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Characteristics of Adolescents with Type 1 Diabetes Who Exhibit Adverse Outcomes

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Abstract

Purpose—The primary purpose of this study was to determine differences in key characteristics between adolescents with type 1 diabetes who experienced the adverse outcomes of poor glycemic control, hypoglycemic events, and hospitalizations due to their disease versus those who do not experience such events. A secondary purpose was to examine differences in outcomes for adolescents using insulin pumps versus daily insulin injections (≥ 2).

Methods—Data from 108 adolescents were divided according to glycemic control ($HbA_{1c} < 8\%$ vs. $\geq 8\%$), hypoglycemic reactions and hospitalizations in the past year (0 vs. ≥ 1 episode of each), and pump versus injection delivery of insulin. The following variables were compared within each grouping: body mass index (BMI) insulin dose, caloric intake, parental educational level, marital status, annual family income, race, and gender. HbA_{1c} was examined in relation to the number of hypoglycemic reactions and hospitalizations in the past year, as well as for any differences between those receiving insulin via pump therapy versus daily injections (≥ 2).

Results—Subjects receiving insulin via pump had better glucose control and were on lower insulin doses than those receiving insulin injections. Subjects with adequate versus inadequate glucose control used a lower insulin dose, checked their blood sugar more frequently, and had fathers with a higher education level. Finally, those with inadequate control were more likely to come from a single parent home, a lower income family, and from an ethnic minority.

Conclusions—Pump therapy for adolescents should be encouraged when appropriate. Also, certain groups of adolescents need increased supervision to manage their disease appropriately. Further research needs to explore what interventions will bring more favorable outcomes for such groups.

In the United States, diabetes mellitus ranks as the fifth leading cause of death due to disease and is one of the few diseases where the death rate has increased since the late 1980's.¹ A majority of these deaths are due to the complications and conditions secondary to diabetes, frequently associated with poor glycemic control. Research has increased the understanding of key management issues with many chronic diseases. However, there is still much more to learn about improving disease outcomes for adolescents with type 1 diabetes.

The Diabetes Control and Complications Trial (DCCT) revolutionized intensive insulin treatment in individuals with type 1 diabetes. In the DCCT, improvements in metabolic control had significant and positive outcomes on the progression of microvascular complications secondary to diabetes.² The glycosylated hemoglobin A1c (HbA_{1c}) was on average 1% higher in adolescents compared to adults; in addition, short term adverse events such as severe

hypoglycemia occurred more frequently among adolescents.³ Thus, glucose control and disease management continues to be particularly more challenging for adolescents. Because of these factors and the longer life expectancy that accompanies youth, attention is needed for adolescents with diabetes in whom effective interventions can have large effects on future morbidity and mortality.

Background

Management of diabetes is complex and includes self monitoring of blood glucose levels, insulin administration, and adjusting for changes in blood glucose that occur secondary to diet, exercise, acute illness, and stress. These factors are complicated during the adolescent period due to evolving physical and social factors within this stage of life. In addition, short term adverse reactions such as hypoglycemia can complicate the management of the disease.

The goal for HbA_{1c} as set by the American Diabetes Association (ADA) is <8% for children ages 6–12 years and <7.5% (or <7% without excessive hypoglycemia) for adolescents ages 13–19 years.⁴ In current literature, most adolescents are above optimal range and thus have inadequate glycemic control. Previous samples from studies of children and adolescents with type 1 diabetes showed average HbA_{1c} ranging from 8.07%–9.07%.^{5–9}

Another measure for comparison and interpretation of metabolic outcomes is insulin dosing. The proper dose and administration of insulin, as well as adherence to insulin regimen, is essential to optimal glycemic control. On review of the literature, current doses of insulin for children and adolescents range from 0.8 to 1 units/kilogram/day (u/kg/day).^{5,7,8,10,11} The most common complication of insulin therapy is hypoglycemia, which can lead to a life-threatening emergency with loss of consciousness. With the advent of intensified insulin treatment, the risk of hypoglycemia has increased along with hypoglycemia unawareness, a condition where an individual receiving insulin is unable to recognize dangerously low blood glucose levels. These concerns are particularly salient for adolescents who are exerting greater levels of independence and autonomy from family and close friends who may be more aware of certain disease-related risks.

The risk of increased episodes of hypoglycemia accompanies the goal of improved glycemic control, especially in children and adolescents who are vulnerable to hypoglycemia due to large variability in intake and energy expenditures.⁴ Bulsara et al.⁵ investigated if there had been an increase in severe hypoglycemia since the introduction of tighter glycemic control as a treatment goal. Prospective data from 1,335 children and adolescents with type 1 diabetes were collected from 1992–2002; severe hypoglycemia was defined as low blood sugar leading to loss of consciousness or seizure. Over the ten years of data collection by Bulsara et al., insulin doses increased on average from 0.83 u/kg/day to 1 u/kg/day ($p<0.001$), incidence of severe hypoglycemia increased, and the average HbA_{1c} decreased at a rate of 0.2% per year (10.9% to 8.1%, $p<0.0001$). These data show that glycemic control improved at the expense of increased frequency of hypoglycemia. A limitation of this study was that modes of insulin delivery (pump versus multiple daily injections) were not differentiated.

Despite overall improvements in glycemic control due to tighter management of daily glucose levels with insulin dosing, individual adolescents frequently run the risk of having episodes of moderate to severe hypoglycemia, as well as hyperglycemia. A moderate level of hypoglycemia usually requires assistance of another person due to a change in ability to think clearly or feeling faint. Severe hypoglycemia can result in seizures and/or loss of consciousness, requiring emergency department or inpatient care. Rewers and colleagues⁸ found that being Caucasian, having a longer duration of diabetes, a coexisting psychiatric disorder and underinsurance predicted a greater chance of severe hypoglycemia in youth.

Families of adolescents with type 1 diabetes face the responsibility of balancing the shared roles of managing the therapeutic regime to prevent both hypoglycemia and hyperglycemia, juxtaposed to developmental concerns of youth at differing stages of maturity. Much of our current knowledge surrounding diabetes outcomes in adolescents is based on assessment and intervention with families. In teens with extremely poor glycemic control (e.g. $\text{HbA}_{1c} \geq 13\%$), the use of home-based, family-centered psychotherapy over an average of 6 months has shown statistically fewer hospitalizations and better metabolic control than a usual care group.¹² Other researchers have successfully incorporated family-focused interventions on education and group discussions, and the use of care ambassadors, non-medical personnel to assist with scheduling and promoting clinic attendance, to optimize glycemic control and to minimize the occurrence of moderate to severe hypoglycemia.^{6,11}

In summary, current research demonstrates that an increased HbA_{1c} is seen among adolescents who are older in age,⁹ and who are from ethnic minorities.^{10,13,14,15,16} Adolescents with a higher HbA_{1c} are more likely to have parents who are single,⁹ have lower education levels and lower household income levels.^{7,10} More frequent hypoglycemia is associated with increased duration of diabetes and Caucasian race.⁸ And finally, positive family involvement has shown to improve outcomes to reduce hypoglycemic reactions and hospitalizations.^{6,11,12} The research reviewed gives support for further study of the variables in this analysis.

The purpose of this study was to determine differences in key characteristics between adolescents with type 1 diabetes who experienced the adverse outcomes of poor glycemic control, hypoglycemic events, and hospitalizations due to their disease versus those who do not experience such events. A secondary purpose was to examine differences in outcomes for adolescents using insulin pumps versus those taking daily insulin injections (≥ 2). The specific research questions were:

1. Do adolescents with type 1 diabetes who experience inadequate glycemic control, hypoglycemic reactions, and diabetes-related hospitalizations exhibit differences in body mass index (BMI), insulin dose, or calorie intake when compared to those who do not experience such outcomes?
2. Are there differences in age, diabetes duration, Tanner stage of sexual maturation or frequency of self blood glucose checks for adolescents with type 1 diabetes who experience inadequate glycemic control?
3. Are there differences in BMI, glycemic control or insulin dose among adolescents using insulin pumps versus multiple daily injections (MDI)?
4. Are race, gender, parental education level, parental marital status, and annual family income associated with inadequate glycemic control, hypoglycemic reactions, diabetes-related hospitalizations, or insulin delivery (pump therapy versus MDI)?

Research Design and Methods

Research Design

The data for this investigation were obtained from a larger, cross-sectional descriptive study entitled “Cardiovascular Risks in Adolescents with Diabetes” (NIH R01 NR07719). The main purpose of this larger study was to explore differences in cardiovascular risks for adolescents with type 1 versus type 2 diabetes mellitus. The current study presented here incorporated a secondary analysis of demographic and clinical data generated from the participants with type 1 diabetes only. Secondary analysis of data is a research methodology in which data in a previous study are used to answer additional research questions concerning the specific sample. Such further analysis can aid in greater understanding of interrelationships of key variables that need future study.¹⁷ Secondary analysis offers a distinct advantage of allowing

investigators to use de-identified data to answer research questions in a less time-consuming manner than collecting original data from a similar study sample. A caveat of using secondary analysis is the importance of ensuring the timeliness and accuracy of the dataset. Given that the most common type of diabetes in adolescents is type 1 diabetes and that these youths experience repeat hospitalizations and occurrences of hypoglycemia more frequently than those with type 2 diabetes, the subset of adolescents with type 1 diabetes was selected for additional analysis of these selected outcomes in addition to glycemic control.

Sample and Setting

In the parent study, participants were adolescents diagnosed with type 1 or type 2 diabetes mellitus, ages 13–18 years, from diverse economic backgrounds, recruited from a diabetes care center in the metropolitan Chicago area. Data collection occurred from 2001–2007. The adolescent subjects needed to speak English; however, parental consents in Spanish were available. Subjects were excluded if their school grade was not appropriate to age within two years (to control for delays in cognitive, behavior, or psychological function), if diabetes had developed as a secondary condition during treatment for another chronic condition, or if the adolescent had known cardiac defects. Consent was obtained from a parent or legal guardian. The subjects also signed assent to participate. Approval for protection of human subjects was obtained through the Institutional Review Boards at the University of Illinois at Chicago and the University of Chicago.

Data Collection Procedures

All data were collected at the University of Illinois at Chicago, General Clinical Research Center, grant number NIH M01-RR-13987. The “Diabetes Treatment and Health Information Sheet for Adolescents with Diabetes” was a survey form developed for the parent study and was pertinent to this analysis. This form asked the subject to quantify the frequency of insulin injections and blood glucose monitoring. It also asked about previous hypoglycemic reactions and hospitalizations in the past year because of diabetes. Parents completed a questionnaire pertaining to demographic information (parent’s highest education level, occupation, marital status, and annual household income).

The subject’s medical record was reviewed for information on anthropomorphic measurements, insulin dose, and mode of delivery. The subjects also kept a three-day food record detailing all dietary intake for 72 hours. This record was reviewed individually with each subject by a registered dietician to verify amounts and then used to calculate the average daily macronutrient content using Nutritionist Pro™ software. The subjects had a one time laboratory draw for HbA_{1c}. Data were obtained by one researcher to assure consistency.

Outcome Measures

For the purpose of this analysis, data from subjects with type 1 diabetes were separated from the larger data set and then divided into groups for comparisons. The first comparison was glycemic control. Those with inadequate glycemic control, as defined by HbA_{1c} $\geq$ 8%, were compared to subjects with adequate glycemic control, defined as HbA_{1c} $<$ 8%. This division at 8% was made for two reasons. First, cited previously in this paper, the ADA sets the HbA_{1c} goal of 7.5% for adolescents 13–19 years of age. Second, the median HbA_{1c} of the data set was 8.4%. The average of these two values is 7.95%, thus leading to the 8% division.

The second comparison was according to the number of hypoglycemic events as measured by self report. Those who reported one or more hypoglycemic events in the past year (defined as an event leading them to need assistance from another person) were compared to those who reported no hypoglycemic events in the past year. The third comparison was between those who reported one or more hospitalizations in the past year due to their diabetes versus those

who reported no hospitalizations in the past year. A final comparison was done between subjects on pump therapy versus those receiving injections.

The independent variables examined for all four comparisons were demographic data, physical data, and dietary intake data. Demographic data included race, gender, annual household income, parental education level, and marital status of parents. The physical data were BMI and Tanner stage, a clinical assessment score from 1 to 5 reflective of sexual maturation. The dependent variables of diabetes-specific data were HbA_{1c} as measured from the one-time laboratory draw and insulin dose measured in u/kg/day. And finally, the average daily macronutrient intake of total calories (kcal) and percents of calories from each carbohydrates, proteins, and fats, as measured by the three-day food record, was analyzed in the four comparison groups.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS®, version 15.0, Chicago, IL) was used for statistical analyses of data. For research questions 1, 2, and 3, multiple independent 2-tailed t-tests were used to analyze differences between means of each of the interval level variables for the four comparison groups (glycemic control, hypoglycemic events, hospitalizations, and pump therapy versus injections). For research question 4, Chi-square analyses were used to test associations of categorical variables for the four comparison groups. The statistical significance level for all analyses was defined as $p \leq 0.05$.

Results

Description of Sample

Data were obtained on 109 adolescents with type 1 diabetes and then plotted on stem-leaf plots to look for extreme outliers. One subject, taking insulin injections, reported 35 hypoglycemic reactions in the past year. Due to this extremely different response, this subject's data were not used for any part of the analysis. Therefore, $n=108$ for most all of the following comparisons. Occasionally it was not possible to obtain a value from the subject's medical record, history, or demographic questionnaire and the n was adjusted accordingly in the tables.

Table 1 shows the ranges and mean values for the sample on weight, BMI, age, duration of diabetes, age at onset of diabetes, average insulin dose per day, HbA_{1c}, number of self blood glucose checks per day, and parental education level. The average HbA_{1c} of the sample was $8.7\% \pm 1.6$ (SD) and is consistent with the previously mentioned average HbA_{1c} from current literature ($8.07\%–9.07\%$).^{5–9} Also consistent with current literature, the average insulin dose of the sample was 1.02 ± 0.3 u/kg/day (mean $\pm$ SD). The literature cites a typical insulin dose range of 0.8–1 u/kg/day for adolescents.^{5,7,8,10,11}

The percentage breakdown of the sample for mode of insulin delivery, number of injections per day, gender, Tanner score, marital status of parents, and family income levels are also shown in Table 1. Of interest, 68.6% of subjects used injections and 31.4% used an insulin pump. Also, a majority of the subjects had parents who were married (67.6%), while 15.7% of subjects came from a single parent family and 16.6% had parents who were divorced or separated.

Macronutrient Content of Diet

Table 2 shows the breakdown of macronutrient intake for the study participants and compares the intake to the acceptable macronutrient distribution range (AMDR) set by the U.S. Department of Health and Human Services (USDHHS).¹⁸ The self-reported total caloric intake

of the subjects ranged from 782–4138 kcal per day. In addition, calories from fat ranged 19.5–69.9% and calories from saturated fats ranged from 6.3–19.2%.

Comparisons

The first comparison was glycemic control (Table 3). Subjects with an HbA_{1c} below 8% (n=42) had similar ages, duration of diabetes, Tanner scores, BMIs, and macronutrient intake as subjects with HbA_{1c} ≥ 8% (n=65). However, those with an HbA_{1c} <8% had a statistically significant lower insulin dose per day (0.9 u/kg/day versus 1.1 u/kg/day, p=0.005), higher father's education level (14.8 versus 13.2 years, p=0.007), and higher frequency of self blood glucose checks per day (4.9 versus 3.9, p<0.001) than those inadequately controlled.

The second comparison was hypoglycemic reactions requiring assistance from another person within the past year. There were 70 subjects who had never had such a reaction and 38 subjects who had one or more (Table 4). There were no statistical differences between the two groups on weight, BMI, HbA_{1c}, insulin dose, parental education level, or macronutrient intake.

Third, subjects who were hospitalized in the past year were compared to those who were not hospitalized (Table 5). No differences were found between groups on BMI, HbA_{1c}, insulin dose, parental educational level, or macronutrient intake. However, those subjects who were hospitalized one or more times in the previous year had a statistically lower caloric intake than those not hospitalized (2075.7 kcal versus 2446.2 kcal, p=0.03).

Finally, subjects who received insulin via pump (n=33) were compared with subjects who received insulin via injections (n= 75) (Table 6). The average insulin dose of subjects on pump therapy was 0.76 u/kg/day; those receiving injections had an average dose of 1.10 u/kg/day (p<0.001). The insulin pump dose was calculated as the average of total daily doses (including basal rate and boluses) from the prior three days as stored by the pump memory. The average HbA_{1c} of subjects who received insulin via pump was 7.9% compared to 9.0% for subjects on injections (p<0.001). The subjects on pump therapy had clinically and statistically improved blood glucose control and received less insulin.

Additional comparisons were done between the groups for the demographic data of gender, race, income level of family, and marital status of the parents. There were no differences among demographic variables between groups on hypoglycemic reactions, hospitalizations, and mode of insulin delivery. However, important differences were found between demographic data for average glucose control (Table 7). There were statistically significant differences based upon marital status of the parents. For subjects in adequate control, only 2.4% came from single parent families, while 78.6% had parents who were married. In comparison, 24.6% of subjects with poor glucose control resided with single parents versus 60% with married parents, p = 0.02.

Also, the subjects with poor control were more likely to come from a lower-income family. Of subjects in poor control, 23.8% had an annual family income of less than \$24,999 compared with just 4.8% of subjects with adequate control, p = 0.05. At the opposite end of the pay scale, 35.7% of subjects with adequate control came from families with an annual income of > \$95,000, while only 17.5% of subjects with poor control came from a family income of the same amount.

Discussion

The findings in this analysis indicate many factors can contribute to poor outcomes in adolescents with diabetes. Perhaps the most relevant findings for practice are those related to mode of insulin delivery and overall glucose control. The adolescents on pump therapy had

better glucose control in addition to the use of lower insulin doses. Similar outcomes of glucose control with pump therapy have been previously documented among adolescents,¹⁹ along with the combination of improved glucose control and lower insulin doses among adolescents on pump therapy.²⁰ Interestingly, there were no differences in demographic variables between subjects on pump therapy compared to subjects on daily injections. Therefore, subjects from lower income families, single parent homes, and African-American or Hispanic race had similar use of insulin pumps as subjects from higher income families, married parents, and Caucasian race.

This analysis also showed characteristics associated with favorable glucose control. The subjects with better control were on a lower insulin dose, checked their blood sugar more frequently, and had fathers with higher education levels than the cohorts with less adequate control. Previous research has shown adolescents who checked blood sugars more frequently had better overall glucose control.²¹ Possible explanations for this finding are adolescents who monitor blood glucose more frequently have a better understanding of the disease, more family involvement or pressure to manage their disease, or more resources for monitoring and management of disease. The finding of a lower insulin dose among those with better glucose control may be related to the previous finding that those on pumps had lower insulin doses and better control.

The statistically significant finding of higher educational levels among fathers of subjects with better glucose control supports previous findings from the southeastern region of the United States.²² However, this contradicts other research finding no difference in father's educational level in relation to HbA_{1c}.¹⁰ Reasons proposed for this relationship in the former study hypothesized that the father's education was an indirect indicator of income level.²² Income level was also shown in this analysis to be associated with more favorable glucose control.

Other differences were seen among the demographic variables when comparing subjects by glucose control. Subjects with poorer control were more likely to come from single parent families, lower income families, and were more likely to be African-American. Research has shown similar findings with income but saw no difference in parental marital status.¹⁰ Other research showed better glycemic control among children with married parents and interestingly related this to the number of glucose checks per day.⁹ The findings of a larger percentage of African-American adolescents in poorer metabolic control supports previous research as well.²³

No differences were found between clinical and demographic variables among those who suffered from one or more hypoglycemic reactions compared to those who had none. This contradicts findings of lower HbA_{1c} being associated with hypoglycemic reactions.²⁴ In addition, the only statistical difference between those subjects who were hospitalized versus those who were not hospitalized was lower caloric intake among subjects with a history of hospitalization. Subjects were asked about being hospitalized because of their diabetes, but were not asked to specify the reason for hospitalization. Reasons could vary from a hypoglycemic reaction to uncontrolled hyperglycemia to secondary infections. Because of this, it is difficult to interpret why a lower caloric intake would be seen among this group.

Also of note is the dietary intake of the group. According to the *Dietary Guidelines for Americans*, a balanced diet for adolescents should range from 2000 to 2800 kcal per day with 45–65% of calories from carbohydrates, 10–35% of calories from protein, 25–35% of calories from fats, and less than 10% of calories from saturated fats.¹⁸

The averages of nutrient intakes among the adolescents fell within the recommended ranges. However, the high range of calories and fat is alarming. Some subject's total caloric intake was as high as 3000 to 4000 kcal/day and calories from fat were as high as 50 to 70% of their

diet. A high-fat, high-calorie diet is of concern for long-term health implications in relation to obesity and cardiovascular disease, especially among adolescents with diabetes who have been shown to be prone to the latter.

Limitations

The first limitation in this analysis is some findings such as number of glucose checks per day, hypoglycemic reactions, hospitalizations, and nutrient intake are based on recall data. The variable of hypoglycemia could be more accurately defined by an actual measure of low blood glucose versus the self report of such an event.

A study assessed 7–12 year old children with type 1 diabetes on the accuracy of their 24 hour recall data and showed children under reported dietary intake.²⁵ This would account for the large variability of macronutrient intake among the adolescents as some subjects may have grossly under reported intake. Also, other variables could easily be under or over reported. This could account for lack of differences between the hypoglycemic reactions and hospitalizations comparisons if those children underestimated the events.

Also, this is a secondary analysis of a larger data set and therefore is limited to the data collected by the larger study. In addition, the data collected is from a correlational design. Therefore, cause-and-effect relationships cannot be established as would with a randomized control trial.²⁶ And finally, there were important findings related to differences among groups based upon marital status and household income level. The family as a unit was not the focus of the study and two parents in the home does not necessarily guarantee a more supportive environment.

Implications

This analysis contributes to existing research on adolescents with type 1 diabetes. The findings suggest that adolescents with type 1 diabetes with certain characteristics may need more guidance and supervision from clinic physicians and nurses to attain more favorable outcomes. These adolescents include those from single parent families, lower income families, and racial minorities. In addition, the strong association between pump therapy and more favorable glucose control in this analysis supports transitioning patients to pump therapy as soon as they are willing to do so. Adolescents must demonstrate a level of responsibility and knowledge of pump management. Family members need to be ready and available to provide the necessary support in order for their teens to be successful with pump therapy.

Further research is needed to explore how adolescents from single parent families and lower income families cope with and manage their diabetes. Also, research is needed to explain why differences exist in glucose control between adolescents with fathers who have a lower versus higher education level and adolescents from Hispanic and African-American versus Caucasian populations. Research should also explore if potential secondary factors among such groups such as literacy or access to care can be targeted for better outcomes.

The findings in this analysis show multiple factors contribute to glycemic control in an adolescent with diabetes. One of the primary management goals is to improve glycemic control thereby limiting complications and chronic conditions that arise secondary to the diabetes. Improving glycemic control among adolescents with type 1 diabetes will have long term implications for overall health and wellness of a large number of individuals worldwide.

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Table 1**Sample Demographic Characteristics**

Variable	(N = 108)
Weight	65.2 ± 14.7 Kg
BMI (Kg/m ²)	23.3 ± 4.1
Age (yrs.)	15.3 ± 1.9
Diabetes Duration (yrs.)	6.2 ± 3.7
Onset Age (yrs.)	9.1 ± 3.4 years
Insulin Dose (n=103)	1.02 ± 0.3u/kg/day
HbA1c (%)	8.7 ± 1.6
Self blood glucose checks/day	4.3 ± 1.3
Parental Education	13.8 ± 2.5 years
Maternal	13.9 ± 2.9 years
Paternal	
Gender	54.6%
Male	45.4%
Female	
Race	67.6%
Caucasian	26.8%
AfricanAmerican	5.6%
Hispanic	
Mode of insulin delivery	68.6%
Daily injections	31.4%
Pump	
# of Injections/day	55.6%
2-3/day	10.2%
4/day	2.8%
5-6/day	
Tanner Score	0.9%
1	4.3%
2	18.5%
3	24.0%
4	52.3%
5	
Marital Status of Parents	15.7%
Single	67.6%
Married	16.6%
Divorced/separated	
Household Income	15.7%
<\$24,999	15.7%
\$25,000-\$44,999	26%
\$45,000-\$74,999	16.6%
\$75,000-\$94,999	24.1%
>\$95,000	

Note: Data presented as either mean ± SD or percentage.

Table 2**Macronutrient Intake**

Macronutrient	Range	Mean	Recommended (by USDHHS ¹²)
Total Calories (kcal)	782 – 4139	2378 ± 676 (SD)	2000–2800
% of calories from carbohydrates	35.3–70.6%	50.0%	45–65%
% of calories from protein	8.3–25.7%	14.8%	10–35%
% of calories from fat	19.5–69.9%	37.0%	25–35%
% of calories from saturated fats	6.3–19.2%	12.9%	10%

Table 3
Differences between Adequate Versus Inadequate Glucose Control

Variable	HbA1c < 8% n=42	HbA1c ≥ 8% n=65	t	df	P value
BMI (kg/m ²)	23.0 ± 4.0	23.5 ± 4.0	-0.57	105	0.5
Age (yrs.)	15.1 ± 1.9	15.5 ± 1.9	-1.04	105	0.3
Duration of Diabetes(yrs.)	5.8 ± 3.9	6.5 ± 3.5	-1.01	105	0.3
Tanner score	4.2 ± 1.0	4.3 ± 0.9	-0.38	105	0.7
Insulin dose ¹ (u/kg/day)	0.9 ± 0.3	1.1 ± 0.3	-2.85	100	0.005**
Self blood glucose checks/day	4.9 ± 1.4	3.9 ± 1.1	3.93	105	0.001**
Total Calories (Kcal)	2409 ± 668	2360 ± 690	0.37	105	0.7
Father's ed. ² (yrs.)	14.8 ± 3.0	13.2 ± 2.7	2.74	96	0.007**
Mother's ed. ³ (yrs.)	14.3 ± 2.7	13.5 ± 2.3	1.46	100	0.1

**
P < .01

¹ for HbA1c<8%, n=38 and HbA1c ≥ 8%, n= 64

² for HbA1c<8%, n=41 and HbA1c ≥ 8%, n= 57

³ for HbA1c<8%, n=41 and HbA1c ≥ 8%, n= 61

Note: Data presented as either mean ± SD or percentage.

Table 4

Differences Related to Hypoglycemic Reactions*

Variable	1 or more hypoglycemic reactions (n=38)	No hypoglycemic reactions (n=70)	t	df	P value
BMI (Kg/m ²)	23.8 ± 3.9	23.0 ± 4.1	-0.96	106	0.34
HbA1c (%)	8.8 ± 1.6	8.6 ± 1.6	-0.59	106	0.52
Insulin dose ¹ (u/kg/day)	1.10 ± 0.3	0.98 ± 0.3	-1.92	101	0.06
Mother's ed. ² (vrs.)	13.8 ± 2.1	13.9 ± 2.7	0.13	101	0.90
Father's ed. ³ (vrs.)	13.6 ± 3.2	14.0 ± 2.8	0.59	97	0.56
Average total Calories (Kcal)	2419 ± 692	2355 ± 671	-0.47	106	0.64
Carbohydrate intake (as % of calories)	50.6 ± 6.3	49.8 ± 7.2	-0.58	106	0.56
Protein intake (as % of calories)	14.6 ± 2.8	14.9 ± 0.2	0.55	106	0.59
Fat intake (as % of calories)	37.4 ± 7.4	36.9 ± 7.4	-0.35	106	0.73

* Hypoglycemia defined as low blood sugar requiring assistance from another person

¹ Hypoglycemic reactions, n=37 and for no reactions, n=66

² Hypoglycemic reactions, n=34 and for no reactions, n=69

³ Hypoglycemic reactions, n=36 and for no reactions, n=63

Note: Data presented as either mean ± SD or percentage.

Table 5
Differences Attributed to Diabetes-Related Hospitalizations

Variable	No hospitalizations in the past year (n=88)	1 or more hospitalizations in the previous year (n=20)	t	df	P value
BMI (Kg/m ²)	23.3 ± 4.0	23.2 ± 4.0	0.07	106	0.94
HbA1c (%)	8.5 ± 1.4	9.4 ± 2.0	-1.70	23.4	0.10
Insulin dose ¹ (u/kg/day)	1.02 ± 0.3	1.02 ± 0.3	0.09	101	0.93
Mother's ed. ² (yrs.)	14.0 ± 2.5	13.2 ± 2.3	1.06	101	0.27
Father's ed. ³ (yrs.)	14.0 ± 3.0	13.4 ± 2.8	0.72	97	0.46
Average total Calories (Kcal)	2446 ± 657	2076 ± 689	2.26	106	0.03*
Carbohydrate intake (as % of calories)	49.9 ± 6.8	50.6 ± 7.4	-0.40	106	0.70
Protein intake (as % of calories)	14.8 ± 3.1	14.6 ± 3.1	0.21	106	0.83
Fat intake (as % of calories)	37.1 ± 7.7	37.2 ± 6.0	-0.06	106	0.95

¹ Hospitalization group, n=18 and for no hospitalization group, n=85

² Hospitalization group, n=19 and for no hospitalization group, n=84

³ Hospitalization group, n=18 and for no hospitalization group, n=81

* P ≤ .05

Note: Data presented as either mean ± SD or percentage.

Table 6

Differences Attributed to Mode of Insulin Delivery

Variable	Multiple daily injections (n=75)	Pump therapy(n=33)	t	df	P value
Weight (Kg)	63.1 ±14.0	69.9 ± 15.2	-2.50	104	0.03*
BMI (Kg/m ²)	23.0 ± 3.9	23.8 ± 4.2	-1.22	104	0.42
Insulin dose(u/kg/day)	1.10 ± 0.3	0.76 ± 0.2	7.90	93.9	<0.001***
HbA1c	9.0% ±1.6	7.9% ± 1.0	4.02	95.4	<0.001***

Note: Values expressed as mean ± SD.

* $P \leq 0.05$ ** $P \leq 0.01$

Table 7

Differences in Demographic Variables by Hypoglycemic Reactions, Hospitalizations, Insulin Delivery, and Glucose Control

Variable	No hypoglycemic reactions	Hypoglycemic reaction ≥ 1	No Hospitalization	≥ 1 Hosp.	Insulin pump	MDI	HbA1c <8%	HbA1c $\geq 8\%$
Parental marital status	n=70	n=38	n=88	n=20	n=33	n=75	n=42	n=65
Married	61.4%	78.9%	71.6%	50%	69.7%	66.7%	78.6%	60%
Single	18.6%	10.5%	14.8%	20%	18.2%	18.6%	2.4%	24.6%
Divorced/Separated	20%	10.5%	13.6%	30%	12.1%	30%	19%	15.3%
	χ^2 6.27(3), P=0.10		χ^2 4.81(3), P=0.19		χ^2 1.05(3) P =0.79		χ^2 10.33(3), P=.02*	
Annual family income	n=68	n=38	n=86	n=20	n=33	n=73	n=42	n=63
<\$24,999	16.2%	15.8%	14%	25%	21.2%	13.7%	4.8%	23.8%
\$25,000-\$44,999	17.6%	13.2%	14%	25%	15.2%	16.4%	14.3%	17.5%
\$45,000-\$74,999	20.6%	36.8%	27.9%	20%	30.3%	24.7%	26.2%	25.4%
\$75,000-\$94,999	17.6%	15.8%	15.1%	25%	21.2%	15.1%	19%	15.9%
>\$95,000	27.9%	18.4%	29.1%	5%	12.1%	30.1%	35.7%	17.5%
	χ^2 3.70 (4), P=0.45		χ^2 7.62 (4), P=0.11		χ^2 4.61 (4) P =0.33		χ^2 9.35 (4), P=.05*	
Race	n=70	n=38	n=88	n=20	n=33	n=75	n=42	n=65
Caucasian	65.7%	71.1%	70.5%	55%	60.6%	70.7%	83.3%	56.9%
African-American	27.1%	26.3%	23.9%	40%	33.3%	24%	11.9%	36.9%
Hispanic	7.1%	2.6%	5.7%	5%	6.1%	5.3%	4.8%	6.2%
	χ^2 1.01(2) P=0.60		χ^2 2.17(2), P=0.34		χ^2 1.11(2) P =0.58		χ^2 8.62(2), P=0.01*	
Gender	n=70	n=38	n=88	n=20	n=33	n=75	n=42	n=65
Male	57.1%	50%	58%	40%	54.5%	54.7%	59.5%	52.3%
Female	42.9%	50%	42%	60%	45.5%	45.3%	40.5%	47.7%
	χ^2 0.51(1), P = 0.48		χ^2 2.12 (1), P=0.15		χ^2 0.00 (1), P=0.99		χ^2 0.54 (1), P=0.46	

* P $\leq$.05