One-Hour Glucose During an Oral Glucose Challenge Prospectively Predicts β-Cell Deterioration and Prediabetes in Obese Hispanic Youth

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OBJECTIVE—In adults, 1-h glucose during an oral glucose tolerance test (OGTT) predicts the development of type 2 diabetes independent of fasting and 2-h glucose concentrations. The purpose of the current investigation was to examine the utility of elevated 1-h glucose levels to prospectively predict deterioration in β-cell function and the development of prediabetes in high-risk youth.

RESEARCH DESIGN AND METHODS—Obese Latino youth with a family history of type 2 diabetes (133 male and 100 female; age 11.1 ± 1.7 years) completed a baseline OGTT and were divided into two groups based upon a 1-h glucose threshold of 155 mg/dL (<155 mg/dL, $n = 151$, or ≥155 mg/dL, $n = 82$). Youth were followed annually for up to 8 years for assessment of glucose tolerance, body composition by dual-energy X-ray absorptiometry, and insulin sensitivity, insulin secretion, and the disposition index by the frequently sampled intravenous glucose tolerance test.

RESULTS—Over time, the ≥155 mg/dL group exhibited a significantly greater decline in β-cell function compared with youth with a 1-h glucose <155 mg/dL ($\beta = -327.8 \pm 126.2$, $P = 0.01$). Moreover, this decline was independent of fasting or 2-h glucose and body composition. When the data were restricted to only participants with normal glucose tolerance at baseline, a 1-h glucose ≥155 mg/dL was independently associated with a 2.5 times greater likelihood of developing prediabetes during follow-up (95% CI 1.6–4.1, $P = 0.0001$).

CONCLUSIONS—These data suggest that a 1-h glucose ≥155 mg/dL during an OGTT is an independent predictor of β-cell deterioration and progression to prediabetes among obese Latino youth.

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Once thought to be an adult disease, type 2 diabetes has emerged as an increasingly prevalent health condition in younger populations (1). Estimates from the SEARCH for Diabetes in Youth Study suggest that the incidence rates of type 2 diabetes among adolescents are as high as 17.0–49.4/100,000 person-years and, among certain ethnic minority groups, may exceed rates of type 1 diabetes (2,3). Cohort studies of high-risk obese youth portray a more troubling picture where as many as 30% of these youth exhibit impairments in glucose regulation (4,5). These data support the potential for a rapid progression to overt type 2 diabetes in youth, which may be exacerbated by pubertal insulin resistance (6,7). As such, identification of youth at highest risk for premature type 2 diabetes is critical in order to initiate appropriate prevention strategies.

In 1997, the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus introduced the term prediabetes to mean either impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) to indicate intermediate stages in the natural history of type 2 diabetes (8). However, prospective epidemiological studies in adults demonstrate the limitations of IFG and IGT in predicting risk, as only one-half of patients with prediabetes eventually convert to diabetes (9,10). These data are supported by pediatric studies where children and adolescents often vacillate between normal glucose tolerance (NGT) and prediabetes (11,12). Therefore, in addition to prediabetes, other markers may be necessary to accurately identify those at highest risk for developing type 2 diabetes.

Recently, 1-h plasma glucose concentration during an oral glucose tolerance test (OGTT) has been shown to be an independent predictor of type 2 diabetes in adults. In a series of analyses, Abdul-Ghani et al. (13–15) found that a 1-h glucose concentration of ≥155 mg/dL predicts the development of type 2 diabetes in two independent cohorts. Moreover, these studies found that 1-h glucose of 155 mg/dL was a better predictor of type 2 diabetes than either fasting or 2-h glucose concentrations yielding the maximal sum of sensitivity (0.75) and specificity (0.79). A recent cross-sectional study (16) of overweight/obese youth found that those with 1-h glucose ≥155 mg/dL were more likely to exhibit IGT; however, independent of glucose tolerance status, those with 1-h glucose ≥155 mg/dL exhibited lower insulin secretion relative to insulin sensitivity (i.e., disposition index [DI]) compared with those with 1-h glucose <155 mg/dL. Unfortunately, the cross-sectional nature of that study limits the ability to draw predictive conclusions about the utility of this threshold over time. Given that conversion

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from prediabetes to overt type 2 diabetes in youth may occur rapidly (11), the identification of sensitive and specific markers for type 2 diabetes is an important question that remains unanswered.

Therefore, the purpose of this study is to examine whether a 1-h glucose concentration ≥155 mg/dL can prospectively predict change in type 2 diabetes risk among high-risk youth. We tested the hypotheses that *1*) obese youth with 1-h glucose concentration ≥155 mg/dL exhibit a deterioration of β-cell function over time and *2*) NGT obese youth with 1-h glucose concentration ≥155 mg/dL have a greater likelihood of developing prediabetes over time.

RESEARCH DESIGN AND METHODS

—Data from 233 obese Latino children (133 male and 100 female; 11.1 ± 1.7 years old at initial visit) who participated in the Study of Latino Adolescents at Risk (SOLAR) diabetes project at the University of Southern California (USC) were used in the present analysis. The SOLAR project is an ongoing longitudinal study in which participants are followed annually for determination of the natural history of type 2 diabetes in high-risk youth. To date, 201 participants had at least one follow-up visit, with some being followed for up to 8 years. Details of the study have previously been published (5). Briefly, children were required to meet the following study entry inclusion criteria: *1*) age 8–13 years, *2*) BMI ≥85th percentile for age and sex, *3*) Latino ancestry (all four grandparents reporting to be Hispanic), and *4*) a family history of type 2 diabetes (at least one parent, sibling, or grandparent). Participants were excluded if they were already diagnosed with type 1 or type 2 diabetes or if they were taking medications known to affect body composition or glucose homeostasis. Written informed consent and assent were obtained from parents and children, respectively. The institutional review board of the USC approved this study.

Outpatient visit

Children arrived at the USC General Clinical Research Center (GCRC) at ~8:00 A.M. after an overnight fast. Weight and height were measured to determine BMI and BMI percentiles, waist circumference was assessed, and a physical examination including Tanner staging based on breast development in girls (17) and pubic hair in boys (18) was performed. A fasting sample was collected for determination of lipid profile (HDL, LDL, and VLDL, triglyceride, and total cholesterol), and a 2-h OGTT using a dose of 1.75 g glucose/kg body wt to a maximum of 75 g was performed. Blood samples were obtained at 0, 30, 60, and 120 min for determination of plasma glucose and insulin concentrations. Glucose tolerance was determined according to the American Diabetes Association (8) as NGT (fasting glucose <100 mg/dL and 2-h glucose <140 mg/dL), IFG (fasting glucose between 100 and 125 mg/dL), and IGT (2-h glucose ≥140 mg/dL).

Inpatient visit

Children were admitted to the GCRC for an overnight stay for determination of total body composition by dual-energy X-ray absorptiometry, body fat distribution by magnetic resonance imaging, and insulin sensitivity (SI) using an insulin-modified frequently sampled intravenous glucose tolerance test (FSIVGTT). Fasting samples were collected at −15 and −5 min prior to administration of glucose (25% dextrose, 0.3 g/kg body wt) at time 0. Subsequent blood samples were collected at time points 2, 4, 8, 19, 22, 30, 40, 50, 70, 100, and 180 min. Insulin (0.02 units/kg body wt, Humulin R [regular insulin for human injection]; Eli Lilly, Indianapolis, IN) was intravenously injected at 20 min. Values for glucose (glucose oxidase method Yellow Springs Instrument 2700 Analyzer; YSI, Yellow Springs, OH) and insulin (ELISA; Linco, St. Charles, MO) were entered into the MINMOD Millennium 2002 computer program (version 5.16) for determination of SI, insulin secretion using the acute insulin response (AIR), and DI as the product of SI and AIR (19).

Statistical analysis

Participants were divided into two groups based upon 1-h glucose concentrations at their initial baseline visit (n = 233, <155 or ≥155 mg/dL). Independent-sample t tests were used to compare anthropometry and body composition at baseline between the two groups (<155 group vs. ≥155 group). Baseline analysis included comparisons between groups for proportions of sex, Tanner stage, and prediabetes status using χ^2 tests and by ANCOVA for SI, AIR, and DI adjusting for age, sex, Tanner stage, body composition, and fasting and 2-h glucose from the OGTT. Data that did not meet the assumptions for normality were $\log_{10}$ transformed; untransformed data are presented for ease of interpretation.

For longitudinal data analyses (n = 201), a hierarchical linear mixed model with a fixed-effects and a random-effects approach (20,21) was used to *1*) evaluate the impact of 1-h glucose ≥155 mg/dL at baseline on changes in DI over time and *2*) estimate the main effects of group assignment (<155 vs. ≥155 group) after controlling for age, sex, Tanner stage, body composition, fasting and 2-h glucose, and baseline DI on changes in DI over time. The grouping variable (<155 vs. ≥155 group) was modeled as a fixed predictor with adjustments made for the variation between individuals in the number of follow-up visits (i.e., random effects). In this model, "visit number" equals "follow-up years." β-Coefficients generated represent the unit changes of DI over time.

Generalized estimating equation model analysis (22) was used to predict the likelihood of developing prediabetes by group (<155 vs. ≥155 group) in only participants who were NGT at baseline (n = 125). Sequential models were developed to adjust for potential confounding effects of age, sex, Tanner stage, body composition, and fasting and 2-h glucose. All data were analyzed using SPSS 20.0 with significance level set at $P \leq 0.05$.

RESULTS

Cross-sectional analysis

Descriptive characteristics of the 233 participants at baseline were compared between those above or below 1-h glucose of 155 mg/dL (Table 1). No differences in age, weight status (overweight vs. obese), or Tanner stage were noted. There was a significantly higher proportion of males in the <155 group compared with the ≥155 group (P = 0.007). Furthermore, prediabetes (IFG or IGT) was more commonly observed among those in the ≥155 group compared with those in the <155 group (P = 0.0002). Additionally, anthropometrics, lipids, and body composition and distribution measures were not different between groups.

Measures of glucose homeostasis and insulin dynamics from the baseline OGTT and FSIVGTT are presented in Table 1. Participants in the <155 group exhibited a healthier metabolic profile, as indicated by significantly lower HbA_{1c}, 2-h glucose, 2-h insulin, area under the curve (AUC) for glucose and insulin, and higher DI compared with those in the ≥155 group. These differences persisted after adjustment for age, sex, Tanner stage, and body composition.

Longitudinal analysis

A total of 201 participants had follow-up data and were included in the longitudinal linear mixed-model analysis. Participants were followed for up to 8 years (4.7 ± 2.7 years), accounting for a total of 1,145 observations. Those with 1-h glucose ≥155 mg/dL at baseline exhibited a significantly lower β-coefficient for DI, indicating greater deterioration of β-cell function over time (model 1 [Table 2]). These findings persisted after age, sex, Tanner stage, body composition, and fasting and 2-h glucose were controlled for (models 2–4 [Table 2]). The pattern of change for the ≥155 group was characterized by a steady decline in DI resulting in a 54.8% decrease by year 8. In contrast, the <155 group was characterized by an initial decrease followed by a subsequent increase in DI, which resulted in a 28.6% higher DI than that at baseline (Fig. 1).

Hierarchical generalized estimating equations were used to examine the odds of developing prediabetes (IFG or IGT) by group among participants with NGT at baseline (n = 125; 747 total observations). NGT participants with 1-h glucose concentrations ≥155 mg/dL at baseline were 2.54 times more likely to develop prediabetes over time (model 1 [Table 3]). These findings persisted after controlling for age, sex, Tanner stage, body composition, and fasting and 2-h glucose concentrations (models 2–4 [Table 3]). Fifty-eight percent of those in the <155 group maintained NGT status throughout follow-up compared with only 28% of those in the ≥155 group (P = 0.004).

Table 1—*Characteristics of participants by 1-h glucose at study entry*

	<155 mg/dL group	≥155 mg/dL group	*P*
n	151	82	
Sex (male/female)	96 (64) / 55 (36)	37 (45) / 45 (55)	0.007
Tanner stage			0.59
1	63 (42)	33 (40)	
2	45 (30)	20 (25)	
3	14 (9)	7 (9)	
4	18 (12)	11 (13)	
5	11 (7)	11 (13)	
Overweight/obese	27 (18) / 124 (82)	12 (15) / 70 (85)	0.53
NGT/prediabetes (IFG or IGT)	115 (76) / 36 (24)	42 (52) / 39 (48)	0.0002
Age (years)	11.1 ± 1.6	11.1 ± 1.8	1.00
BMI (kg/m^2)	28.9 ± 5.8	28.3 ± 4.8	0.52
BMI percentile (%)	97.1 ± 3.3	97.2 ± 2.9	0.82
Waist (cm)	89.7 ± 13.9	87.1 ± 12.2	0.19
SBP (mmHg)	109.4 ± 13.0	111.7 ± 11.7	0.18
DBP (mmHg)	62.5 ± 6.9	64.4 ± 6.2	0.04
SAAT (cm^2)	345.9 ± 157.4	333.1 ± 124.4	0.82
IAAT (cm^2)	49.8 ± 23.6	47.3 ± 17.6	0.56
Lean tissue mass (kg)	38.0 ± 10.3	35.8 ± 9.7	0.11
Fat mass (kg)	26.1 ± 11.0	24.1 ± 9.0	0.25
TAG (mg/dL)	110.3 ± 56.6	107.5 ± 61.3	0.57
HDL (mg/dL)	36.8 ± 8.8	38.3 ± 8.0	0.13
LDL (mg/dL)	94.6 ± 21.9	93.4 ± 20.7	0.72
VLDL (mg/dL)	22.2 ± 11.3	21.5 ± 12.3	0.53
Total cholesterol (mg/dL)	153.5 ± 26.0	153.3 ± 26.0	0.96
HbA_{1c} (%)	5.5 ± 0.3	5.6 ± 0.3	0.05
Fasting glucose (mg/dL)	89.3 ± 6.2	89.1 ± 6.4	0.85
1-h glucose (mg/dL)	130 ± 15.9	171.5 ± 15.6	<0.0001
2-h glucose (mg/dL)	118.7 ± 15	132.8 ± 17.3	<0.0001
Glucose AUC (mg · dL^{-1} · h^{-1})	14,948.3 ± 12,66.1	17,723.6 ± 1,385.4	<0.0001
Fasting insulin (μU/mL)	17.2 ± 10.2	15.7 ± 9.4	0.34
1-h insulin (μU/mL)	161.4 ± 124.1	232.7 ± 149.6	0.02
2-h insulin (μU/mL)	144.7 ± 129.4	186.7 ± 132.8	0.003
Insulin AUC (μU · mL^{-1} · h^{-1})	17,992.3 ± 11,574.2	22,248.8 ± 13,173.7	0.003
SI ($\times 10^{-4}$ min^{-1} · μU · mL^{-1})	2.1 ± 1.5	2.1 ± 1.3	0.64
AIR (μU/mL)	1,848.2 ± 1,246.4	1,572.9 ± 1,292.7	0.03
DI ($\times 10^{-4}$ min^{-1})	2,708.4 ± 1,162.4	2,321 ± 1,034	0.006

Data are means ± SD, *n* (%), or *n* (%) / *n* (%) unless otherwise indicated. DBP, diastolic blood pressure; IAAT, intraabdominal adipose tissue; SAAT, subcutaneous abdominal adipose tissue; SBP, systolic blood pressure; TAG, triglycerides.

CONCLUSIONS—In the current study, we demonstrate that a 1-h glucose concentration during an OGTT differentiates diabetes risks and prospectively predicts deterioration in β-cell function and progression to prediabetes among obese Latino youth. These data extend previous cross-sectional studies in youth and support the potential prospective utility of 1-h glucose concentrations during an OGTT to identify youth at highest risk for developing type 2 diabetes. Furthermore, these findings are independent of traditional risk factors for type 2 diabetes.

Longitudinal epidemiological studies in adults (13–15) have established a cutoff value (155 mg/dL) for 1-h plasma glucose concentration during an OGTT as a strong, independent predictor of type 2 diabetes. Abdul-Ghani et al. (15) reported that the rate of conversion to diabetes over 8 years was significantly greater in NGT participants with 1-h glucose concentrations ≥155 mg/dL compared with individuals whose 1-h glucose concentration did not exceed 155 mg/dL (8.5 vs. 1.3%). Furthermore, the predictive ability of 1-h glucose concentrations was significantly stronger than either fasting or 2-h glucose levels. The authors suggested that, while individuals with NGT are typically considered at low risk for the development of type 2 diabetes, a subgroup of those reaching a 1-h threshold of 155 mg/dL during an OGTT may be at increased risk for future type 2 diabetes. Although the specific threshold identified by Abdul-Ghani et al. has been confirmed in two separate cohorts, others have identified alternative 1-h glucose thresholds that may confer increase risk for type 2 diabetes. In a cross-sectional analysis, Manco et al. (23) identified 161 mg/dL as a 1-h threshold for differentiating type 2 diabetes risk factors including IGT, insulin resistance, and β-cell dysfunction among European adults.

Only two cross-sectional studies in the pediatric population have tested the utility of 1-h glucose concentration during an OGTT to identify diabetes risk (16,24). Tfayli et al. (16) examined a biracial group

Table 2—*Linear mixed models of DI over time by 1-h glucose at baseline*

Dependent variables and effects	β ± SE	*P*
Model 1, DI (adjusted)		
Intercept	2,078.5 ± 111.3	<0.0001
1-h glucose (<155)	341.5 ± 137.9	0.01
Model 2, DI (adjusted)		
Intercept	3,563.3 ± 370.2	<0.0001
1-h glucose (<155)	279.5 ± 130.0	0.03
Age	−53.4 ± 27.6	0.05
Sex	−201.8 ± 133.6	0.13
Tanner stage	−146.2 ± 47.8	0.002
Model 3, DI (adjusted)		
Intercept	3,957.2 ± 395.6	<0.0001
1-h glucose (<155)	338.8 ± 126.6	0.008
Age	24.9 ± 31.2	0.43
Sex	−334.6 ± 155.7	0.03
Tanner stage	−85.2 ± 57.6	0.14
Lean tissue mass (kg)	−0.022 ± 0.008	0.008
Fat mass (kg)	−0.018 ± 0.006	0.009
Model 4, DI (adjusted)		
Intercept	5,672.7 ± 747.2	<0.0001
1-h glucose (<155)	327.8 ± 126.2	0.01
Age	19.8 ± 31.2	0.53
Sex	−373.7 ± 155.8	0.02
Tanner stage	−83.8 ± 57.9	0.15
Lean tissue mass (kg)	−0.022 ± 0.008	0.007
Fat mass (kg)	−0.014 ± 0.006	0.03
Fasting glucose (mg/dL)	−14.5 ± 6.9	0.04
2-h glucose (mg/dL)	−2.9 ± 2.2	0.19

(African American and Caucasian) of overweight and obese youth and found that, independent of adiposity and glucose tolerance status, children with 1-h glucose concentration ≥155 mg/dL exhibited ~41% lower DI compared with those with a 1-h glucose value below this threshold. A second cross-sectional study in youth by Manco et al. (24) used receiver operating characteristic analysis to try to establish and validate the best 1-h glucose threshold for identifying diabetes risk. The authors reported that a cutoff value of ≥132.5 mg/dL identified IGT with 80.8% sensitivity and 74.3% specificity. Both of the aforementioned pediatric studies used cross-sectional designs, which have inherent limitations that are exacerbated by growth-related changes in children and adolescents. The present findings extend these previous studies to show that a 1-h glucose concentration of ≥155 mg/dL does indeed predict diabetes risk over time and that the predictive ability is independent of other known risk factors. Of interest, when we modeled 1-h glucose based on the threshold identified by Manco et al. (132.5 mg/dL), we observed a significant association with changes in DI that was similar in magnitude to the effect for the 155 threshold (β = −329.1, *P* = 0.02). However, this threshold was not associated with increased odds of developing prediabetes in our cohort (odds ratio 1.5, *P* = 0.19). It is plausible that population variation in terms of age, sex, or race/ethnicity may impact the predictive utility of various thresholds, as these factors have been shown to affect diabetes risk in youth (6,25,26).

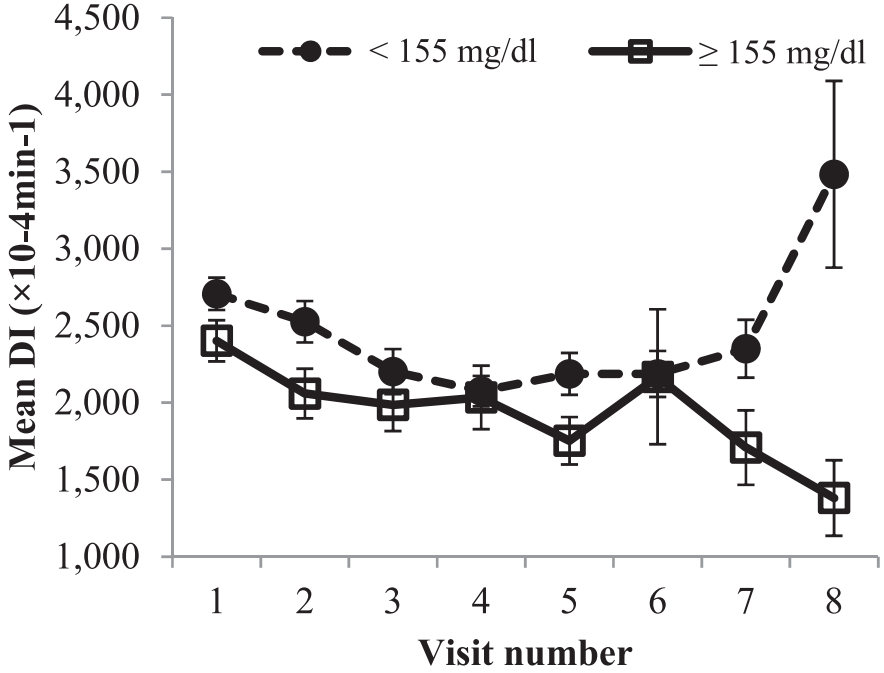

Figure 1—*Changes in DI over time in the <155 mg/dL and ≥155 mg/dL groups.*

Little is known about the natural history of type 2 diabetes in youth. Most studies to date examining the pathophysiology of type 2 diabetes in youth have been cross-sectional in nature. Similar to findings in adult studies (27,28), β-cell dysfunction is thought to be a key feature in the development of type 2 diabetes (7,29). Using cross-sectional data from this cohort, we previously observed that both IFG and IGT were associated with impaired β-cell function (5,30). Furthermore, recent studies suggest that obese youth with glucose levels toward the upper limit of the normal range (i.e., fasting glucose between 90 and 100 mg/dL and 2-h glucose between 120 and 140 mg/dL) exhibited lower β-cell function compared with youth whose fasting and 2-h glucose concentrations are <90 mg/dL and 120 mg/dL, respectively (31,32). These findings have been confirmed longitudinally (33), where obese NGT youth with 2-h glucose concentrations between 120 and 139 mg/dL exhibited a significantly greater likelihood of developing IGT than obese NGT youth with 2-h glucose levels between 100 and 119 mg/dL (42 vs. 21%, respectively). Collectively, these reports support impaired β-cell function as an important pathophysiologic process

Table 3—*Multivariable-adjusted odds ratios (95% CI) for developing prediabetes for NGT at baseline*

	Odds ratio (95% CI)	*P*
Model 1		
<155	1	
≥155	2.5 (1.6–4.1)	0.0001
Model 2[a]		
<155	1	
≥155	2.6 (1.6–4.2)	0.0001
Model 3[b]		
<155	1	
≥155	3.1 (1.9–4.9)	<0.0001
Model 4[c]		
<155	1	
≥155	2.4 (1.4–4.2)	0.0015

[a]Model 2 adjusted for age, sex, and Tanner stage. [b]Model 3 adjusted for age, sex, Tanner stage, lean tissue mass, and fat mass. [c]Model 4 adjusted for age, sex, Tanner stage, lean tissue mass, fat mass, fasting glucose, and 2-h glucose.

underlying prediabetes and overt diabetes in youth. The current results build upon these previous findings to indicate that independent of fasting or 2-h glucose levels, a higher 1-h glucose concentration is associated with β-cell dysfunction and the development of prediabetes.

Although it remains unclear whether the primary defect underlying type 2 diabetes in youth is related to insulin action or secretion, using β-cell function may offer the most robust risk measure. Recent studies in adults suggest that early defects in insulin secretion play a pivotal role in the pathophysiology of type 2 diabetes (34). A large prospective study reported that the impairment of first-phase insulin secretion (measured by the insulinogenic index during an OGTT) is a common characteristic of both IFG and IGT. Similarly, recent studies in youth (11,35) suggest that obese adolescents with prediabetes (IFG or IGT) exhibit primary defects in insulin secretion (commonly in first-phase insulin secretion) rather than insulin resistance. However, these studies focused exclusively on obese adolescents who presumably already had some degree of insulin resistance. It is possible that higher 1-h glucose reflects impairments in the first-phase insulin secretion and that elevation in 2-h glucose reflects second- or late-phase insulin secretion. Our cross-sectional results suggest that differences in DI between the ≥155 group and the <155 group were the result of insulin secretion rather than SI, as the latter was not different between groups. If we model our longitudinal data with either SI or insulin secretion as the dependent variable, secretion rather than sensitivity appears to be the differentiating factor between groups over time. Independent of the mechanism, our data suggest that 1-h glucose concentrations of at least 155 mg/dL during an OGTT may identify children at high risk for developing type 2 diabetes and who could benefit from focused and intensive prevention efforts. Moreover, the predictive ability of 1-h glucose was independent of fasting markers of diabetes risk including IFG or an HbA_{1c} ≥5.7%. Given that pediatricians often have to make clinical decisions about patients based upon a single visit, including a 1-h glucose measure during a standard 2-h OGTT may help identify those in need of more aggressive or closer follow-up.

To our knowledge, this was the first longitudinal study in youth to examine the threshold of 1-h glucose concentration (155 mg/dL) in relation to changes in type 2 diabetes risk and development of prediabetes over time. We focused on a high-risk cohort, assessed diabetes risk using robust measures of insulin sensitivity and secretion from the FSIVGTT to estimate β-cell function, controlled for the potential confounding effects of maturation and body composition, and used powerful statistical modeling techniques to account for the variance component across time. Despite these strengths, we acknowledge potential limitations that should be considered. First, we analyzed the data based on a single OGTT at baseline. Libman et al. (36) demonstrated poor reproducibility of the OGTT in overweight youth, with 2-h glucose being less reproducible than fasting glucose. It would be worthwhile to examine whether the reproducibility of 1-h glucose more closely resembles that of fasting or 2-h measures and whether repeated measures of 1-h glucose ≥155 mg/dL are more consistently associated with diabetes risk than is repeated IFG or IGT status. Second, given the longitudinal nature of the study, not all participants were available for every year of testing, so controlling for missing data by linear mixed modeling was necessary. Third, owing to the low conversion rate to overt type 2 diabetes (only three participants developed diabetes), we opted to focus on changes in diabetes risk factors (β-cell dysfunction and prediabetes). Future studies will need to recruit much larger cohorts followed over longer periods to definitively test the utility of 1-h glucose concentrations to predict the development of overt diabetes in youth. Lastly, we applied a single cutoff point of 1-h glucose based upon adult studies to prospectively identify changes in diabetes risk factors. Future studies should use receiver operating characteristic analysis to identify the maximum sensitivity and specificity of a 1-h glucose concentration to predict the development of type 2 diabetes across representative pediatric populations. These studies will not only allow for optimization of the best 1-h glucose threshold but may also be used to compare the predictive power of this risk marker with other established diabetes risk factors such as fasting and postchallenge glucose concentrations as well as HbA_{1c}.

In summary, a glucose concentration ≥155 mg/dL at 1 h during an OGTT may be an early independent marker of future type 2 diabetes risk as measured by deterioration in β-cell function and progression to prediabetes in overweight and obese Latino youth with a family history of type 2 diabetes.

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J.Y.K. analyzed data and wrote the manuscript. M.I.G., C.M.T.-C., and M.J.W. researched data and reviewed and edited the manuscript. M.C. analyzed data and reviewed and edited the manuscript. G.Q.S. researched data, reviewed and edited the manuscript, and assisted in writing the manuscript. G.Q.S. is the guarantor of this work and, as such, had full access to all the data in the study and takes

responsibility for the integrity of the data and the accuracy of the data analysis.

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