Association of Younger Age With Poor Glycemic Control and Obesity in Urban African Americans With Type 2 Diabetes

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Background: Type 2 diabetes mellitus is highly prevalent in minority populations in the United States. We studied the relationship of age to glycemic control in a predominantly urban African American population with type 2 diabetes.

Methods: We selected all patients with type 2 diabetes who were enrolled in the Grady Diabetes Clinic, Atlanta, Ga, between April 1, 1991, and December 31, 1998, and had a hemoglobin A1c (HbA1c) level measured at their initial visit and at follow-up 5 to 12 months later (n=2539). Patients were divided into 4 age categories: less than 30 years, 30 to 49 years, 50 to 69 years, and more than 69 years old. We also studied the relationship of age to HbA1c level in a primary care clinic.

Results: At baseline, average HbA1c levels were 9.9%, 9.5%, 9.2%, and 8.8% in the 4 groups ranked in increasing age, respectively (P<.001), and body mass indexes (calculated as weight in kilograms divided by the square of height in meters) were 37.8, 33.9, 31.6, and 29.2, respectively (P<.001). On follow-up, HbA1c level improved in all groups (P<.001), but there was still a trend for younger patients to have higher levels of HbA1c. There was little change in body mass index with time. Younger age, longer diabetes duration, higher body mass index, less frequent interval visits, and treatment with oral agents or insulin were associated with a higher HbA1c level at follow-up. Our findings in a primary care clinic showed also that HbA1c level and body mass index were negatively correlated with age (P<.001).

Conclusion: Our data show a high prevalence of obesity and poor glycemic control in young adult urban African Americans with diabetes.

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The increasing prevalence of type 2 diabetes mellitus is reaching epidemic proportions. According to the National Health and Nutrition Examination Survey (NHANES),1 the prevalence of diabetes mellitus in the US population 40 to 74 years of age increased from 8.9% in 1976 to 1980 (NHANES II) to 12.3% in 1988 to 1994 (NHANES III). It is estimated that 14 million Americans had diabetes in 1995, and this number is expected to increase to 22 million in the year 2025.2 Diabetes is a significant health problem in African Americans and Mexican Americans, for whom prevalence rates are 1.6 and 1.9 times the rate for whites.3 It is widely believed that the increase in obesity4,5 and sedentary lifestyles6 in the US population are largely to blame for this growing problem.5

Although type 2 diabetes mellitus has been considered historically a disease of middle aged and older individuals, recent surveys show that its prevalence has been increasing in younger patients. A study done at a midwestern metropolitan area medical center showed that the incidence of type 2 diabetes increased 10-fold in their adolescent population between 1982 and 1994.7 Another survey of native Americans and Alaska Natives showed a similar 18% increase in prevalence of diagnosed diabetes in individuals younger than 20 years.8 Reports from Canada, Japan, and Libya also show an increasing prevalence of type 2 diabetes in young individuals.9-11 Since diabetes complications are related to the severity of hyperglycemia and to the duration of the disease,12-14 young adult individuals who start their hyperglycemic exposure at an early age would be at high risk for end-organ damage. A number of studies have reported on the relationship of age to glycemic control in patients with type 2 diabetes, but they have focused largely on middle-aged and elderly patients. The conclusions of these studies have been mixed, showing a high prevalence of poor con-
control in the elderly,\textsuperscript{13} better glycemic control in older patients,\textsuperscript{16} or no effect of age on metabolic control.\textsuperscript{17}

Since there has been little comparison of the glycemic control of young adult vs elderly patients, we performed a retrospective study of 2539 patients with type 2 diabetes who presented to the Grady Diabetes Clinic, Atlanta, Ga, between 1991 and 1998. We examined the contribution of age to glucose control at the initial visit and after an average of 8 months of care. Since referral bias could be a confounding factor for patients seen in a diabetes clinic, we also investigated the relationship of age to hemoglobin A\textsubscript{1c} (HbA\textsubscript{1c}) levels in patients with diabetes treated in a neighborhood primary care clinic. We chose HbA\textsubscript{1c} level as our outcome variable because of epidemiologic\textsuperscript{12,18} and prospective\textsuperscript{13,14,19} studies that showed a significant and continuous association between HbA\textsubscript{1c} level and diabetes-related vascular complications.

METHODS

DIABETES CLINIC STUDY

The largest number of patients was available at the Grady Diabetes Clinic in Atlanta. This outpatient facility is based at a municipal hospital and provides comprehensive diabetes care to inner-city residents. Most patients are African American and have type 2 diabetes. Patients are cared for by a team of nurse providers, physicians, dietitians, podiatrists, and a social worker, within the context of a management program that we have described previously.\textsuperscript{20,21}

Briefly, an education program emphasizing lifestyle modifications and self-management skills is offered to all patients at their initial visit and projects 6 to 8 return visits within the first year. In patients without symptomatic hyperglycemia or a history of ketosis, medications are reduced or discontinued to permit intensive dietary and lifestyle interventions, and to allow patients to reduce their caloric intake to lose weight, without an increased risk of hypoglycemia. An adapted American Diabetes Association exchange diet\textsuperscript{22} was taught to patients from 1991 to 1994. After 1994, dietary education was simplified, focusing on a healthy diet low in fat.\textsuperscript{21} If glycemic goals are not met after the first 1 to 2 months, pharmacologic therapy is started or advanced according to a stepped-care protocol for intensification of therapy.

A historical cohort of patients was selected for the study from an on-site diabetes registry according to the following criteria: all patients having type 2 diabetes, with an initial visit between April 1, 1991, and December 31, 1998, and with HbA\textsubscript{1c} levels measured at the time of the intake visit and at follow-up 5 to 12 months later. Patients were classified as having type 2 diabetes on the basis of previously described historical and treatment features, including lack of history of ketoacidosis, lack of absolute requirement for insulin, presence of obesity, and/or strong family history of diabetes.\textsuperscript{20} Patient characteristics available in the registry include date of birth, sex, race, date of diagnosis of diabetes, weight, height, and type of therapy at presentation and at each subsequent visit. Type of therapy was recorded as diet alone, oral agent (one type or combination), or insulin (including use of insulin alone or in combination with oral agents). The time interval and number of interval visits between the intake and the follow-up visit were also recorded for each patient. For patients with more than 1 follow-up visit during the 5- to 12-month period after presentation, the last visit was chosen as the outcome visit. Patients were divided into 4 age groups: less than 30 years, 30 to 49 years, 50 to 69 years, and more than 69 years of age.

RESULTS

DIABETES CLINIC

Patient Characteristics

Of 3084 patients with type 2 diabetes who presented to the Grady Diabetes Clinic between April 1, 1991, and December 31, 1998, 2539 patients met selection criteria of having HbA\textsubscript{1c} levels measured at their initial visit and at follow-up 5 to 12 months later. As shown in Table 1, the patients were 90% African American, 66% female, and had an average age of 55 years, diabetes duration of 5.2 years, HbA\textsubscript{1c} level of 9.2%, and BMI of 32.2 (4 patients did not have a weight recorded at baseline, and 172 patients did not have a weight recorded at follow-up). The high female-male ratio is consistent with prevalence data from NHANES III.\textsuperscript{1} At baseline, 23% of patients were being treated with diet alone, 40% with oral agents, and 37% with insulin alone or in combination with oral agents. The average period between baseline and follow-up HbA\textsubscript{1c} measurements was 8 months, during which patients had on average 4 interval clinic visits.

There was a similar ethnic and sex distribution among all age groups. The majority of patients were in the 30- to 49- and 50- to 69-year age groups. All 4 groups had the same average duration between initial and follow-up outcome visits. Patients younger than 50 years had a significantly shorter duration of known diabetes than patients aged 50 years and older (P < .001). Significant trends were found in BMI in that younger patients were, on average, significantly more obese than older patients (P < .001). Among

NEIGHBORHOOD HEALTH CENTER STUDY

We also analyzed the HbA\textsubscript{1c} data of 597 consecutive established patients with type 2 diabetes who were treated at a neighborhood primary care clinic between February 1, 1999, and October 31, 1999. The clinic is located in the same referral area as the diabetes clinic and is part of the Grady Health System. For purpose of analysis, patients were divided into 4 age groups according to the same cutoffs as in the diabetes clinic.

STATISTICS

Differences in means between groups were tested with analysis of variance. Kruskal-Wallis and Mann-Whitney tests were used to compare means for variables that were not normally distributed. Paired t tests were used to test the difference in mean HbA\textsubscript{1c} and body mass index (BMI; calculated as weight in kilograms divided by the square of height in meters) at baseline and follow-up within groups. Pearson correlation analysis was used to evaluate correlation between 2 variables. Analysis by χ\textsuperscript{2} was used to test differences in distribution of type of therapy between groups. Multiple linear regression analysis was performed to assess the influence of patients’ characteristics on HbA\textsubscript{1c} levels at presentation and at follow-up. Year of presentation (1991-1994 vs 1995-1998) was also included in the regression analysis to account for the impact of any change in patient education and management practices in the clinic during the 1991 to 1998 period. P < .05 was considered significant. SPSS version 9.0 software (SPSS Inc, Chicago, Ill) was used for the analyses. The reference range of HbA\textsubscript{1c} was 3.5% to 6.0%, and obesity was defined as a BMI of 30 or more.\textsuperscript{24}
the 4 groups ranked in increasing age, 77%, 63%, 53%, and 40% were obese, with a BMI of 30 or more (P < .001). The average HbA1c level at baseline was significantly higher in younger patients than older patients; average HbA1c levels were 9.9%, 9.5%, 9.2%, and 8.8%, respectively, in the 4 groups ranked in increasing age (P < .001).

Improvement in HbA1c

On follow-up, HbA1c improved in all age groups (Figure 1). The lack of statistical significance for the improvement in HbA1c in the younger-than-30-years age group is likely due to the small sample size (P = .06). There was a trend for a quantitatively larger decrease in HbA1c level during the follow-up period in older patients as compared with younger patients, although this trend was not statistically significant (P = .62). Absolute HbA1c levels decreased by 0.9%, 1.1%, 1.1%, and 1.3% in the 4 groups ranked in increasing age, respectively. At 8 months, there was still a statistically significant trend for younger patients to have higher HbA1c levels across all age groups (P < .001).

We also analyzed the proportion of patients with HbA1c levels less than 7.0%, considered by the American Diabetes Association to be the goal HbA1c level, as well as the proportion of patients with a level greater than 8.0%, considered by the American Diabetes Association to require action on the part of providers (Figure 2). At baseline, 19% to 23% of patients had an HbA1c level less than 7.0%, increasing to 33% to 41% at 8 months, with no significant difference between groups. However, the prevalence of having an HbA1c level greater than 8.0% at baseline increased from 54% to 75% with decreasing age (P < .001). Even though glycemic control improved in all 4 groups at follow-up, the trend toward a higher prevalence of HbA1c values greater than 8.0% in younger patients persisted. The proportion of patients having an HbA1c level greater than 8.0% at follow-up increased from 31% to 48% with decreasing age (P < .001). There was little change in BMI at follow-up. The BMI increased by 0.3 in the 30- to 49-year and 50- to 69-year age groups (P = .008 and P < .001, respectively) and did not change in the other 2 groups.

Distribution of Therapy at Baseline and Follow-up

At baseline, Figure 3 shows that, with increasing age, the percentage of patients treated with diet alone in-
creased (P = .001), whereas the proportion of patients treated with insulin decreased (P < .001). Even though the overall prevalence of patients treated with diet alone increased at follow-up, there was still a significant trend for more frequent insulin use in younger age (P < .001).

Figure 4 shows the follow-up HbA1c level for patients treated with diet, oral agents, or insulin at 5 to 12 months. There was no significant difference in HbA1c level between groups for patients treated with diet alone. However, HbA1c levels tended to increase with decreasing age for patients treated with oral agents or insulin (P < .001).

Among patients treated with oral agents at follow-up, sulfonylureas alone (glipizide or glyburide) were used in 84% of patients, with an average dose (±SD) of 11.9 ± 7.5 mg, 10.6 ± 6.8 mg, 9.4 ± 6.5 mg, and 9.4 ± 7.6 mg in the 4 groups ranked by increasing age, respectively (no significant difference, P = .26). The remaining 16% of oral agent–treated patients were treated with metformin monotherapy or a sulfonylurea–metformin combination.

We also determined the average dose of insulin used by insulin-treated patients at follow-up. After correction for body weight, there was no significant difference in the amount of insulin used between the 4 groups. The average dose of insulin used was 0.5, 0.4, 0.4, and 0.3 U/kg of body weight for the 4 groups ranked by increasing age, respectively (P = .16).

Multivariate Linear Regression Analysis

Multivariate linear regression analysis was used to determine the contribution of patients’ characteristics to HbA1c level at baseline (Table 2). Younger age, African American ethnicity, lower BMI, and being treated with oral agents or insulin were independently associated with higher HbA1c levels. Multivariate linear regression was used also to determine the contribution of patients’ characteristics to HbA1c levels at follow-up (Table 3). Patients’ sex, ethnicity, and change in BMI had no effect on follow-up HbA1c level. The year of presentation to the clinic was a significant contributor to follow-up HbA1c level, with better follow-up HbA1c level being achieved in later years. Younger age, longer diabetes duration, and

Table 2. Multivariate Linear Regression to Predict HbA1c Level at Presentation

<table>
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<tr>
<th>Variable</th>
<th>Standardized Coefficients</th>
<th>P Value</th>
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<tr>
<td>Ethnicity†</td>
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<td>Year of presentation‡</td>
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<td>Age, y</td>
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<td>BMI at baseline</td>
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<td>Oral agent therapy at presentation§</td>
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<tr>
<td>Insulin therapy at presentation</td>
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</table>

Table 3. Multivariate Linear Regression to Predict HbA1c Level at Follow-up

<table>
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<tr>
<th>Variable</th>
<th>Standardized Coefficients</th>
<th>P Value</th>
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<tbody>
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<tr>
<td>Ethnicity†</td>
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<td>Age, y</td>
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<td>Change in BMI</td>
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<td>Diabetes duration, y</td>
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<td>Baseline HbA1c, %</td>
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<tr>
<td>Oral agent therapy at presentation§</td>
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<td>&lt;.001</td>
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<tr>
<td>Insulin therapy at presentation</td>
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<td>.02</td>
</tr>
<tr>
<td>No. of interval visits</td>
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<tr>
<td>Follow-up duration, mo</td>
<td>0.138</td>
<td>&lt;.001</td>
</tr>
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</table>

Abbreviations: BMI, body mass index; HbA1c, hemoglobin A1c.

*Female is 1, male is 0.
†African American ethnicity is 1, all others are 0.
‡Years of presentation 1995 to 1998 are 1, all others are 0.
§Oral agent therapy is 1, all others are 0.
| Insulin therapy is 1, all others are 0.
higher BMI, less frequent interval visits, longer follow-up duration within the study (closer to 12 months rather than closer to 5 months), and treatment with oral agents or insulin were all associated with a higher HbA1c level at 5 to 12 months.

**NEIGHBORHOOD PRIMARY CARE CLINIC**

Of 597 patients, 5 patients were younger than 30 years, 102 patients were 30 to 49 years old, 346 were 50 to 69 years old, and 144 were older than 69 years. The patients were 96% African American and 79% female, and had average (±SD) age of 62±12 years, diabetes duration of 10±8 years, HbA1c level of 8.5%±2.3%, and BMI of 32.8±8.0. At presentation, 22% of patients were being treated with diet alone, 54% with oral agents alone, and 24% with insulin alone or in combination with oral agents. The average HbA1c levels (±SD) were 9.4%±4.2%, 9.0%±2.3%, 8.7%±2.2%, and 7.5%±1.9%, and average BMI (±SD) was 37.6±6.7, 34.7±8.3, 33.1±8.3, and 30.6±6.5 in the 4 age groups ranked by increasing age, respectively (P<.001 and P=.004 for HbA1c and BMI, respectively). There was a significant negative correlation between age and HbA1c (r = -0.25, P<.001) and between age and BMI (r = -0.23, P<.001). Using multivariate linear regression analysis, we found that the inverse relationship between age and HbA1c remained significant even after correcting for BMI (P<.001).

**COMMENT**

Our study shows that, in a predominantly African American patient population coming to a municipal hospital diabetes clinic, younger patients have worse glycemic control at referral and are more obese than older patients. On follow-up, younger patients also show relatively less improvement in glycemic control, despite a high prevalence of insulin use in this age group. Despite the provision of intensive dietary education, there was no clinically significant change in BMI in all age groups. The main determinants for improvement in HbA1c levels were older age, shorter diabetes duration, lower BMI, and more frequent visits to the diabetes clinic. Even in the primary care clinic, younger patients tended to be more obese and more hyperglycemia, making it unlikely that our diabetes clinic findings were due to a referral bias, ie, younger patients with poor control being referred preferentially to a specialty clinic.

It is not clear why younger patients have worse glycemic control than older patients. Older patients may have better access to medical care, or may be more motivated in taking care of their diabetes and more compliant with their diet and medications. Glasgow et al25 reported that older patients with diabetes had significantly better scores than younger patients on an instrument that measured barriers to glucose testing, regular physical activity, healthy low-fat eating, and compliance with medication. At follow-up, we found that the proportion of patients treated with diet alone increased in all age groups. It is unlikely that patients had their medications discontinued inappropriately, since the average HbA1c level in patients treated with diet alone at follow-up was close to 7.0% across all groups, and since most of the elevation in HbA1c levels in the youngest age group occurred in pharmacologically treated patients. Therefore, it seems likely that the persistence of HbA1c elevation in younger individuals may be due, at least in part, to inadequately low medication dosage or to infrequent use of combination drug regimens.

Since younger patients in our study were more obese than older patients, they would be expected to be more insulin resistant, and possibly require more aggressive therapy to achieve glycemic control. However, our data show that the dose of insulin per kilogram of body weight was comparable across all age groups, approximately 0.3 to 0.5 U/kg. Previous studies have suggested that high dosages of insulin are needed for insulin therapy to be effective in obese patients with type 2 diabetes. The feasibility trial of the Veterans Affairs cooperative study on glycemic control and complications in type 2 diabetes showed that the insulin dosage needed to achieve good glycemic control was close to 100 U of insulin per day at 2 years of follow-up.26 The average BMI for patients in that study was close to 31. Similarly, in a study using intensive insulin therapy for type 2 diabetes, Henry et al27 found that the daily insulin dose required to achieve glycemic control was 100 U at 6 months of follow-up; patients had an average weight of 93 kg and a BMI of 31.4 kg/m². These studies indicate that typical insulin needs for good control are on the order of 1 U/kg per day, but the amount of insulin used in the present study was on average half of this dosage.

Other characteristics also appear to impact glycemic control. The findings that African Americans are more likely to have elevated HbA1c level at presentation is consistent with data from NHANES III showing increased prevalence of poor control in this population.28 In addition, better glycemic control was obtained in patients who had more frequent follow-up visits. This is consistent with a previous observation by Slocum et al,29 who reported a positive relationship in the Grady Diabetes Clinic between improvement in HbA1c level and more frequent follow-up visits. Our data also showed that longer diabetes duration was associated with less improvement in HbA1c. Longer duration of diabetes is known to be associated with poor control,28 possibly because of progressive impairment of insulin secretion with time because of β-cell failure,30 which makes the response to diet alone or oral agents unlikely. Diabetes duration was not a determinant of HbA1c level at referral, possibly because many patients had been diagnosed recently as having diabetes and had an elevated HbA1c level at baseline that improved promptly with therapy. Better follow-up HbA1c levels were being achieved in later years than in earlier years, probably secondary to the introduction in the mid to late 1990s of clinic-wide efforts that emphasize intensification of glycemic control.31-33
is due to deterioration in patients’ adherence to dietary recommendations with time, as they move further away from the initial 2 months of dietary emphasis that the clinic provides.

Of note, our study showed minimal or no change in BMI at follow-up despite standard educational and dietary measures. This is consistent with the negligible weight reduction achieved in other studies that targeted changes in diet and/or physical activity as a means to decrease body weight and improve diabetes control. In general, patients with diabetes tend to gain weight with time. Patients assigned to the conventional arm (diet alone or low-dose medication) of the United Kingdom Prospective Diabetes Study gained on average 2.5 kg during a period of 10 years. In the same study, patients assigned to sulfonylureas or insulin gained 2 and 3 times as much weight, respectively, probably because of improved control, less catabolism, and less glucosuria.

Relatively little is known about the relationship of age to glycemic control in patients with diabetes. Longitudinal data from the Strong Heart Study showed that the median HbA1c level in surveyed Native Americans did not change between the baseline (1989-1992) and follow-up (1994-1995) surveys, but age was inversely related to HbA1c level at both baseline and follow-up. At follow-up, patients aged 49 to 58 years, 59 to 68 years, and 69 to 78 years had median HbA1c values of 9.0%, 8.4%, and 7.4%, respectively. Sherr et al reported on data from NHANES III (1988-1994) and found no significant association between age and HbA1c levels in a population that was nearly 80% white. However, younger patients were more likely to have an elevated HbA1c level; the proportion of patients with an HbA1c level above 8.0% in patients aged 20 to 54, 55 to 64, 65 to 74, and older than 74 years was 41.5%, 38.2%, 37.2%, and 26.9%, respectively. More recently, a cross-sectional study in Native Americans found a significant inverse relationship between age and HbA1c level. These reports overall are consistent with our finding of poor metabolic control in younger patients with diabetes.

Our analysis has a number of strengths. We analyzed data in a large sample of patients, both at presentation and at follow-up, which allowed us to examine the response of different age groups to diabetes management. We also had the opportunity to study an emerging group of patients, specifically patients younger than 30 years, and identify them as a group at high risk for diabetes complications, because of their poor glycemic control. We also had follow-up data about change in weight and use of pharmacologic therapy, which are considered major determinants and targets in relation to glycemic control. In addition, data from a primary care site were consistent with our specialty diabetes clinic findings.

Our study also has some limitations. Since most of our patients were African American, our conclusions may or may not apply to other ethnicities, even though our review of the literature suggests that our results may be generalizable. In addition, the average follow-up period in our study was 8 months, and it is possible that a longer follow-up would allow younger patients’ HbA1c levels to improve to a level comparable to those of older individuals. Use of oral agents in our clinic is also formulary-limited to sulfonylureas and metformin, and better glycemic control might have been achieved had more combination therapy been used and had other insulin secretagogues and insulin sensitizers been available. Finally, we lack data on physical activity and dietary adherence. These 2 factors are hard to measure accurately, but they also contribute to glycemic control and may help explain our findings.

Our findings raise a number of important issues that need to be addressed. Not only is the prevalence of type 2 diabetes in young adults increasing nationwide, but it appears to be associated with poor glycemic control. Interventions aiming at improving diabetes control should be multifaceted and should involve more effective measures for weight reduction, use of aggressive pharmacologic therapy, and more frequent clinic visits. School-based national programs that emphasize lifestyle modifications to limit caloric intake, favor healthy food choices, and encourage physical activity are urgently needed to help reverse the increasing prevalence of obesity in younger individuals. Encouraging young adults to seek medical care and improving their access to care through youth-oriented diabetes treatment programs may heighten their awareness of the seriousness of diabetes and improve their adherence to management. Further research is needed to determine whether specific physiological characteristics and/or sociocultural, economic, and access-to-care barriers contribute to the differences in glycemic control between age groups.

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