4
Age			
5–12	Weight in the 85th–94th percentile	12.7	1.2, 131.4
	Weight ≥ 95th percentile	4.5	1.1, 18.3
	Hispanic ethnicity	5.5	1.3, 23.7
	Black race	9.3	2.9, 30.3
	Gender (female)	2.3	0.9, 6.3
	Missing race/ethnicity	1.0	0.2, 5.5
13–19	Weight in the 85th–94th percentile	10.0	2.1, 48.7
	Weight ≥ 95th percentile	6.5	2.0, 21.6
	Hispanic ethnicity	8.4	1.6, 43.6
	Black race	1.4	0.5, 3.8
	Gender (female)	2.1	0.9, 4.9
	Missing race/ethnicity	1.3	0.4, 4.1
Gender			
Male	Weight in the 85th–94th percentile	1.8	0.2, 19.7
	Weight ≥ 95th percentile	23.1	2.2, 243.5
	Hispanic ethnicity	4.3	0.6, 30.4
	Black race	3.1	0.9, 10.7
	Age at diagnosis	1.4	1.2, 1.6
	Missing race/ethnicity	2.0	0.5, 7.7
Female	Weight in the 85th–94th percentile	22.1	3.7, 130.4
	Weight ≥ 95th percentile	4.2	1.4, 12.6
	Hispanic ethnicity	9.5	2.4, 37.7
	Black race	2.7	1.0, 7.3
	Age at diagnosis	1.4	1.2, 1.6
	Missing race/ethnicity	1.0	0.3, 3.4

CI = confidence interval

OR = odds ratio

ent from each other, as evidenced by the overlapping confidence limits. Hispanic children and adolescents were 6.2 times and black children and adolescents were 2.8 times as likely as non-Hispanic white children and adolescents to be diagnosed with Type 2 diabetes, after controlling for gender, age, and BMI. The odds of being diagnosed with Type 2 diabetes relative to Type 1 diabetes were twice as high for girls as for boys and increased by 40% for each one-year increase in age.

Nearly two-thirds of children and adolescents diagnosed with Type 2 diabetes were girls. Therefore, we undertook a stratified analysis, fitting the logistic regression model previously described separately for girls and boys. This analysis showed that females were at a higher risk than males of developing Type 2 diabetes when they had a BMI in the 85th–94th percentile, whereas males were found to be at a higher risk of developing Type 2 diabetes only when they had a BMI ≥95th percentile (after controlling for the other risk factors). Girls with a BMI in the 85th–94th percentile were 22 times as likely as girls with a BMI <85th percentile to be diagnosed with Type 2 diabetes relative to Type 1 diabetes, whereas boys with a BMI in the 85th–94th percentile were no more likely than their counterparts with a BMI <85th percentile to be diagnosed with Type 2 relative to Type 1 diabetes. Females with a BMI ≥95th percentile, by contrast, were only 4 times as likely as girls with a BMI <85th percentile to be diagnosed with Type 2 diabetes, whereas males with a BMI ≥95th percentile were 23 times as likely as males with a BMI <85th percentile to be diagnosed with Type 2 diabetes relative to Type 1 diabetes.

Among those with Type 2 diabetes, 45.7% were black and 14.1% were Hispanic. In addition, 97.4% of black children and adolescents with Type 2 diabetes had a BMI ≥95th percentile, compared with only 41.7% of Hispanics. After controlling for BMI, Hispanic children and adolescents had a greater likelihood of being diagnosed with Type 2 diabetes relative to Type 1 than did black children. When BMI was not accounted for, black children and adolescents were 6.6 times as likely as white children and adolescents to have Type 2 relative to Type 1 diabetes, whereas Hispanic children and adolescents were at a 2.6 times greater risk of having Type 2 relative to Type 1 diabetes. The ORs were reversed once BMI was controlled: black children and adolescents were 2.8 and Hispanic children and adolescents 6.2 times as likely as white children and adolescents to have Type 2 relative to Type 1 diabetes.

The age range of 5–19 years spans a large time frame in which there are many developmental changes that could lead to increased body mass as well as insulin resistance. To assess any difference that might exist between children (≤12 years) and adolescents (13–19 years), we stratified the bivariate and multivariate analyses by these age groups. Among the 424 children ages 5–12 years, 31 (7.3%) were diagnosed with Type 2 diabetes. In the multivariate model for this age group, BMI in the 85th–94th percentile (OR = 12.7; CI 1.2, 131.4), BMI ≥95th percentile (OR = 4.5; CI 2.0, 21.6), black race (OR = 9.3; CI 2.9, 30.3), and Hispanic ethnicity (OR = 5.5; CI 1.3, 23.7) were all strong predictors of Type 2 diabetes. Among the 237 adolescents ages 13–19 years, 61 (25.7%) had Type 2 diabetes. In the multivariate model for this age group, BMI in the 85th–94th percentile (OR = 10.0; CI 2.1, 48.7), BMI ≥95th percentile (OR = 6.5; CI 2.0, 21.6), and Hispanic ethnicity (OR = 8.4; CI 1.6, 43.6) were all strong predictors of Type 2 diabetes (see Table 2).

DISCUSSION

Over the five-year period under study, the percentage of children and adolescents with newly diagnosed diabetes who were classified as having Type 2 diabetes doubled. Those more likely to be diagnosed with Type 2 relative to Type 1 diabetes had a BMI ≥85th percentile, were Hispanic or black, were girls, and were older. The associations for overweight status (BMI ≥85th percentile) differed between girls and boys. This is not a novel observation and likely reflects that a larger proportion of the BMI in boys would be lean, rather than adipose, tissue mass. Overweight girls are also more likely to be less physically active than overweight boys (and thus less protected against Type 2 diabetes).

The multivariate modeling suggests that overweight status plays a greater role in the risk of Type 2 diabetes in black children and adolescents than in Hispanic children and adolescents. After controlling for overweight status (BMI ≥85th percentile), the OR associated with black race declined substantially and significantly, whereas that associated with Hispanic ethnicity increased (although not significantly). While nearly all black children with Type 2 diabetes had a BMI ≥95th percentile, fewer than half of the Hispanic children with Type 2 diabetes had a BMI ≥95th percentile. Preventing overweight and obesity in black children and adolescents is therefore particularly important for reducing the risk of Type 2 diabetes in this group. Other interventions, in addition to weight management, may need to be identified to prevent the development of Type 2 diabetes in Hispanic children.

This study has several methodological limitations. Importantly, we did not establish a case definition for Type 1 or Type 2 diabetes. We classified patients as having Type 1 or Type 2 diabetes based on the pediatric diabetologist's diagnosis in the medical record. The original intent of this study was to assess anecdotal evidence of an increase in Type 2 diabetes among Florida children and adolescents and to describe risk factors for a diagnosis of Type 2 relative to Type 1 diabetes. We could not establish a case definition postfacto, because the medical records were often weak in documenting initial clinical features and laboratory studies, and subsequently varied depending on the uncertainty of the diagnosis. The American Diabetes Association/American Academy of Pediatrics Consensus Statement *Type 2 Diabetes in Children and Adolescents* states: "In most patients, classification can be made reliably on the basis of clinical presentation and course."[8,9] In our study, diagnosis was made by the physician, based on clinical characteristics, and sometimes the diagnosis was changed based on the course (in 19.5% of children initially thought to have Type 1 diabetes). Lack of case definition forced us to draw conclusions about the likelihood of a diagnosis of Type 2 diabetes over Type 1 diabetes, rather than about the risk factors for Type 2 diabetes in children and adolescents.

Incidence of Type 2 diabetes in children and adolescents could not be assessed in this study of a referred clinical population. Nonetheless, the significantly increasing proportion of children and adolescents with diabetes being diagnosed with Type 2 diabetes is consistent with the anecdotal evidence and reports of increases in the incidence and prevalence of Type 2 diabetes in children and adolescents.[1,2,4–8]

As the proportion of 5- to 19-year-old patients with diabetes having Type 2 diabetes increased over the five-year period of the study, the total number in this age group referred for diabetes remained stable. It is unlikely that the increase in proportion of Type 2 diabetes reflects increased physician awareness of this disease in younger people, because the occasional occurrence of Type 2 diabetes in children and adolescents has been recognized by pediatric diabetologists for many years. For example, in 1971, Knowles reported that ~3.5% (11/300) of the patients in the juvenile diabetes clinic at Cincinnati General Hospital had "stable middle-aged onset type" diabetes, associated with being overweight and responsive to oral hypoglycemic treatment.[12] The five-year time frame covered by this study is too brief to reflect a true change in physician awareness of this disease, especially among academic pediatric diabetologists who had been discussing this condition in numerous forums for several years before 1994. The increase in numbers of patients with Type 2 diabetes, and simultaneous decrease in Type 1 diabetes patients seen at the university centers in this study likely results from a change in referral patterns. The study covered a period in which increasing numbers of pediatric endocrinologists were establishing private practices in the referral areas. Patients with Type 2 diabetes are more likely than those with Type 1 disease to be at the socioeconomic level devolving on the university centers.

This study compared children and adolescents with Type 2 diabetes to those with Type 1 diabetes to describe factors associated with a diagnosis of Type 2 versus Type 1 diabetes in children and adolescents. In this study, children and adolescents with Type 1 diabetes were found to have similar gender, "race/ethnicity," and body weight distributions as the general population and were therefore used as the comparison group. Patients with Type 2 diabetes looked very different, however. The children and adolescents in this study identified as having Type 2 diabetes were more overweight than those with Type 1 diabetes. Our society must strive to control obesity among all children and adolescents by implementing public health policies and programs to promote healthful nutrition choices and regular physical activity. Such practices are essential to eliminating Type 2 diabetes among children and adolescents. Black and Hispanic children and adolescents, in particular, will benefit from such improvements.

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