Parental Characteristics Associated With Outcomes in Youth With Type 2 Diabetes: Results From the TODAY Clinical Trial

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OBJECTIVE

This study examined parental factors associated with outcomes of youth in the Treatment Options for type 2 Diabetes in Adolescents and Youth (TODAY) clinical trial.

RESEARCH DESIGN AND METHODS

Of 699 youth with type 2 diabetes in the TODAY cohort, 623 (89.1%) had a parent participate and provide data at baseline, including weight, HbA_{1c}, blood pressure, symptoms of depression, binge eating (BE), and medical history. Youth were followed 2–6.5 years. Data were analyzed using regression models and survival curve methods.

RESULTS

Parental diabetes (43.6% of parents) was associated with higher baseline HbA_{1c} ($P < 0.0001$) and failure of youths to maintain glycemic control on study treatment (53.6% vs. 38.2% failure rate among those without a diabetic parent, $P = 0.0002$). Parental hypertension (40.6% of parents) was associated with hypertension in youth during TODAY (40.4% vs. 27.4% of youth with and without parental hypertension had hypertension, $P = 0.0008$) and with higher youth baseline BMI *z* scores ($P = 0.0038$). Parents had a mean baseline BMI of 33.6 kg/m^2. Parental obesity (BMI >30 kg/m^2) was associated with higher baseline BMI *z* scores in the youth ($P < 0.0001$). Depressive symptoms in parents (20.6% of parents) were related to youth depressive symptoms at baseline only ($P = 0.0430$); subclinical BE in parents was related to the presence of subclinical BE ($P = 0.0354$) and depressive symptoms ($P = 0.0326$) in youth throughout the study period.

CONCLUSIONS

Parental diabetes and hypertension were associated with lack of glycemic control, hypertension, and higher BMI *z* scores in youth. Further research is needed to better understand and address parental biological and behavioral factors to improve youth health outcomes.

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A complete list of the TODAY Study Group can be found in the APPENDIX.

Youth-onset type 2 diabetes has been on the rise for two decades in the U.S. Diabetes-related complications and comorbidities, including retinopathy, hypertension, and albuminuria, are now observed in adolescents (1–8). Treatment Options for type 2 Diabetes in Adolescents and Youth (TODAY) was one of the first large randomized clinical trials to evaluate the safety and efficacy of different treatment regimens (9). The multicenter study group enrolled and monitored the largest ethnically diverse and well-characterized cohort of youth with type 2 diabetes in the world.

A family history of type 2 diabetes increases the risk of children developing diabetes (10), but whether the presence of diabetes in the parent is associated with more difficulty in achieving and maintaining glycemic control in youth and/or the earlier development of diabetes-related complications is unknown. The physical and mental health status of a parent may affect the general health or functioning of the child (11,12). However, whether the presence of parental obesity, hypertension, and/or depression is associated with greater hypertension, obesity, and depressive symptoms in their children with type 2 diabetes has not been well studied. The TODAY study collected data from the parents of youth participants, allowing for analyses that could help increase our understanding of how parental health status may affect the health and behavior of youth with type 2 diabetes. This information could inform the future development of targeted parent/child interventions to improve outcomes for youth with type 2 diabetes. The current analyses examined the following questions in TODAY study participants:

1. Is the presence of diabetes in a parent associated with poorer glycemic outcomes (failure to maintain glycemic control), youth medication adherence, BMI *z* score, and diabetes-related complications?
2. Is the presence of parental hypertension or obesity associated with hypertension or obesity in the offspring?
3. Is the presence of depressive symptoms or binge eating (BE) in parents associated with youth outcomes?
4. Is the occurrence of medical serious adverse events (SAEs) in parents (reflecting major medical problems in parents according to standard clinical trial SAE criteria) associated with failure to maintain glycemic control in their youth, youth medication adherence, BMI *z* score, and diabetes-related complications?

RESEARCH DESIGN AND METHODS

The design of the TODAY study has been previously described (13,14). Overweight youth (n = 699, ages 10–17) with recent-onset type 2 diabetes (median 5 months) were randomized to receive metformin alone, metformin with rosiglitazone, or metformin with an intensive lifestyle intervention. The primary outcome was time to treatment failure based on glycemic control (HbA_{1c} >8% [>64 mmol/mol]) over 6 months or inability to wean from temporary insulin therapy within 3 months after acute metabolic decompensation. Data collected on youth at baseline included age, sex, race/ethnicity, and family structure (with whom the participant lived). Height, weight, HbA_{1c}, and blood pressure were assessed in youth at baseline, every 2 months in the first year, and quarterly thereafter. Urine albumin and creatinine were assessed at baseline and annually. Medication adherence based on pill count was assessed at each follow-up visit with a goal of ≥80%. SAEs (based on standard definitions for clinical trials) that occurred in youth during the study were also collected. Hypertension was defined as high blood pressure (≥130/80 mmHg or ≥95th percentile for age, sex, and height based on Centers for Disease Control and Prevention normative data) or use of appropriate medication. Microalbuminuria was defined as an albumin-to-creatinine ratio ≥30 μg/mg in two of three urine samples collected over ≥3 months or use of appropriate medication. Retinopathy was assessed by fundus photography in the last year of the study (7).

Depressive symptoms during the past 2 weeks were assessed using the Children's Depression Inventory (CDI) for participants up to age 16 or the Beck Depression Inventory (BDI) for those 16 or older. A score ≥13 on the CDI or ≥14 on the BDI indicated clinically significant levels of depressive symptoms (15,16). Responses on the self-report Youth Eating Disorder Examination Questionnaire (Y-EDEQ) were used to identify the presence of BE, defined as the number of times in the past 28 days the participant reported episodes of overeating with an associated loss of control. Subclinical BE was defined as reporting 1–3 BE episodes in the past month, and clinical BE was ≥4 (17). The BDI, CDI, and Y-EDEQ were administered to the youth at baseline, month 6, and month 24 of the study. Youth hypertension, microalbuminuria, depressive symptoms, subclinical BE, and clinical BE were assessed at baseline and cumulatively during the entire study period (including baseline through end of study visits).

Each youth was accompanied by an adult caregiver, called the family support person (FSP), most of whom were parents. The FSP had to provide signed informed consent stating willingness to perform functions, including accompanying the youth to all study visits and participating in data collection. Baseline data were collected from FSPs, including age, sex, race/ethnicity, height, and weight measured by clinic staff, depressive symptoms (BDI), and an adult version of the EDEQ to determine subclinical and clinical BE defined in a similar manner as for the youth (18). History of diabetes and hypertension were obtained from the biological FSP parent via self-report at baseline. Highest household level of education and total household annual income were recorded. SAEs occurring in FSPs, such as death, hospitalization, birth of a baby with a congenital anomaly, disability, or any other life-threatening medical event, were documented during follow-up.

The protocol was approved by the institutional review board for each of the participating institutions. All participants provided informed consent and minor child assent.

Statistical Methods

Associations between parental characteristics and youth outcomes were analyzed using logistic regression models (for binary outcomes) and general linear models (for continuous outcomes).

Comparison of glycemic failure on assigned treatment in the youth by parental diabetes status and diagnosis of youth hypertension by parental hypertension were analyzed using survival curve methodology with log-rank tests. At baseline, all TODAY youth were free of glycemic failure per study protocol but could be enrolled if

previously diagnosed with hypertension that was controlled with appropriate medical therapy.

All analyses were considered exploratory, with statistical significance defined as $P < 0.05$. SAS 9.3 software (SAS Institute Inc., Cary, NC) was used for all analyses.

RESULTS

Of the 699 TODAY youth participants, 623 (89.1%) had a parent join as the FSP at baseline and were included in the analysis sample; 88.6% of FSPs were mothers (97.6% biological) and 11.4% were fathers (95.8% biological). There were no differences in baseline youth characteristics (sex, race/ethnicity, age, BMI, HbA_{1c}, blood pressure) between those included or not included in the analyses. Characteristics of the parents and youth are reported in Table 1. At baseline, 63.3% of parents were obese, 43.6% reported diabetes, 40.6% reported hypertension, and 74.2% reported a total annual household income of <$50,000. Youth characteristics have been previously described (5,7,9,19–22): 63.4% were female, at baseline 42.6% lived with both parents, their mean BMI *z* score was 2.23, and 45.4% were unable to maintain glycemic control regardless of assigned treatment during an average follow-up of 3.8 years.

Each parent characteristic from Table 1 (apart from age, sex, and race/ethnicity) was univariately related to each youth outcome collected at baseline or during the study. Tables 2 and 3 present the results from these associations, and significant results are further discussed

Table 1—Characteristics of the parent and youth participants in the TODAY study (*n* = 623)

	Parent at baseline*	Youth at baseline	Youth during study**
Age (years)	41.5 ± 6.7	13.9 ± 2.0	—
Female	88.6	63.4	—
Race/ethnicity			
Non-Hispanic Black	33.8	32.1	—
Hispanic	35.5	40.0	—
Non-Hispanic White	23.4	21.2	—
Other	7.3	6.7	—
Household highest level of education			
Less than high school	25.7	—	—
High school or GED	24.8	—	—
Some college	32.6	—	—
College degree or higher	16.9	—	—
Household total annual income			
<$25,000	40.4	—	—
$25,000–$49,999	33.8	—	—
≥$50,000	25.8	—	—
Family structure			
Living with both parents	—	42.6	—
Living with either one	—	54.4	—
Living with neither	—	3.0	—
BMI (kg/m^2)	33.6 ± 7.8	35.0 ± 7.7	36.0 ± 7.9
BMI >30 kg/m^2	63.3	71.4	76.9
BMI *z* score	—	2.23 ± 0.47	2.18 ± 0.50
Diabetes	43.6	100	—
HbA_{1c}, % (mmol/mol)	—	6.0 ± 0.8 (42 ± 9)	7.1 ± 1.6 (54 ± 17)
Medication adherence ≥80%	—	—	57.1
SAE(s) reported ≥1	16.4	—	21.5
Hypertension	40.6	17.8	32.6
Diabetic retinopathy	—	—	14.1
Microalbuminuria	—	5.9	18.1
CDI score	—	7.1 ± 6.4	—
BDI score	8.3 ± 8.8	6.0 ± 7.5	—
Depressive symptoms†	20.6	15.0	27.9
Categories of BE‡			
Subclinical BE	10.8	17.1	40.9
Clinical BE	5.3	8.3	17.1

Data are presented as mean ± SD or %. *Highest level of education and annual income refer to information on the household; parental diabetes and hypertension refer to information on the biological FSP parent; all other parent factors refer to information on the primary caregiver parent at baseline except for SAE(s) reported, which were based on data collected during the study. **Youth factors during the study include baseline data. †The presence of clinically significant mood impairment or depressive symptoms within the last 2 weeks was indicated by a CDI score ≥13 (for participants <16 years old) or a BDI score ≥14 (for participants ≥16). At baseline, 24% of the youth were ≥16 years old and completed the BDI; all others completed the CDI. ‡BE episodes were the number of times in the past 28 days the participant reported episodes of overeating with an associated loss of control; subclinical BE was defined as 1–3 episodes, and clinical BE was defined as ≥4 episodes.

Table 2—Association between parent (rows) and youth (columns) factors at baseline and during the study*

	Youth factors							
	Baseline				During study**			
Parent factors	BMI *z*	HbA_{1c} (%)	HbA_{1c} (mmol/mol)	Hypertension (%)	Medication adherence ≥80% (%)	SAE(s) reported (%)	Hypertension (%)	Loss of glycemic control (%)
BMI >30 kg/m^2								
No	2.04 ± 0.47	6.0 ± 0.7	42 ± 8	13.7	60.7	12.9	25.0	36.3
Yes	2.29 ± 0.40	6.0 ± 0.8	42 ± 9	14.0	59.3	22.4	33.2	46.7
P value	**<0.0001**	0.6502	0.6502	0.9369	0.8109	**0.0275**	0.1115	0.0606
Diabetes								
No	2.23 ± 0.46	5.9 ± 0.7	41 ± 8	14.8	53.4	18.9	32.5	38.2
Yes	2.24 ± 0.47	6.2 ± 0.8	44 ± 9	21.8	60.9	23.4	32.6	53.6
P value	0.7910	**<0.0001**	**<0.0001**	**0.0262**	0.0724	0.1863	0.9953	**0.0002**
SAE reported								
None	2.21 ± 0.47	6.0 ± 0.8	42 ± 9	16.3	57.4	20.4	31.7	43.0
≥1	2.32 ± 0.45	6.1 ± 0.8	43 ± 9	25.5	55.6	27.5	37.3	57.8
P value	**0.0317**	0.1647	0.1647	**0.0330**	0.7412	0.1188	0.2754	**0.0060**
Hypertension								
No	2.19 ± 0.47	5.9 ± 0.7	41 ± 8	13.1	59.1	19.6	27.4	46.9
Yes	2.30 ± 0.45	6.2 ± 0.8	44 ± 9	24.9	53.5	22.9	40.4	42.9
P value	**0.0038**	**0.0004**	**0.0004**	**0.0002**	0.1899	0.3286	**0.0008**	0.3237
Depressive symptoms								
No	2.23 ± 0.46	6.0 ± 0.7	42 ± 8	18.1	57.5	19.2	33.4	44.5
Yes	2.22 ± 0.48	6.1 ± 0.7	43 ± 8	16.7	55.9	27.0	29.4	49.2
P value	0.8328	0.1252	0.1252	0.6976	0.7566	0.0601	0.3858	0.3489
Subclinical BE†								
No	2.22 ± 0.48	6.0 ± 0.8	42 ± 9	17.9	56.5	21.4	33.0	45.3
Yes	2.29 ± 0.35	6.1 ± 0.8	43 ± 9	16.7	65.6	24.2	28.8	51.5
P value	0.2700	0.6707	0.6707	0.8087	0.1574	0.5963	0.4899	0.3399
Clinical BE								
No	2.23 ± 0.46	6.0 ± 0.8	42 ± 9	17.9	58.2	21.3	32.8	46.5
Yes	2.25 ± 0.54	6.2 ± 0.8	44 ± 9	15.6	43.3	28.1	28.1	37.5
P value	0.7898	0.1893	0.1893	0.7445	0.1103	0.3773	0.5817	0.3196
Household annual income								
<$25,000	2.24 ± 0.46	6.0 ± 0.8	42 ± 9	21.1	53.4	26.8	33.3	46.9
$25,000–$49,999	2.24 ± 0.47	6.0 ± 0.8	42 ± 9	13.1	58.8	21.5	31.9	47.1
≥$50,000	2.20 ± 0.47	6.0 ± 0.7	42 ± 8	21.2	64.2	17.1	32.9	37.0
P value	0.6917	0.5084	0.5084	0.0582	0.1292	0.0834	0.9542	0.1075

*Mean ± SD or % of the factor in the youth are shown in the table by the status of a factor in the parent. The *P* values are from unadjusted models testing for an association between the parental factor and the youth factor ($P < 0.05$ in bold). **Youth factors during the study include baseline data. †Clinical BE (≥4 episodes) was excluded from the comparison group of normal plus overeaters vs. subclinical BE (1–3 episodes).

Table 3—Association between parent (rows) factors and youth (columns) depressive symptoms and BE at baseline and during the study*

	Youth factors					
	Depressive symptoms		Subclinical BE†		Clinical BE	
Parent factors	Baseline	During study	Baseline	During study	Baseline	During study
BMI >30 kg/m^2						
No	11.5	25.0	15.3	29.6	3.3	12.2
Yes	12.0	22.0	18.7	36.2	10.5	17.5
P value	0.8945	0.5245	0.4339	0.2538	**0.0119**	0.1875
Diabetes						
No	14.8	27.2	19.3	34.6	8.0	16.9
Yes	14.5	27.2	17.2	37.1	7.9	16.1
P value	0.9206	0.9965	0.5211	0.5609	0.9752	0.8021
SAE reported						
None	14.9	28.2	19.1	33.9	8.2	17.4
1 or more	15.2	26.5	16.3	45.4	8.9	15.7
P value	0.9552	0.7183	0.5255	**0.0462**	0.8064	0.6798
Hypertension						
No	14.3	27.9	17.2	33.5	8.0	15.4
Yes	15.1	26.1	20.4	39.0	8.1	18.4
P value	0.7667	0.6231	0.3535	0.2116	0.9864	0.3420
Depressive symptoms						
No	13.2	26.2	17.6	34.7	7.9	15.6
Yes	20.8	33.3	21.3	41.0	10.7	22.1
P value	**0.0430**	0.1150	0.3750	0.2464	0.3246	0.0936
Subclinical BE†						
No	14.5	26.5	17.1	34.4	8.0	16.4
Yes	17.2	39.4	30.9	50.0	12.7	25.0
P value	0.5786	**0.0326**	**0.0183**	**0.0354**	0.2268	0.0980
Clinical BE						
No	15.1	27.7	18.7	35.6	8.2	17.0
Yes	9.4	31.3	14.8	41.7	12.9	22.6
P value	0.3462	0.6690	0.6048	0.5501	0.3915	0.4386
Household annual income						
<$25,000	16.2	28.1	18.0	34.4	6.4	16.6
$25,000–$49,999	20.1	33.5	20.2	40.3	9.2	14.5
≥$50,000	7.8	18.5	17.0	30.4	9.1	19.6
P value	**0.0053**	**0.0074**	0.7591	0.2281	0.4863	0.4771

*% of the factor in the youth are shown in the table by the status of a factor in the parent; *P* values from unadjusted models testing for an association between the parental factor and the youth factor ($P < 0.05$ in bold). Youth factors during the study include baseline data. †Clinical BE (≥4 episodes) was excluded from the comparison group of normal plus overeaters vs. subclinical BE (1–3 episodes).

below. Parental diabetes was significantly related to youth glycemic control (Table 2 and Fig. 1*A*). Baseline HbA_{1c} was significantly higher in youth who had a parent with diabetes (mean 6.2% [SD 0.8]; 44 mmol/mol [SD 9]) compared with those whose parent did not have diabetes (mean 5.9% [SD 0.7]; 41 mmol/mol [SD 8]; $P < 0.0001$). Of those with a parent who had diabetes, 53.6% failed to maintain glycemic control (reached primary outcome) compared with 38.2% of those without a parent with diabetes ($P = 0.0002$). Figure 1*A* shows treatment failure by parental diabetes status, reflected in the statistically significantly higher youth baseline HbA_{1c} in those whose parents had diabetes and the widening difference between failure rates over time. When analyses evaluating parental diabetes were restricted to only FSP biological mothers ($n = 532$), all the associations between maternal diabetes and youth glycemic control remained ($P = 0.0002$). Given the small number of FSP biological fathers ($n = 67$), similar analyses were not performed for the fathers.

Parental diabetes also related to youth hypertension at baseline ($P = 0.0262$) but not to hypertension diagnosed in youth during the entire trial period. No association was found between diabetes in a parent and youth diabetic retinopathy or microalbuminuria (data not shown), in youth BMI *z* score at baseline, or in medication adherence during the study. Among parents with a BMI >30 kg/m^2, the baseline mean (SD) BMI *z* score of the youth was 2.29 (0.40) compared with 2.04 (0.47) among youth with a nonobese parent ($P < 0.0001$). Changes in youth BMI and BMI *z* scores were minimal during the study and were not explored further.

Parental hypertension was related to hypertension in the youth. Whereas there were higher rates of hypertension at baseline in youth with a parent with hypertension (24.9% vs. 13.1%, $P = 0.0002$), the change in the percentage of youth free of hypertension during the entire study period was similar in those with and without parental hypertension (Fig. 1*B*). By the end of the study, 40.4% of the youth with parental hypertension had been diagnosed with hypertension compared with 27.4% of those with no hypertensive parent ($P = 0.0008$). In 143 parents with both diabetes and hypertension, 30.8% of youth had hypertension at baseline compared with 13.9% of youth with parents with either diabetes or hypertension or neither ($P < 0.0001$). Among the parents with and without hypertension, the mean (SD) BMI *z* score of the youth at baseline was 2.30 (0.45) and 2.19 (0.47), respectively ($P = 0.0038$). Parental hypertension also related to higher HbA_{1c} at baseline ($P = 0.0004$).

The percentage of youth with significant depressive symptoms at baseline was 20.8% in participants with a parent with depressive symptoms at baseline versus 13.2% in those without a parent with depressive symptoms ($P = 0.0430$; Table 3); the relationship was no longer significant by the end of the study. Also, depressive symptoms in the parent did not relate to youth BMI *z* score or HbA_{1c} at baseline and did not correlate with medication adherence, development of diabetes-related complications, or occurrence of SAEs in youth during the study.

Parental subclinical BE (1–3 episodes in the past month) at baseline, reported by 10.8% of the FSP parents, related to greater depressive symptoms in the youth by the end of the study ($P =$

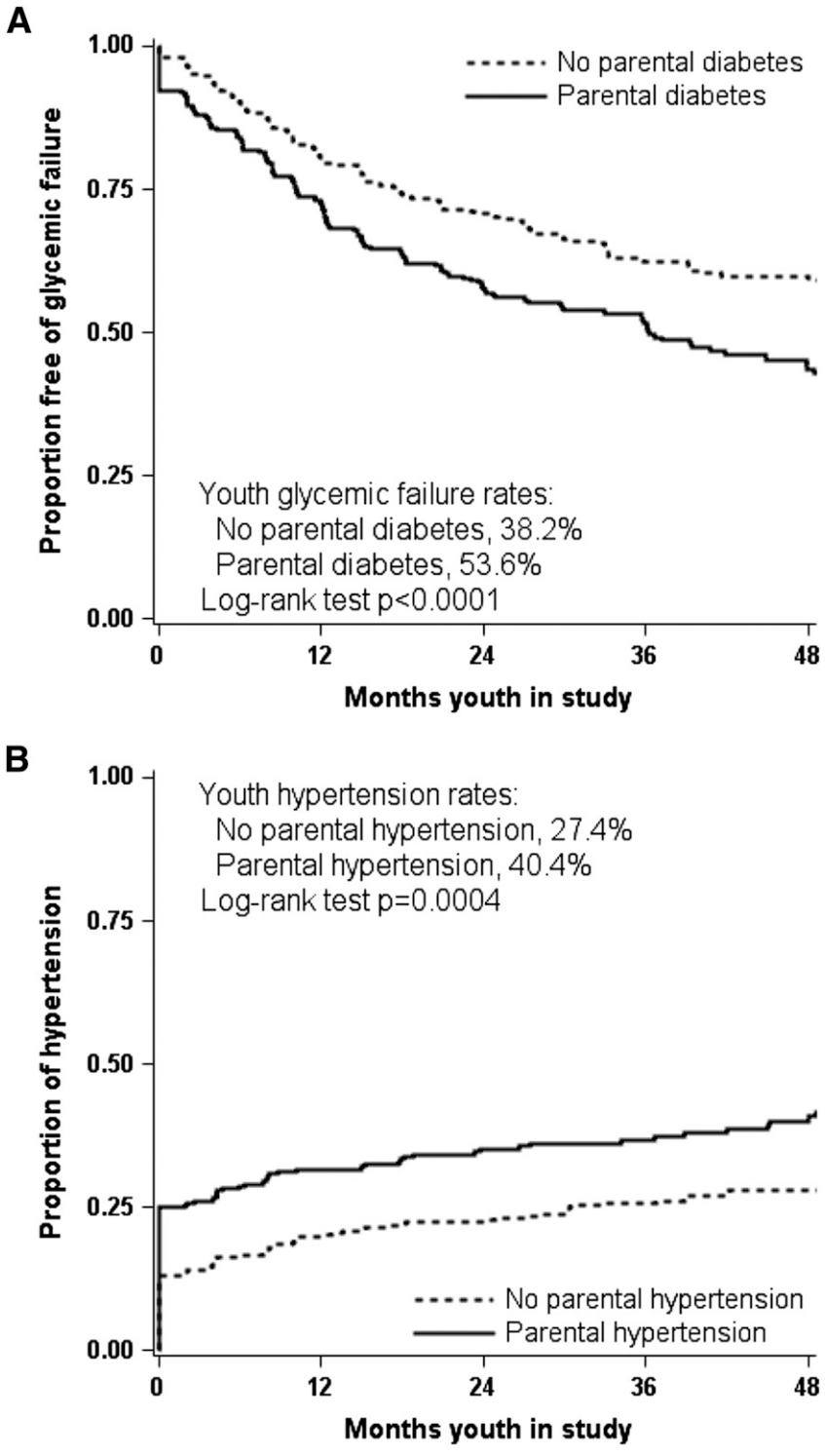

Figure 1—Survival curves to 48 months and log-rank test results based on data up to 6 years of follow-up. *A*: Freedom from glycemic failure in youth on assigned treatment by parental diabetes. At baseline, all TODAY youth were free of glycemic failure per study protocol. *B*: Hypertension in youth by parental hypertension. At baseline, youth were eligible if diagnosed with hypertension that was controlled by appropriate medication.

0.0326) and to subclinical BE in the youth at baseline (P = 0.0183) and cumulatively by the end of the study (P = 0.0354). Parental clinical BE at baseline was not significantly related to any other youth outcomes, but was only present in 5.3% of parents.

Low household education level (less than college degree) was associated with a higher baseline BMI z score in the offspring (data not shown; P = 0.0340) and development of microalbuminuria (data not shown; P = 0.0091). Low household annual income (<$50,000) was related to the presence of youth depressive symptoms at baseline (P = 0.0053) and cumulatively by the end of the study (P = 0.0074). Youth who failed randomized diabetes treatment assignment (loss of glycemic control) were more likely to have a parent with at least one SAE (57.8%) versus 43.0% of the TODAY youth with no SAEs in a parent (P = 0.0060). There were 195 SAEs in 111 FSPs, including 11 deaths (7 related to cardiovascular disease and 1 cancer). SAEs were predominantly hospitalizations (94%), and the most common were related to cardiovascular disease (26%), infections (11%), and renal disease (9%). Offspring of parents with SAEs had higher BMI z scores (P = 0.0317) and more hypertension at baseline (P = 0.0330) and were more likely to be classified with subclinical BE episodes by the end of the study (P = 0.0462). However, parental SAEs were not associated with medication adherence, diagnosis of hypertension by the end of the study, retinopathy, microalbuminuria, or depressive symptoms in the youth.

CONCLUSIONS

A history of type 2 diabetes in a first-degree relative is a well-known risk factor for diabetes developing at a young age (23,24), and TODAY has already reported that 59.6% of the study cohort had a nuclear family member with diabetes, which rose to 89.5% when grandparents were included (9). Our analyses have shown a significant relationship between glycemic control in youth with type 2 diabetes and diabetes diagnosed in a parent. Most striking is the very early relationship between parental diabetes status and youth glycemic control, followed by a continuing significant effect over time shown in Fig. 1*A*. An area of future research could include investigations to further our understanding on how parents' glycemic control affects youth's glycemic control where one or both parents have a diagnosis of type 2 diabetes.

This inequity early in the natural history of youth onset type 2 diabetes may be due to environmental, lifestyle, genetic, and epigenetic factors. The possible role of an adverse intrauterine

environment on the development of diabetes was introduced more than two decades ago (25) and was further studied in the Pima Indians and other populations (26). The extent to which youth-onset type 2 diabetes is associated with specific genetic abnormalities is currently under investigation. TODAY previously reported a significant association between higher HbA_{1c} at baseline and failure to maintain glycemic control, possibly related to greater deterioration in pancreatic β-cell function (19). These findings highlight the importance of identifying and closely monitoring youth with type 2 diabetes who may require early intensification of therapy, which occurs more frequently in those with a parental history of diabetes.

Many youth (17.8%) already had hypertension at baseline, which was more common in those with a parental history of hypertension. This is not a surprising result, considering the occurrence of youth hypertension may be largely genetically determined. Youth hypertension at baseline was also more common in those with parents with diabetes. It is possible that a pediatrician or family practitioner, knowing about the positive family history of hypertension and/or diabetes, would be more diligent in checking the status of the youth. The higher prevalence of youth with hypertension at baseline in the 143 parents with diabetes and hypertension (30.8% vs. 13.9% of youth with parents with diabetes or hypertension or neither) may be due to increased clinician attention as well as to the compounding effect of a parent with multiple diagnoses. Environmental influences, such as parental obesity, presence of depressive symptoms or BE, and household annual income, were not associated with hypertension in youth.

Elevated depressive symptoms in parents were associated with elevated depressive symptoms in youth at baseline. This is consistent with the large body of literature reporting that indicators of parental depression relate to a range of youth problems in cognitive, behavioral, and emotional domains (27). This has been shown for maternal and paternal depression (28,29). The effect of socioeconomic status (as expressed by household annual income) on the relationship between depressive symptoms in parents and youth as a confounder or mediator bears further study.

We did not find a relationship between symptoms of depression in parents and youth baseline BMI, baseline HbA_{1c}, medication adherence, or development of complications. In several studies of youth in the community, parental depression has been associated with poor parenting skills and especially low levels of warmth and high levels of parental criticism (30,31). These factors have been found to be associated with poorer adherence and glycemic control in children with type 1 diabetes (32), although Butler et al. (33), who found a relationship between parenting style and youth depression in a group of adolescents with type 1 diabetes, found no relationship between parenting style and adherence. In a sample of adolescents with type 1 and type 2 diabetes, Eckshtain et al. (34) found that parental depression had an indirect effect on youth depression, via less parental involvement, and that youth depression was related to glycemic control. They reported that parents with elevated depressive symptoms performed less monitoring of youth and that this behavior was associated with poorer glycemic control, as was parent-reported youth depression. However, youth reports of depressive symptoms in TODAY did not relate to glycemic control. In the current study, we relied on youth self-report of depressive symptoms, and this method may explain why we found no relationship. Also, youth were involved in an active and highly supportive intervention with a number of caring adults, and these relationships might have ameliorated any negative effects of parental depression on their outcomes.

Disordered eating is a significant comorbidity that can complicate the medical management of diabetes. Children who report engaging in disordered eating behaviors are at greater risk for developing increased shape and weight concerns than those who do not report these behaviors and are at increased risk for developing type 2 diabetes (35,36). TODAY previously reported that at baseline, type 2 diabetes youth with BE had higher levels of obesity, greater global eating, and weight and shape concerns (21). An association between disordered eating in parents without diabetes, particularly mothers, and children has been previously reported (37). Twin studies suggest that this relationship is due to the moderate heritability of disinhibited eating moderated by a shared environment (38,39). We did not find an association between parental BE and youth outcomes in our study but did find an association between subclinical BE in parents and subclinical BE in their youth with type 2 diabetes, suggesting that assessments for disordered eating in parents as well as in youth may be important.

Although the links that we found between parental mental health difficulties (depression, disordered eating) and youth outcomes are not dramatic, they are of concern. The data cited earlier suggest that depression and disordered eating in parents may contribute to these and other problems in their children, which in turn may predict problems in adulthood. It is important for researchers to explore these outcomes more fully. Also, practitioners should take these mental health issues into account when planning their interventions. This might include assessments of depression and disordered eating in parents as well as youth and behavioral/psychosocial interventions that target the family rather than only the child, using a family-centered approach to care. In the TODAY study, a parent was involved in the intervention itself, but his or her role was to support the child, and any potential benefit for the parent would have been indirect. A true family-centered approach would help the parent focus on his or her own needs and problems as well. For example, it would be interesting to learn whether an intervention for a parent with diabetes that addresses parental glycemic control and weight would result in improved youth glycemic control and weight.

Limitations of this study include the small number of FSP participants who were fathers and the use of self-reported recent depressive symptoms (2 weeks) and eating behaviors (28 days) rather than clinical diagnoses derived from structured psychiatric interviews. Furthermore, we lack information concerning depression and BE in non-FSP parents. Because we did not measure parenting behaviors, we cannot assess this potential connection. Diagnoses of diabetes and hypertension in parents

were obtained by self-report, which may underestimate their prevalence. There was also lack of HbA_{1c} data in parents. Strengths of the current study include the large, well-characterized multiethnic cohort of subjects with youth-onset type 2 diabetes and detailed data collected from their parents.

In conclusion, this treatment trial of youth-onset type 2 diabetes found parental diabetes, hypertension, and obesity were associated with failure to maintain glycemic control and a greater prevalence of hypertension and obesity in the youth. Further research is needed to better understand the factors responsible for these findings.

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R.S.W., P.M.T., S.M., S.W., and P.M.Y. researched data and wrote or edited parts of the manuscript. L.E. performed the analysis, researched data, and reviewed and edited the manuscript. R.G. researched data and reviewed the manuscript. K.M. reviewed or edited parts of the manuscript. J.P. wrote or edited parts of the manuscript. L.E. 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.

Appendix

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References

1. Ettinger LM, Freeman K, DiMartino-Nardi JR, Flynn JT. Microalbuminuria and abnormal ambulatory blood pressure in adolescents with type 2 diabetes mellitus. J Pediatr 2005;147:67–73
2. Maahs DM, Snively BM, Bell RA, et al. Higher prevalence of elevated albumin excretion in youth with type 2 than type 1 diabetes: the SEARCH for Diabetes in Youth study. Diabetes Care 2007;30:2593–2598
3. Farah SE, Wals KT, Friedman IB, Pisacano MA, DiMartino-Nardi J. Prevalence of retinopathy and microalbuminuria in pediatric type 2 diabetes mellitus. J Pediatr Endocrinol Metab 2006; 19:937–942
4. Eppens MC, Craig ME, Cusumano J, et al. Prevalence of diabetes complications in adolescents with type 2 compared with type 1 diabetes. Diabetes Care 2006;29:1300–1306
5. TODAY Study Group. Rapid rise in hypertension and nephropathy in youth with type 2 diabetes: the TODAY clinical trial. Diabetes Care 2013;36:1735–1741
6. Mayer-Davis EJ, Davis C, Saadine J, et al.; SEARCH for Diabetes in Youth Study Group. Diabetic retinopathy in the SEARCH for Diabetes in Youth Cohort: a pilot study. Diabet Med 2012; 29:1148–1152

7. TODAY Study Group. Retinopathy in youth with type 2 diabetes participating in the TODAY clinical trial. Diabetes Care 2013;36:1772–1774
8. TODAY Study Group. Lipid and inflammatory cardiovascular risk worsens over 3 years in youth with type 2 diabetes: the TODAY clinical trial. Diabetes Care 2013;36:1758–1764
9. Zeitler P, Hirst K, Pyle L, et al.; TODAY Study Group. A clinical trial to maintain glycemic control in youth with type 2 diabetes. N Engl J Med 2012;366:2247–2256
10. Rosenbloom AL, Silverstein JH, Amemiya S, Zeitler P, Klingensmith GJ; International Society for Pediatric and Adolescent Diabetes. ISPAD Clinical Practice Consensus Guidelines 2006-2007. Type 2 diabetes mellitus in the child and adolescent. Pediatr Diabetes 2008;9:512–526
11. Von Bertalanffy L. *General System Theory: Foundations, Development, Applications*. New York, NY, George Braziller, 1968
12. Patterson JM, Garwick AW. The impact of chronic illness on families: a family systems perspective. Ann Behav Med 1994;16:131–142
13. TODAY Study Group, Zeitler P, Epstein L, Grey M, et al. Treatment options for type 2 diabetes in adolescents and youth: a study of the comparative efficacy of metformin alone or in combination with rosiglitazone or lifestyle intervention in adolescents with type 2 diabetes. Pediatr Diabetes 2007;8:74–87
14. TODAY Study Group. Design of a family-based lifestyle intervention for youth with type 2 diabetes: the TODAY study. Int J Obes (Lond) 2010;34:217–226
15. Kovacs M. *The Children's Depression Inventory (CDI) Manual North Tanawanda*. New York, NY, Multi-Health Systems, 1992
16. Beck AT, Steer RA, Brown GK. *Manual for the Beck Depression Inventory-II*. San Antonio, TX, Psychological Corporation, 1996
17. Goldschmidt AB, Doyle AC, Wilfley DE. Assessment of binge eating in overweight youth using a questionnaire version of the Child Eating Disorder Examination with Instructions. Int J Eat Disord 2007;40:460–467
18. Fairburn CG, Beglin SJ. Assessment of eating disorders: interview or self-report questionnaire? Int J Eat Disord 1994;16:363–370
19. TODAY Study Group. Effects of metformin, metformin plus rosiglitazone, and metformin plus lifestyle on insulin sensitivity and β-cell function in TODAY. Diabetes Care 2013;36:1749–1757
20. Anderson BJ, Edelstein S, Abramson NW, et al. Depressive symptoms and quality of life in adolescents with type 2 diabetes: baseline data from the TODAY study. Diabetes Care 2011;34:2205–2207
21. Wilfley D, Berkowitz R, Goebel-Fabbri A, et al.; TODAY Study Group. Binge eating, mood, and quality of life in youth with type 2 diabetes: baseline data from the today study. Diabetes Care 2011;34:858–860
22. TODAY Study Group. Treatment effects on measures of body composition in the TODAY clinical trial. Diabetes Care 2013;36:1742–1748
23. Gill-Carey O, Hattersley AT. Genetics and type 2 diabetes in youth. Pediatr Diabetes 2007;8(Suppl. 9):42–47
24. American Diabetes Association. Standards of medical care in diabetes—2014. Diabetes Care 2014;37(Suppl. 1):S14–S80
25. Hales CN, Barker DJ, Clark PM, et al. Fetal and infant growth and impaired glucose tolerance at age 64. BMJ 1991;303:1019–1022
26. McCance DR, Pettitt DJ, Hanson RL, Jacobsson LT, Knowler WC, Bennett PH. Birth weight and non-insulin dependent diabetes: thrifty genotype, thrifty phenotype, or surviving small baby genotype? BMJ 1994;308:942–945
27. Hanington L, Heron J, Stein A, Ramchandani P. Parental depression and child outcomes—is marital conflict the missing link? Child Care Health Dev 2012;38:520–529
28. Martins C, Gaffan EA. Effects of early maternal depression on patterns of infant-mother attachment: a meta-analytic investigation. J Child Psychol Psychiatry 2000;41:737–746
29. Ramchandani PG, O'Connor TG, Evans J, Heron J, Murray L, Stein A. The effects of pre- and postnatal depression in fathers: a natural experiment comparing the effects of exposure to depression on offspring. J Child Psychol Psychiatry 2008;49:1069–1078
30. Cummings EM, Davies PT. Maternal depression and child development. J Child Psychol Psychiatry 1994;35:73–112
31. Barber BK, Stolz HE, Olsen JA. Parental support, psychological control, and behavioral control: assessing relevance across time, culture, and method. Monogr Soc Res Child Dev 2005;70:1–137
32. Davis CL, Delamater AM, Shaw KH, et al. Parenting styles, regimen adherence, and glycemic control in 4- to 10-year-old children with diabetes. J Pediatr Psychol 2001;26:123–129
33. Butler JM, Skinner M, Gelfand D, Berg CA, Wiebe DJ. Maternal parenting style and adjustment in adolescents with type I diabetes. J Pediatr Psychol 2007;32:1227–1237
34. Eckshtain D, Ellis DA, Kolmodin K, Naar-King S. The effects of parental depression and parenting practices on depressive symptoms and metabolic control in urban youth with insulin dependent diabetes. J Pediatr Psychol 2010;35:426–435
35. Wilfley DE, Schwartz MB, Spurrell EB, Fairburn CG. Using the eating disorder examination to identify the specific psychopathology of binge eating disorder. Int J Eat Disord 2000;27:259–269
36. Fiore K. *Bingeing Boosts Diabetes Risk*. [Internet]. 14 Nov 2013. Available from http://www.medpagetoday.com/MeetingCoverage/ObesityWeek/42912. Accessed 16 July 2014
37. Jahnke DL, Warschburger PA. Familial transmission of eating behaviors in preschool-aged children. Obesity (Silver Spring) 2008;16:1821–1825
38. Javaras KN, Laird NM, Reichborn-Kjennerud T, Bulik CM, Pope HG Jr, Hudson JI. Familiality and heritability of binge eating disorder: results of a case-control family study and a twin study. Int J Eat Disord 2008;41:174–179
39. Thornton LM, Mazzeo SE, Bulik CM. The heritability of eating disorders: methods and current findings. Curr Top Behav Neurosci 2011;6:141–156