Body Mass Index at the Time of Diagnosis of Autoimmune Type 1 Diabetes in Children

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Objectives To describe the body mass index (BMI) distribution of children developing autoimmune type 1 diabetes (T1D) compared with the general population and to assess factors associated with BMI at T1D onset.

Study design Children age 2-<19 years enrolled in the Pediatric Diabetes Consortium at 7 US pediatric diabetes centers at T1D onset were included. Eligibility for analysis required a diagnosis of T1D, ≥1 positive diabetes autoantibody, and availability of BMI within 14 days of diagnosis. BMI at diagnosis was compared with the general population as described by the 2000 Centers for Disease Control. Regression analysis was used to assess the association between BMI and various participant characteristics.

Results BMI scores for the 490 participants were slightly lower than the 2000 Centers for Disease Control population (P = .04). The median BMI percentile for age and sex was 48th, 11% of the children were overweight (BMI ≥85th and <95th percentile), 8% obese (BMI ≥95th and <99th percentile), and 2% severely obese (≥99th percentile), percentages that were comparable across age and sex groups. Higher BMI Z-scores were associated with African American and Hispanic race/ethnicity (P = .001) and lower hemoglobin A1c (P < .001), and diabetic ketoacidosis, age, and Tanner stage were not associated.

Conclusions Although the BMI distribution in children developing autoimmune T1D was lower than that of the general population, 21% of children were obese or overweight. Youth who are overweight, obese, racial/ethnic minority, and/or present without diabetic ketoacidosis should not be presumed to have type 2 diabetes because many patients with autoantibody-positive T1D present with the same clinical characteristics. *(J Pediatr 2013;162:736-40)*.

The increasing prevalence of overweight and obesity in US children and adolescents has been a public health concern for the past 20 years and is predicted to nearly double by 2030.[1] A similar trend has been observed in children with type 1 diabetes (T1D) with the percentage of overweight patients tripling to 37% since the 1980s.[2] Moreover, recent studies have reported that 10%-34% of youth with obesity and clinically diagnosed with type 2 diabetes (T2D) phenotype have the immunologic markers of T1D,[3,4] providing further evidence that children with T1D can no longer be characterized as slender individuals who are "rarely obese" at presentation.[5] Although it is likely that differences in body mass index (BMI) influence the spectrum of initial clinical findings of youth with new onset T1D, large studies that have examined this question are scarce in the literature.

The Pediatric Diabetes Consortium (PDC) is a collaborative research group that is working together to improve the care of children with diabetes through sharing of best practices.[6] More than 1000 youth with T1D, ranging in age from 0-18 years, have been enrolled in the initial PDC protocol, whose aim is to describe how diabetes is currently being treated in children and adolescents with new onset T1D at pediatric diabetes specialty centers in the US. The children and adolescents who have enrolled in the PDC represent a large and geographically diverse cohort of youth with T1D. The primary purpose of this article is to describe how the BMI distribution of children developing autoimmune T1D compares with the general population, as described by the Centers for Disease Control (CDC). We also determined the influence of demographic

BMI	Body mass index
CDC	Centers for Disease Control
DKA	Diabetic ketoacidosis
HbA1c	Hemoglobin A1c
NHANES	National Health and Nutrition Examination Survey
PDC	Pediatric Diabetes Consortium
T1D	Type 1 diabetes
T2D	Type 2 diabetes

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*A list of members of the Pediatric Diabetes Consortium is available at www.jpeds.com (Appendix).

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(ie, age, sex, race/ethnicity) and socioeconomic factors on BMI, as well as the potential impact of BMI on clinical presentation of T1D.

Methods

The PDC has enrolled 1053 children and adolescents <19 years of age diagnosed with T1D from July 2009 to April 2011 and managed by 1 of the 7 consortium centers within 3 months of diagnosis. Written informed consent was obtained from participants 18 years of age and from parents of children <18 years of age. Written assent also was obtained from youth according to the local Human Subjects Investigational Review Board guidelines.

To be included in this study, participants had to have a clinical diagnosis of autoimmune T1D, including at least 1 diabetes autoantibody present (islet cell autoantibody 512/insulinoma associated antibody 2, and/or glutamic acid decarboxylase autoantibody, within 91 days of diagnosis, and/or insulin autoantibody within 14 days of diagnosis), have height and weight data measured by health care provider within 14 days of diagnosis, and be ≥2 years (to determine BMI percentile), and <19 years of age. One participant was excluded for having a BMI that was an outlier because of failure to thrive and other severe medical conditions.

Demographic, socioeconomic, and clinical data were retrieved from medical records and from interview of the participant and/or parent. Clinical characteristics at time of diagnosis included age at diagnosis, presence of diabetic ketoacidosis (DKA), weight, height, and Tanner stage (from examination within ±91 days of diagnosis, imputed as stage 1 for girls <8 years of age and boys <10 years of age). The hemoglobin A1c (HbA1c) measurement within ±14 days of diagnosis was used in analysis. DKA status at presentation was classified as confirmed DKA (either pH <7.3 or serum bicarbonate <15 mEq/l),[7] unconfirmed DKA (provider determined only), or no DKA. Unconfirmed DKA cases were not included in the analyses.

BMI was computed from the closest height and weight measured by the health care provider within 14 days of diagnosis (mean 3 days) and computed as weight (in kilograms) divided by the square of height (in meters). BMI percentile and SDS for age and sex was calculated using 2000 CDC population growth chart data.[8] According to pediatric standards for ages 2-19 years, patients were classified as overweight when BMI percentile was ≥85% and <95%, obese when BMI percentile was ≥95% and <99%, and severely obese when BMI percentile was ≥99%.[9]

Statistical Analyses

The BMI distribution of the T1D cohort was compared with the BMI distribution of the 2000 CDC population[8] using Student *t* test. Comparisons also were performed in subgroups based on age, sex, and age-sex combined. Although results are reported using the entire range of BMI z-score data, analyses were performed with truncated data (±3 SD) to verify that outliers did not have undue leverage.

Least squares regression was used to determine if BMI z-score at diagnosis was associated with DKA status, HbA1c at diagnosis, age, sex, race/ethnicity, number of diabetes-associated autoantibodies, and/or Tanner stage. A multivariate model was constructed using stepwise selection with $P < .10$ required to be included in the model. We had information on family income, parent education, and health insurance but elected to use parental education given collinearity among the variables. Only factors with P values <.01 were considered statistically significant because of multiple comparisons, although factors with $P < .10$ were included in the model to adjust for potential confounding. Interaction terms were tested for all variables included in the final multivariate model with P value <.01 required to be included. Continuous variables were examined for nonlinear trends by testing quadratic terms in the regression model. Multivariate model residuals were examined for an approximate normal distribution.

All reported P values were 2-sided. All analyses were conducted using SAS v. 9.3 (SAS Institute, Cary, North Carolina).

Results

For the 490 children included in the analysis, the mean age at the time of T1D diagnosis was 9.5 years (range 2-18 years); 48% were female, 61% non-Hispanic White, 26% Hispanic, 7% African American, and 6% other race. Of the 355 patients tested for all 3 diabetes autoantibodies, 134 (38%) were positive for all 3, 143 (40%) were positive for 2 out of 3, and 78 (22%) were positive for 1 only. A total of 147 children (31%) presented with DKA. By ethnicity, 31% of non-Hispanic White, 24% of Hispanic, and 47% of African American children presented with DKA. The majority (66%) of patients was prepubertal: 100% were 2-<5 years old, 99% were 5-<9 years old, 57% were 9-<12 years old, and 6% were 12-<19 years old. Family income and parental education were relatively high (53% with income ≥$75 000 and 53% with a college education) and most had some form of health insurance (65% private insurance and 30% Children's Health Plan/Medicaid/Medicare). A family history of T1D (parent or sibling) was present in 7% of participants, and 6% had a family history of T2D. Thirty-seven comorbidities were present in 36 (7%) patients, including thyroid disease (n = 21), celiac disease (n = 7), asthma (n = 7), autoimmune adrenal disease (n = 1), and alopecia areata totalis (n = 1).

The median BMI percentile for age and sex was 48th overall and 40th, 49th, 55th, and 48th for patients 2-<5 year old, 5-<9 year old, 9-<12 years old, and 12-<19 years old, respectively. Overall, 11% were overweight, 8% obese, and 2% severely obese, percentages that were comparable across age and sex groups (**Table I**).

The PDC new onset T1D cohort mean BMI z-score was slightly lower than the 2000 CDC population[8] (mean = −0.13, 95% CI: −0.25 to −0.01, P = .04; **Table I**). The mean BMI z-score in new onset T1D girls was lower than