

Metabolic Risk and Health Behaviors in Minority Youth at Risk for Type 2 Diabetes

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OBJECTIVE— The purpose of this study was to determine the impact of sex and race/ethnicity on metabolic risk and health behaviors in minority youth.

RESEARCH DESIGN AND METHODS— A total of 173 seventh graders (46% male and 54% female; 49% Hispanic and 51% African American) with BMI \geq 85th percentile and a family history of diabetes were assessed with weight, height, BMI, percent body fat, and waist circumference measures. Laboratory indexes included 2-h oral glucose tolerance tests with insulin levels at 0 and 2 h, fasting A1C, and lipids. Insulin resistance was estimated by homeostasis model assessment (HOMA-IR). Youth also completed questionnaires evaluating health behaviors.

RESULTS— Average BMI (31.6 ± 6.4 kg/m²) and percent body fat ($39.5 \pm 10.6\%$) were high. All participants demonstrated insulin resistance with elevated HOMA-IR values (8.5 ± 5.2). Compared with African American youth, Hispanic youth had higher triglycerides and lower HDL cholesterol despite similar BMI. Hispanic youth reported lower self-efficacy for diet, less physical activity, and higher total fat intake. Male youth had higher glucose (0 and 2 h) and reported more physical activity, more healthy food choices, and higher calcium intake than female youth.

CONCLUSIONS— Screening high-risk youth for insulin resistance and lipid abnormalities is recommended. Promoting acceptable physical activities and healthy food choices may be especially important for Hispanic and female youth.

Diabetes Care 34:193–197, 2011

Obesity and overweight have increased in youth at an alarming rate. The latest statistics indicate that rates of obesity have risen among adolescents from 5% in 1970 to $>18\%$ in 2008, and rates of overweight in adolescents now exceed 34% (1). Further, rates of obesity and overweight have increased at even higher rates in minority youth; Hispanic male and black female adolescents are now significantly more likely to have high BMI than white adolescents (1). Among inner city and minority youth, the prevalence of overweight can be as high as 50% (2). Recent estimates from a population-based study suggest that the prevalence of type 2 diabetes among adolescents is 0.22 case/1,000 youth, with significantly higher rates for His-

panic (0.48 case/1,000 youth) and black adolescents (1.05 cases/1,000 youth), and these rates are likely to continue to increase with rising obesity rates (3). Thus, there is a need to better understand this high-risk population.

Obesity in adolescence is a strong predictor of adult obesity (4), with increased risks for type 2 diabetes and cardiovascular disease, resulting in significant morbidity and mortality (5). Although the relationships between obesity, insulin resistance, type 2 diabetes, and other conditions have been well established in adults, insulin resistance is now becoming more prevalent in youth (5). Obese youth exhibit hyperinsulinemia, increased adiposity, dyslipidemia, and insulin resistance (6), and one study

showed that 70% of obese youth had at least one risk factor for cardiovascular disease (4).

In addition to health problems, obesity in youth is associated with poor health behaviors related to both nutrition and physical activity (7). Studies of obese youth suggest that their understanding of basic nutrition is lacking, and overweight youth consume lower levels of nutrients than their healthy-weight peers (8). Further, obese youth report lower self-efficacy, the belief that they are capable of performing the desired behaviors, for physical activity (9). Ethnic minority youth may have poorer health behaviors than their white peers. White adolescents, for example, have been shown to be more physically active than minority adolescents (10). In Latino youth, several studies have linked greater acculturation to the majority culture with higher rates of obesity related to poorer diet, including lower intake of fruits and vegetables and increased intake of sugar, and lower rates of physical activity (11). Thus, the investigation of health behaviors in overweight minority youth at risk for type 2 diabetes is warranted.

The majority of previous studies in obese minority youth were focused on either metabolic risk or health behaviors but not both. In this report, we explore the anthropometric, metabolic, and health behaviors associated with insulin resistance and risk for type 2 diabetes in Hispanic white and non-Hispanic African American adolescents. Differences in sex and race/ethnicity are investigated.

RESEARCH DESIGN AND METHODS

— The current study is a secondary analysis of baseline data from a randomized clinical trial of a school-based intervention for youth at risk for type 2 diabetes (12). Seventh grade youth from six schools in a New England city were invited to participate if they had BMI \geq 85th percentile and a family member with diabetes. Seventh graders were targeted because of their increased risk for type 2 diabetes at puberty. Youth were excluded if they had an existing chronic disease (other than asthma) or were involved in another clinical trial. For interested students, parents were contacted to

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Received 22 June 2010 and accepted 15 September 2010. Published ahead of print at <http://care.diabetesjournals.org> on 20 September 2010. DOI: 10.2337/dc10-1197.

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describe the study and obtain informed consent in line with university institutional review board requirements.

Between April 2004 and December 2006, 380 students were screened for eligibility, with 234 students meeting the inclusion criteria and 28 families refusing to enroll (the most common reason for refusal was lack of interest). Of the 206 students who consented/assented to participate, 4 students were later ineligible because of low BMI, 1 was promoted to eighth grade, 1 was expelled, 7 refused, and 5 moved after consenting; these youth were not statistically different in sex and age from participants. Data for the remaining 188 participants were collected by trained research staff in school-based clinics. For purposes of these analyses, data from 15 students who did not self-categorize as either Hispanic or African American were excluded before analyses. Their representative groups were white ($n = 5$), more than one race ($n = 5$), other ($n = 1$), and unspecified ($n = 4$). Data analyses were performed for the remaining 173 participants.

Anthropometric measures

Weight in kilograms and percent body fat were measured with a scale and body composition analyzer (model BF-350; Tanita Corporation of America, Arlington Heights, IL). The leg-to-leg bioimpedance method was used to determine percent body fat. Height was measured using a wall-mounted stadiometer, calibrated in 1/8-cm intervals. Waist circumference was determined at the umbilicus at the end of a normal expiration, and hip measures were taken at the widest portion of the hip using a Gulick tape measure.

Metabolic measures

Oral glucose tolerance tests (OGTTs) were performed with a standard glucose load (1.75 g glucose/kg body wt up to a maximum of 75 g) (Trutol 100; NERL Diagnostics, East Providence, RI). Insulin resistance was estimated by homeostasis model assessment (HOMA) of insulin resistance (HOMA-IR) using the equation, $HOMA-IR = \text{fasting insulin (microunits per milliliter)} \times \text{fasting glucose (millimoles per liter)} / 22.5$. A value >2.2 is indicative of insulin resistance. Fasting A1C levels were determined using the DCA 2000 Analyzer (Bayer, Tarrytown, NY). The normal range is $<6.5\%$ (13). Lipids, including total cholesterol, HDL cholesterol, and triglycerides were measured (Cholestech LDX system; Cholestech, Hay-

ward, CA). LDL cholesterol was calculated using the formula, $LDL \text{ cholesterol} = (\text{total cholesterol} - HDL \text{ cholesterol}) - (\text{triglycerides}/5)$ (14). Those who had laboratory values within the prediabetes range were referred to their primary care providers for further evaluation and follow-up.

Health behaviors

The Health Behavior Questionnaire (15) was used to measure Dietary Intention (13 items, intentions to choose foods considered heart healthful), Usual Food Choices (14 items, usual food selections), Perceived Support for Physical Activity (18 items, social support for physical activity among family members, teachers, and friends), and Social Reinforcement for Healthy Food Choices (7 items, social support for heart-healthy food from family members, teachers, and friends). These scales use dichotomous forced-choice formats among two foods or Yes/No. Positive values indicate healthier choices or greater support for healthy choices, and negative values indicate poorer choices or support. Internal consistency values for the current study are as follows: Dietary Intent, $\alpha = 0.69$; Usual Food Choices, $\alpha = 0.68$; Support for Physical Activity, $\alpha = 0.60$; and Social Reinforcement for Healthy Food Choices, $\alpha = 0.87$. In addition, the Dietary Self-Efficacy scale (5 items, e.g., "How sure are you that you can eat a baked potato instead of French fries?") and Physical Self-Efficacy scale (5 items, e.g., "How sure are you that you can choose to jog during recess?") were used to measure self-efficacy. These scales use a 3-point Likert-type scale, with 1 = not sure, 2 = a little sure, and 3 = very sure. Internal consistency for the current study was $\alpha = 0.85$ for Dietary Self-Efficacy and $\alpha = 0.64$ for Physical Self-Efficacy. Scores on the self-efficacy scales range from -15 to 15 .

The Revised Godin-Shephard Activity Survey (16) measures self-reported activity. Subjects report the number of times in an average week that they spent >15 min in activities classified as mild (3 METs), moderate (5 METs), or strenuous (9 METs). The MET is the standard unit of work measure used in exercise physiology that involves the ratio of oxygen consumption, body weight, and unit of time. The number of times students engaged in each activity is multiplied by the MET level and summed to provide a weekly total.

Dietary intake was estimated by averaging two 24-h recalls (one weekend and one weekday). Interviews were conducted at school by a registered dietitian or diet technician, and food models were used to improve estimation of portion sizes. Nutrient intake was analyzed using Nutritionist Pro software (version 2.4.1; First Data Bank, San Bruno, CA). Values were compared with National Health and Nutrition Examination Survey 2001–2002 average intakes and dietary reference intakes for age and sex but not race/ethnicity (17).

Statistical analysis

Analyses were performed with SAS (version 9.1). The effects of sex and ethnicity were examined on all available variables, using χ^2 tests for noncontinuous variables and standard least-squares ANOVA models for continuous variables. To correct for skewness, HOMA values were transformed using the logarithm function.

RESULTS

Demographic, socioeconomic, and health perception indicators

The 173 adolescents (80 male and 93 females) were 11–15 years old (12.9 ± 0.7 years). Of the total, 84 (49%) were Hispanic, and 89 (51%) were African American. We found significant differences between racial/ethnic groups related to guardians' marital status ($P = 0.002$), education ($P < 0.001$), and self-rated health score ($P = 0.002$), with Hispanic families more likely to report marriage, a lower level of education (i.e., less than high school), and poorer self-rated health (scores ranged from 1 = poor to 4 = excellent).

Metabolic risk

As seen in Table 1, average BMI ($31.6 \pm 6.4 \text{ kg/m}^2$) and percent body fat ($39.5 \pm 10.6\%$) were high. As shown in Table 2, fasting insulin levels ($37.9 \pm 21.3 \mu\text{U/ml}$) were high, and 100% of the participants had high HOMA-IR (8.5 ± 5.2). Glucose (0-h), A1C, triglycerides, total cholesterol, HDL cholesterol, and LDL cholesterol were within normal ranges. Prediabetes (glucose 100–125 mg/dl [$4.6\text{--}6.9 \text{ mmol/l}$]) was present in 15% (26 participants) (18).

Health behaviors

As seen in Table 3, adolescents reported fairly high support for physical activity (9.6 ± 5.4). However, they reported fairly

Table 1—Anthropometric measures: total and by ethnicity and sex

Measure	Total	Hispanic	African American	P value	Male	Female	P value
n	173	84	89		80	93	
Age (years)	12.9 ± 0.7	12.9 ± 0.7	12.9 ± 0.7	0.74	13.1 ± 0.8	12.7 ± 0.6	0.01
Height (cm)	159.3 ± 10.6	157.0 ± 13.3	161.4 ± 6.8	0.006	161.5 ± 13.8	157.5 ± 5.8	0.01
Weight (kg)	77.6 ± 17.9	74.5 ± 15.5	80.4 ± 19.5	0.03	79.0 ± 18.7	76.4 ± 17.2	0.36
BMI (kg/m ²)	31.6 ± 6.4	31.2 ± 13.4	30.7 ± 6.7	0.73	31.2 ± 13.6	30.7 ± 6.1	0.73
Body fat (%)	39.5 ± 10.6	38.4 ± 9.8	40.4 ± 11.2	0.20	36.8 ± 12.7	41.9 ± 7.4	0.002
Waist circumference (cm)	94.6 ± 14.7	93.1 ± 13.5	95.9 ± 15.6	0.22	95.6 ± 15.9	93.7 ± 13.5	0.40
Hip circumference (cm)	107.0 ± 12.0	105.1 ± 9.7	108.7 ± 13.5	0.053	106.7 ± 11.9	107.3 ± 12.2	0.73

Data are means ± SD.

low self-efficacy for physical activity (2.4 ± 2.3) and perceived benefits for activity (3.9 ± 0.70). Adolescents reported fairly high self-efficacy for diet (6.4 ± 6.0) and dietary knowledge (7.0 ± 5.8), but they reported poor usual food choices (-1.7 ± 5.6) and dietary intent (-1.5 ± 5.7).

Self-reported energy intake was lower than expected (Table 4); however, the percentage of kilocalories from fat was $>30\%$ for the entire sample. Participants had lower intake than the recommended average requirements for vitamin E, vitamin K, calcium, potassium, fiber, and magnesium (17). Dietary Reference Intakes were met for iron, sodium, protein, and carbohydrate. Compared with the average U.S. child aged 9–13 years, our students reported lower intake of all nutrients except vitamins A and C (17).

Sex differences

As seen in Tables 1 and 2, age, height, fasting glucose, and 2-h OGTT were significantly higher in male than in female participants (all $P < 0.01$). As expected, female participants had higher percent body fat than male participants, but there were no sex differences in the presence of

prediabetes. Table 3 indicates that male participants reported greater physical activity and healthier usual food choices (both $P = 0.005$). Although kilocalorie intake was not significantly different between sexes (Table 4), male participants had higher intake of potassium, calcium, phosphorus, and magnesium than did female participants (all $P = 0.01$). None of the female participants met the Dietary Reference Intake values for these nutrients and male participants met only the suggested levels for phosphorus (17).

Racial/ethnic differences

As seen in Tables 1 and 2, African American youth were significantly taller and heavier than Hispanic youth, whereas Hispanic youth had higher triglycerides and lower HDL cholesterol (all $P = 0.05$). There were no ethnic differences in the prevalence of prediabetes. Hispanic youth reported significantly less physical activity and less diet self-efficacy than African American youth (Table 3). Hispanic youth reported significantly higher intake of total fat, monounsaturated fat, and polyunsaturated fat than African American youth (Table 4).

With logHOMA as the dependent

variable, we fitted an ANCOVA model to test for main effects and interactions, using a backward elimination algorithm to arrive at the best model. The final model ($F_{1,144} = 3.69$, $P = 0.01$, $R^2 = 0.071$) included sex, BMI, and the sex \times BMI interaction, with a steeper slope for girls than for boys. These variables were weakly but significantly related to logHOMA. Ethnicity was not retained in the best model as a significant predictor for insulin resistance.

CONCLUSIONS— In this study, we described metabolic indicators and health behaviors in a sample of African American and Hispanic youth at high risk for type 2 diabetes by virtue of BMI and family history. The average adolescent in our study manifested insulin resistance, while maintaining normal glucose levels, but without the elevated lipids associated with metabolic syndrome (19). As expected, higher BMI was related to higher insulin resistance (19). In addition, the relationship between BMI and insulin resistance was stronger for girls than for boys. Although our participants were selected for being at high risk for type 2 diabetes, the prevalence of insulin resis-

Table 2—Metabolic measures: total and by ethnicity and sex

Measure	Total	Hispanic	African American	P value	Male	Female	P value
n	173	84	89		80	93	
Glucose, 0-h (mg/dl)	90.6 ± 11.0	90.3 ± 11.3	90.9 ± 10.8	0.76	93.3 ± 12.0	88.3 ± 9.6	0.004
Insulin, 0-h (μ U/ml)	37.9 ± 21.3	37.3 ± 21.2	38.5 ± 21.6	0.71	38.4 ± 23.0	37.5 ± 19.9	0.83
A1C (%)	5.3 ± 0.3	5.2 ± 0.3	5.3 ± 0.4	0.10	5.2 ± 0.4	5.3 ± 0.3	0.61
Triglycerides (mg/dl)	91.0 ± 56.7	112.7 ± 71.9	72.1 ± 27.7	<0.001	91.5 ± 56.3	90.6 ± 57.3	0.92
Total cholesterol (mg/dl)	151.9 ± 29.7	154.8 ± 28.4	149.3 ± 30.7	0.31	155.9 ± 30.9	148.5 ± 28.4	0.15
HDL cholesterol (mg/dl)	40.2 ± 11.7	37.6 ± 11.0	42.5 ± 11.9	0.008	40.5 ± 13.0	39.9 ± 10.6	0.76
LDL cholesterol (mg/dl)	93.1 ± 29.0	94.2 ± 28.1	92.1 ± 29.8	0.67	96.6 ± 32.1	90.0 ± 25.8	0.16
Glucose, 2-h (mg/dl)	103.2 ± 20.0	104.8 ± 23.2	101.8 ± 16.7	0.30	108.0 ± 21.2	99.2 ± 18.1	0.005
Insulin, 2-h (mg/dl)	126.4 ± 92.3	130.1 ± 100.8	123.0 ± 84.9	0.66	113.6 ± 79.9	136.6 ± 100.5	0.12
HOMA-IR	8.5 ± 5.2	8.2 ± 5.7	8.6 ± 5.4	0.59	8.9 ± 6.1	8.1 ± 4.3	0.66

Data are means ± SD.

Table 3—Health behaviors: total and by ethnicity and sex

Measure	Total	Hispanic	African American	P value	Male	Female	P value
n	173	84	89		80	93	
Support for Physical Activity	9.6 ± 5.4	8.7 ± 5.9	10.5 ± 4.7	0.05	10.3 ± 4.9	9.0 ± 5.8	0.21
Physical Activity Self-Efficacy	2.4 ± 2.3	2.3 ± 2.5	2.5 ± 2.1	0.69	2.6 ± 2.4	2.2 ± 2.3	0.37
Physical activity reported (MET)	996.9 ± 417.3	907.5 ± 434.6	1,078.1 ± 385.7	0.006	1,131.7 ± 406.1	888.0 ± 392.9	<0.001
Dietary Intention	-1.5 ± 5.7	-1.1 ± 6.1	-1.8 ± 5.4	0.44	-0.8 ± 5.7	-2.1 ± 5.6	0.13
Usual Food Choice	-1.7 ± 5.6	-1.3 ± 6.1	-2.1 ± 5.1	0.33	-0.5 ± 5.8	-2.8 ± 5.2	0.009
Dietary habits	1.6 ± 2.5	1.7 ± 3.6	1.5 ± 2.3	0.63	1.8 ± 2.5	1.4 ± 2.5	0.31
Social Reinforcement for Healthy							
Food Choices	-2.1 ± 10.1	-3.3 ± 9.5	-1.0 ± 10.6	0.14	-3.3 ± 10.3	-1.0 ± 9.9	0.14
Diet Self-Efficacy	6.4 ± 6.0	5.2 ± 6.8	7.5 ± 5.5	0.013	6.6 ± 5.9	6.2 ± 6.5	0.68

Data are means ± SD.

tance at 100% is surprising and differs from a previous study of overweight youth, in which the prevalence of insulin resistance was only 25% (20). However, our sample may have been at higher risk because of a family history of diabetes, which was not a requirement in other studies. The high percentage of Hispanic youth in our population may have also influenced the increased prevalence of insulin resistance, because a genetic predisposition to diabetes has been reported in some Hispanic populations (3).

Our data suggest that, despite lower percent body fat, male youth had higher blood glucose levels at fasting and after a glucose load than did female youth. Female youth reported poorer food choices and lower intake of calcium, similar to other studies (21), suggesting that they engage in less healthy eating behaviors than male youth. It is important to note, however, that underreporting of total kilocalories consumed is common, particularly among overweight adolescent girls (22). In addition, female youth reported engaging in less physical activity than male youth, in line with studies showing a sex difference in physical activity within ethnic groups and across ages

(10). Specifically, a precipitous decline in activity levels has been reported in girls between ages 9 and 19 (23). Because inactivity is related to overweight, programs to improve girls' knowledge and attitudes about the benefits of activity and finding sex-acceptable ways to increase high-intensity activity among girls should be priorities.

In our sample, Hispanic youth had poorer lipid profiles than African American youth, including higher triglyceride and lower HDL cholesterol levels. This finding is similar to a recent study, in which Hispanic youth had twice the prevalence of metabolic syndrome than non-Hispanic white youth, with significantly higher levels of triglycerides and lower HDL cholesterol (24). It is possible that the difference in lipid profile is related to diet; Hispanic youth in our study reported a higher fat intake than African American youth, and it has been shown that Hispanic youth with greater Anglo acculturation have diets higher in fat (11). In addition, Hispanic youth reported lower diet self-efficacy and less physical activity than African American youth.

Few studies have examined activity levels in overweight minority groups, but

there is evidence that Hispanic and African American girls have the lowest levels of moderate to vigorous activity compared with those of other racial/ethnic groups (10). Higher dietary fat intake and lower levels of physical activity reported by the Hispanic youth in our sample suggest that they have poorer health behaviors related to weight and cardiovascular health than African American youth. Further research is needed to determine the effects of acculturation on nutrition, activity, and behavioral and metabolic parameters in high-risk youth.

This study has important limitations. Nutrition, activity, and health behavior measures were based on self-report and may be subject to socially desirable responses. The sample was self-selected to participate in an intervention trial and was obtained from a population with a high prevalence of overweight (3). Therefore, relationships among metabolic parameters and health behaviors may not generalize to other populations. In addition, despite reminders, it is possible that some participants were not fasting for blood draws, resulting in higher rates of prediabetes and HOMA-IR. Last, we did not measure acculturation, which may

Table 4—Nutrient intake: total and by ethnicity and sex

Measure	Total	Hispanic	African American	P value	Male	Female	P value
n	173	84	89		80	93	
Energy (kcal)	1,827.3 ± 569.5	1,858.6 ± 531.4	1,791.7 ± 611.5	0.46	1,859.6 ± 453.6	1,799.7 ± 654.0	0.50
Fat (g)	65.3 ± 26.0	69.6 ± 25.5	60.4 ± 25.8	0.02	66.1 ± 20.8	64.7 ± 29.8	0.73
Monounsaturated fat (g)	20.5 ± 8.9	22.0 ± 8.9	18.7 ± 8.5	0.02	21.3 ± 7.1	19.8 ± 10.1	0.28
Polyunsaturated fat (g)	11.0 ± 5.9	12.1 ± 6.3	9.7 ± 5.0	0.006	10.7 ± 4.2	11.2 ± 7.0	0.50
Potassium (mg)	1,922.2 ± 648.9	1,914.3 ± 619.6	1,931.2 ± 684.7	0.84	2,071.7 ± 591.3	1,794.0 ± 671.5	0.005
Calcium (mg)	679.5 ± 299.6	655.5 ± 285.0	707.0 ± 314.9	0.24	754.5 ± 321.2	615.3 ± 265.1	0.002
Phosphorus (mg)	976.1 ± 318.9	960.3 ± 307.9	994.1 ± 332.1	0.46	1,058.8 ± 297.2	905.3 ± 321.4	0.002
Magnesium (mg)	174.1 ± 61.6	169.4 ± 58.4	179.5 ± 65.1	0.27	186.6 ± 56.3	163.4 ± 64.3	0.01

Data are means ± SD.

help to explain some results for the Hispanic youth.

Despite these limitations, our findings suggest the need to develop strategies to identify insulin resistance, such as periodic screening with an OGTT, in high-risk youth, especially Hispanic and female youth. Few affordable and accessible child-focused programs are available or have proven to be very successful. Researchers and practitioners, therefore, have the responsibility to develop interventions to prevent and treat overweight, insulin resistance, prediabetes, type 2 diabetes, and their consequences in this population. It is not yet clear whether family involvement is necessary for reducing adolescent obesity, but previous studies have shown that in younger children, promoting family reinforcement of healthy behaviors and increasing physical activities that are attractive to specific ethnic and sex groups is important (25).

Acknowledgments—This work was supported by the National Institutes of Health (NIH) (grant 1R01-NR-008244) and in part by the NIH National Center for Research Resources/Clinical and Translational Science Awards Program (grant 1UL1-RR-024139-01 awarded to Yale University School of Medicine).

No potential conflicts of interest relevant to this article were reported.

M.G.H. researched data and wrote the manuscript. S.S.J. wrote the manuscript. J.A.W. researched data and conducted data analyses. V.L.J. researched data and contributed to the introduction. M.G. designed the study, contributed to discussion, and reviewed/edited the manuscript.

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