Risk Factors for Type 2 Diabetes in a Sixth-Grade Multiracial Cohort

The HEALTHY study

THE HEALTHY STUDY GROUP*

OBJECTIVE — HEALTHY is a 3-year middle school intervention program designed to reduce risk factors for type 2 diabetes. The prevalence of diabetes risk factors at baseline in a cohort of 6,358 sixth-grade students is reported.

RESEARCH DESIGN AND METHODS — Forty-two schools at seven U.S. sites were randomly assigned to intervention or control. Students participated in baseline data collection during fall of 2006.

RESULTS — Overall, 49.3% of children had BMI ≥85th percentile, 16.0% had fasting blood glucose ≥100 mg/dl (<1% had fasting blood glucose ≥126 mg/dl), and 6.8% had fasting insulin ≥30 μU/ml. Hispanic youth were more likely to have BMI, glucose, and insulin levels above these thresholds than blacks and whites.

CONCLUSIONS — Sixth-grade students in schools with large minority populations have high levels of risk factors for type 2 diabetes. The HEALTHY intervention was designed to modify these risk factors to reduce diabetes incidence.

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The HEALTHY study is determining the effectiveness of a 3-year intervention that changes the school environment with regard to nutrition, physical activity, and health messaging and facilitates student and parent behavior change to reduce risk factors for type 2 diabetes (BMI ≥85th percentile, fasting glucose ≥100 mg/dl, and fasting insulin ≥30 μU/ml). A pilot study in eighth-grade students showed a high prevalence of diabetes risk factors, but almost no diabetes (1). We report baseline data in sixth graders before the HEALTHY intervention was begun.

RESEARCH DESIGN AND METHODS

Forty-two middle schools with at least 50% of students eligible for free or reduced-price lunch or belonging to a minority group, with an annual student attrition rate ≤25%, and with a guarantee of at least 225 min of physical education every 10 days were recruited by seven centers (list available in an online appendix at http://care.diabetesjournals.org/cgi/content/full/dc08-1774/DC1). All sixth-grade students were invited to participate and were offered a 50 U.S.D. incentive for data collection. This study was approved by institutional review boards, and informed parental consent and child assent were obtained.

Data collection

Methods for data collection were described previously (1). Ethnicity and race were collected by student self-report: any student checking "Hispanic or Latino" ethnicity was classified as Hispanic, non-Hispanics choosing only "black or African American" race were classified as black, non-Hispanics choosing only "white" race were classified as white, and all other response categories were combined into "other." Students underwent a fasting blood draw; those with known diabetes or those who were unable to participate in physical education classes were not eligible.

Statistical methods

BMI percentile by age and sex was calculated using the SAS program provided by the Centers for Disease Control and Prevention referencing the year 2000 (2,3). The "other" racial/ethnic group was too heterogeneous to interpret and was not included in the analysis. *P* values are given from analyses of generalized linear mixed models (SAS Proc GLIMMIX) that included a random effect for school. If the overall effect was significant ($P < 0.05$), then pairwise comparisons were performed.

RESULTS

A total of 6,358 sixth-grade students had complete and valid data. Overall, 57.6% of the sixth-grade students were recruited to participate (range 44.4–87.0%). The mean number of participants per school was 151 (range 73–229).

Table 1 presents student characteristics. Tests for the effect of race/ethnicity on percentage at risk for each factor were conducted, and all were statistically significant ($P < 0.0001$): 52.4% of Hispanics, 47.9% of blacks, and 43.6% of whites had BMI ≥85th percentile; 19.3% of Hispanics, 10.4% of blacks, and 13.9% of whites had fasting glucose ≥100 mg/dl; and 8.3% of Hispanics, 5.2% of blacks, and 3.5% of whites had fasting insulin ≥30 μU/ml. The distribution of fasting glucose and fasting insulin across three BMI percentile categories (<85, 85–94, and ≥95%) showed that for fasting glucose ≥100 mg/dl, pairwise tests were significant for 85–94 versus ≥95% and for <85 versus ≥95%; for fasting insulin ≥30 μU/ml, all three pairwise comparisons were significant.

When the combined effects of race/ethnicity and BMI percentile on the glycemic risk factors were analyzed, Hispanics had the highest percentage with fasting glucose ≥100 mg/dl across all three BMI categories (Hispanics 16.9, 19.3, and 23.0%; blacks 7.5, 6.2, and 18.1%; and whites 11.7, 15.7, and

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Table 1—*Sixth-grade student characteristics*

Age (years)	11.8 ± 0.6 (9–15)
Sex (male)	47.6
Race/ethnicity	
Hispanic	53.1
Black	19.7
White	18.8
Other	8.4
Positive self-report first-degree family history of diabetes	16.4
Tanner stage (self-report Pubertal Development Scale)	
Male	
1	15.5
2	38.6
3	38.1
4	6.5
5	0.3
Female	
1	5.8
2	13.0
3	42.7
4	34.9
5	3.6
BMI (kg/m^2)	22.3 ± 5.5
Male	22.4 ± 5.5
Female	22.2 ± 5.5
BMI percentile (categorical, adjusted for age and sex)	
<85%	50.7
85–94%	19.7
≥95%	29.6
Fasting glucose (mg/dl)	93.4 ± 6.7
Fasting glucose (categorical)	
<100 mg/dl	84.0
100–109 mg/dl	14.7
110–125 mg/dl	1.2
≥126 mg/dl	0.1*
Fasting insulin (μU/ml)	13.3 ± 11.6
Fasting insulin ≥30 μU/ml (categorical)	6.8

Data are means ± SD (minimum-maximum) or percent unless otherwise indicated. $N = 6,358$. *Six subjects had fasting glucose ≥126 mg/dl at screening; only one of these values was confirmed on follow-up clinical testing.

17.7%). The percentage with fasting insulin ≥30 μU/ml rose dramatically across all three BMI categories, and again Hispanics had the highest percentage at risk (Hispanics 0.7, 3.6, and 22.5%; blacks 1.0, 2.2, and 14.5%; and whites 0.6, 2.2, and 11.8%).

The proportion of the total sample with all three risk factors for diabetes was 2.3%. In contrast, 43.7% of students had all three factors below the risk cutoffs. There was no difference by sex. Among those with a family history of diabetes, 4.6% had all three risk factors. Risk varied minimally by race/ethnicity, with 2.9% of Hispanic, 2.0% of black, and 1.3% of white youth having all three risk factors.

CONCLUSIONS — The percentage of overweight youth in our cohort was higher than that reported for the National Health and Nutrition Examination Survey (NHANES) in a representative sample of U.S. children (4) but similar to rates reported in other predominantly minority cohorts (5,6), including our 2003 pilot study of eighth-grade students (1). Hispanics had the greatest percentage of overweight/obesity, followed by blacks, similar to results from NHANES (4).

Mean glucose was higher than reported in overweight Mexican Americans of comparable age (78–81 mg/dl) (7), similar to reports in high-risk Mexican-American youth with a family history of diabetes (91.5 mg/dl) (6,8) and American Indians in this age range (91.8 mg/dl) (9) and lower than that in our eighth-grade pilot cohort (98.2 mg/dl) (1). The percentage of students with impaired fasting glucose (IFG) was higher than that for teens from NHANES (10–12) and that for a community sample of teens in Cincinnati (13). However, it was notably lower than the IFG rate of 40.5% in our eighth-grade pilot study (1). There was virtually no undiagnosed diabetes, indicating that the rate of conversion from IFG to diabetes in youth was very low or that children who developed diabetes were symptomatic and sought medical care early or both. With regard to race/ethnicity, IFG was most common in Hispanics, intermediate in blacks, and least common in whites, similar to results in NHANES (10).

Previous reports have shown an effect of race/ethnicity on insulin levels and IFG in youth. Insulin levels have been reported previously to be affected by pubertal stage and race/ethnicity, with black girls having the highest values (14,15). In our cohort, more Hispanics had insulin ≥30 μU/ml than blacks and whites, who were not statistically different. Hyperinsulinism varied across the BMI percentile categories. Hispanics had the greatest percentage with IFG in all BMI percentile groups. Blacks showed the greatest effect of increasing BMI on IFG. A relatively small percentage of students (2.3%) had all three diabetes risk factors; this percentage was increased twofold in those with a family history of diabetes.

Our results confirm high rates of overweight/obesity in sixth graders, similar to our eighth-grade pilot (1), but with lower rates of metabolic abnormalities. This finding justifies research, such as the HEALTHY trial, to evaluate interventions to reduce diabetes risk in middle-school students.

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APPENDIX

The HEALTHY Writing Group is as follows: Francine R. Kaufman (chair), Kathryn Hirst, Barbara Linder, Tom Baranowski,

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