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Longitudinal Associations between Sex, Diabetes Self-Care, and Health-Related Quality of Life Among Youth with Type 1 or Type 2 Diabetes Mellitus

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Abstract

Objective—To examine the longitudinal associations between sex, diabetes self-care and the health-related quality of life (HRQL) of children and adolescents with Type 1 or Type 2 diabetes.

Study design—The sample included 910 Type 1 and 241 Type 2 participants, ages 10–22 at baseline, from SEARCH for Diabetes in Youth, a longitudinal observational study. The primary outcome measure was the Pediatric Quality of Life Inventory (PedsQL). Repeated measures,

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mixed model regression analysis was conducted using data from baseline and at least one follow-up assessment, spanning approximately 4 years.

Results—HRQL was higher among those with Type 1 versus Type 2 diabetes. Among Type 1 participants, higher (better) PedsQL total scores over time were related to higher parent education ($p=0.0007$), lower HbA1c values ($p<.0001$), and greater physical activity during the past 7 days ($p=0.0001$). There was a significant interaction between sex and age ($p<0.0001$); girls' HRQL remained stable or decreased over time, whereas males' HRQL increased. For participants with Type 2 diabetes, there was no significant interaction by age and sex, but lower total HRQL was related to being female ($p=0.011$) and higher BMI-z scores ($p=0.014$).

Conclusions—HRQL in this cohort varied by diabetes type. The interaction between sex and age for Type 1 participants, coupled with poorer HRQL among females than males with Type 2 diabetes, suggests the impacts of diabetes on HRQL differ by sex and should be considered in clinical management. Encouraging physical activity and weight control continue to be important in improving HRQL.

List of key words not in title

SEARCH for Diabetes in Youth; PedsQL; exercise; blood sugar testing

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Health-related quality of life (HRQL) is an important outcome for adolescents with diabetes, having been linked to better clinical markers such as HbA1c and better psychosocial health such as less depression and anxiety.[1–4] Although we know that improvements in diabetes management by adolescents can lead to improvements in quality of life,[5–6] self-care management and good glycemic control are difficult for many adolescents to attain and clearly are influenced by many variables.[2, 7] For example, self-care autonomy and reduced parental involvement have been shown to predict poorer self-care management.[2, 8–9] This can be problematic, given that adolescence is a time when youth routinely begin to assume more responsibilities for their daily care.

To date, the majority of research examining pediatric diabetes and HRQL has occurred in Type 1 youth, although Type 2 diabetes is becoming increasingly more common.[7, 10] There are important distinctions between Type 1 and Type 2 diabetes. Those with Type 1 diabetes require insulin, are typically of normal weight, and are diagnosed throughout childhood.[11] Pediatric cases of type 2 diabetes are most often diagnosed between the ages of 10 to 19 years of age, at a time when adolescents are becoming more independent from parents and peer influences predominate.[2] Type 2 incidence is strongly related to obesity, and treatment of these children chiefly involves lifestyle modifications in diet and exercise, but some also require daily medication.[12] Type 2 diabetes disproportionately affects families who may have less education or other resources, in contrast to Type 1 diabetes that can occur in families across the spectrum of socioeconomic status.[2] Comparisons of HRQL between those with Type 1 and Type 2 diabetes suggest that youth with Type 2 diabetes have lower HRQL than those with Type 1 diabetes.[13–15] However, children diagnosed with diabetes of either type generally need strong family assistance to manage their diabetes in the face of these challenges.[2]

Previous work has suggested that adolescent females are more likely than males to have poorer metabolic control, which may be due to hormonal changes during puberty[16] and/or poorer adherence to treatment and lifestyle recommendations.[17–18] Research on the relationship between sex, age, diabetes management and HRQL has led to some variation in results, due to a lack of longitudinal studies, varying ages of disease onset, different HRQL assessment tools, and/or a focus of Type 2 diabetes. Naughton et al reported a significant interaction between age and sex on generic HRQL among Type 1 participants; males reported higher (better) generic HRQL than females in the adolescent age groups, and HRQL was similar for males and females during the elementary school years.[13] No significant interaction by age and sex was found among youth with Type 2 diabetes. Lawrence et al examined diabetes-specific HRQL and reported lower diabetes-specific HRQL among females with Type 1 diabetes than males.[1] Although these analyses are cross-sectional, they suggest that adolescent females, in particular, may be at greatest risk for poorer HRQL.

To further explore these relationships using longitudinal data, the SEARCH incident cohorts were used to investigate the associations between sex, diabetes self-care management and the HRQL of children and adolescents with Type 1 or Type 2 diabetes. Self-care management was included to extend our previous cross-sectional work, given that more diabetes care is assumed by youth as they age. Based on previous research findings, we hypothesized that: (1) HRQL would be higher in Type 1 participants than Type 2 participants irrespective of age and sex; (2) HRQL would be higher in males than in females for both Type 1 and Type 2 participants as they aged; and (3) better diabetes self-management would be related to higher HRQL regardless of sex, for both Type 1 and Type 2 participants as they aged.

METHODS

SEARCH is a multicenter, population-based study of youth with non-gestational, clinically diagnosed diabetes who were less than age 20 at the time of diabetes diagnosis. [19] Participants were identified from geographically defined populations in Ohio, Washington, South Carolina and Colorado; from health plan enrollees in Hawaii and California; and among health service beneficiaries in three American Indian populations, and participants in the Pima Indian Study in Arizona.[20]

Prior to protocol implementation, the study was approved by the local Institutional Review Board(s) for each center. Adult participants and parents of youth under 18 years of age completed a brief survey to collect information on age at diagnosis, treatment history, and demographics (race/ethnicity; sex). Survey respondents, excluding those whose diabetes was secondary to another health condition, were then invited to a study visit. Written informed consent was obtained from participants older than 18 years of age or from a parent or guardian of minor children. Written assent was also obtained from minor participants as governed by local Institutional Review Board(s). During the study visit, additional clinical, demographic, and HRQL information was collected by participant interviews, and blood was drawn and urine was collected. A physical examination was completed to measure systolic and diastolic blood pressure, height, weight, and waist circumference. Youth whose diabetes was incident in 2002 through 2005 and who completed a baseline study visit were invited to return for follow-up visits at approximately 12, 24, and 60 months after their baseline visit.

For the current analyses, youth were included if they had Type 1 or Type 2 diabetes diagnosed between 2002–2005, and completed the baseline SEARCH study visit plus at least one follow-up visit. Because questions related to diabetes self-care and exercise habits were only asked of children 10 years of age and older, children under 10 years of age at the time of the initial clinic visit were excluded from these analyses. This resulted in 910 children with Type 1 diabetes of whom 319, 362, and 229 had 1, 2, or 3 follow-up assessments, respectively, with a mean time between the baseline and last visit of 3.9 years. For Type 2 diabetes, 241 youth were identified of whom 102, 94, and 45, had 1, 2, or 3 follow-up assessments, respectively, with a mean time between the baseline and last visits of 3.8 years.

In order to examine potential biases in the resultant cohorts due to demographic factors, we examined characteristics of those youth who did and did not return for at least one subsequent SEARCH clinic visit. These results indicated that participants who had any follow-up visits tended to be younger at their initial clinic visit than those who did not return in subsequent years (14.0 years versus 14.6 years, t-test $p<0.0001$). There were no differences in retention by sex (chi-square, $p=0.46$) or race/ethnicity (chi-square, $p=0.11$).

Measures

Diabetes and Health Information—Data were collected regarding the clinical presentation at diabetes onset, diagnostic laboratory testing, prior and concurrent medical conditions (eg, thyroid and/or kidney disorders, asthma, hypertension), diabetes treatment, concomitant medications, status of diabetes care, type of health care provider(s), household resources to assist in diabetes management, proportion of diabetes care completed by the child, type of health insurance, and other demographic items. This information was updated at each subsequent clinic visit.

Pediatric Quality of Life Inventory (PedsQL)—The PedsQL is a 23-item, multidimensional generic quality of life instrument designed for use with children and adolescents.[21–22] The form contains five subscales: physical health, psychosocial health, emotional functioning, social functioning, and school functioning. Both a total score and individual subscale scores can be calculated. Acceptable levels of reliability and validity for the PedsQL have been reported in both healthy and chronically ill children.[21–22] Scores range from 0–100, and higher PedsQL scores indicate better levels of functioning and HRQL. All participants self-administered these forms, although staff was available to provide assistance. The PedsQL was completed at each clinic visit.

HbA_{1c}—Blood samples obtained at the baseline study visit were processed locally and shipped on ice for analysis to the Northwest Lipid Laboratory, University of Washington-Seattle. An ion exchange unit, Variant II, Bio-Rad Diagnostics (Hercules, CA), quantified the glycated hemoglobin ($HbA1_{c}$). Normal values range from 3.9 – 6.1%. Optimal $HbA1_c$

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goals for children are: <8% for ages 8–12, <7.5% for 13–18 years olds, and < 7% for 18+ years.[23] Only baseline HbA1c values were used in the current analyses.

Body Mass Index Z-Score—Height and weight measurements collected at the baseline clinic visit were used to calculate body mass index (BMI) (kg/m^2). A BMI-z score was calculated by comparing each participant's BMI measure with age and sex specific standards published by the National Center for Health Statistics (NCHS). Using the 2000 Centers for Disease Control and Prevention U.S. age-specific growth charts, participants were classified as obese (BMI z-score ≥ 95^{th} percentile), overweight (85th to 95th percentiles), or normal (<85^{th} percentile).[24]

Self-Care Variable—This was a one-item question that asked the children/adolescents to estimate the proportion of their daily diabetes care they completed on their own. Response categories were: none, 1–25%, 26–75%, 76–99%, or all. This question was asked at baseline and at each of the follow-up visits.

Exercise in the Past 7 Days—Participation in physical activity was measured by one question that asked the children/adolescents on how many of the past 7 days they participated in physical activity that made them sweat or breathe hard. Responses ranged from 0–7 days. This question was asked at baseline and at each follow-up visit.

Type of insulin treatment—Type of insulin treatment was categorized as an ordinal variable with coding: 1) no treatment or oral medication only, 2) insulin less than 3 times per day, 3) insulin 3+ times a day, and 4) insulin pump. This question was asked at baseline and at each follow-up visit.

Statistical Analyses

Statistical analyses were conducted using repeated measures, mixed model analyses stratified by diabetes type. Dependent variables were the total score of the PedsQL (primary outcome) and the PedsQL subscale scores (secondary outcomes) from each visit. Analyses were conducted using the original scale for the PedsQL total and subscale scores (i.e., no transformations); model assumptions were checked and found to hold. Cronbach's alpha coefficients for the PedsQL total scores were calculated by age group, sex, and diabetes type, and indicated high levels of internal consistency reliability as outlined by Varni et al (ie, all > .70).[22] The demographic variables examined were sex, race/ethnicity, parent education, and type of health insurance. All demographic variables were treated as fixed in the mixed model analyses. The clinical variables included were the BMI-z score, duration of diabetes, type of diabetes treatment, and mean $HbA_{1c.}$ All clinical variables were time varying in the analyses. The self-care variables included in the models were the participants' estimates of the proportion of their diabetes care completed on their own, and exercise in the past 7 days. Both were time varying in the analyses. The physical activity variable was treated as a continuous measure. From the repeated measured mixed models, none of the correlations between any of these covariates and the PedsQL total score exceeded r=0.30.

The means of the PedsQL total and subscale scores by age group were calculated based on the scores reported by each participant while in that age range (Table II). For example, if a female participant was seen at age 13 and again at age 15, her average score from the two visits was used to calculate the mean for the category "13–15 year old females."

The demographic, clinical, and diabetes self-care variables by diabetes type were summarized as frequencies and percentages for categorical variables, and means and standard deviations for continuous variables. Mixed model regression models were then fit to look at the simultaneous effects of these variables on the PedsQL total and subscale scores by diabetes type. Due to our previous findings,[13] sex by age interaction terms were considered in the models. All analyses were completed using SAS Version 9.2. P-values less than 0.05 were considered statistically significant.

RESULTS

The baseline characteristics of the participants are presented in Table I. Youth with type 1 diabetes were predominantly male, non-Hispanic White, of normal weight, and younger than their counterparts with type 2 diabetes. Youth with type 2 diabetes were more likely to complete a higher percentage of their diabetes management on their own ($p<0.0001$), but tested their blood sugar less often per day ($p<0.0001$), and had engaged in exercise less frequently over the past 7 days ($p<0.0001$) than Type 1 participants.

In unadjusted analyses, HRQL was significantly higher (better) for youth with Type 1 diabetes as compared with those with Type 2 diabetes on all PedsQL total and subscale scores (Tables I and II). HRQL scores were also generally higher for males than females for both Type 1 and Type 2 participants (Table II). Among the Type 1 youth, there were significant interactions between age and sex for all PedsQL total and subscale scores; girls' HRQL scores remained stable or decreased over time, whereas males' HRQL scores increased. Among the Type 2 participants, there were no significant interactions by age and sex. Both the males and females with Type 2 diabetes had significantly higher (better) PedsQL total subscale scores as they aged, except for physical and emotional functioning.

Repeated measures mixed model regression was used to examine the effects of demographic, clinical, and diabetes management variables on the PedsQL total and subscale scores by diabetes type from the baseline through the follow-up assessments. For Type 1 participants (Table III), there was a significant interaction between sex and age on all PedsQL total and subscale scores. In general, these results indicated that boys had stable or significant improvements in HRQL as they aged, whereas the girls reported significantly worse emotional, school, social functioning and total HRQL as they grew older. Higher parent education was significantly related to all PedsQL subscales and total scores, and having private health insurance, compared with no health insurance, was positively related to better reported physical ($p=0.0079$), social ($p=0.0021$) functioning over time. HbA1c values at baseline were negatively associated with all PedsQL subscale and total scores, indicating that those with better glycemic control reported higher HRQL and functioning over time. There was no association between HRQL and the percentage of diabetes self-care completed on their own, but there were highly positive associations between the number of days the participants engaged in physical activity over the past 7 days, and higher (better) total PedsQL and all subscale scores, except for school functioning.

Results for the Type 2 participants are presented in Table IV. Given the relatively small sample of Type 2 youth, more emphasis should be placed on differences in the size of the beta coefficients than on the p-values when comparing the results from those with type 1 and those of type 2 diabetes. Among the Type 2 participants, females had lower PedsQL total, emotional, physical and psychosocial functioning than the males. Unlike the Type 1 youth, however, there was no significant interaction between sex and age. Age was a positive predictor for better psychosocial and social functioning among Type 2 participants. Being non-Hispanic White was positively related to better physical functioning (p=0.016). Having private health insurance was positively related to better emotional (p=0.008), psychosocial (p=0.044) and social functioning (p=0.024). Higher BMI_z scores were related to poorer psychosocial (p=0.01), school (p=0.035), social (p=0.013), and total PedsQL score (p=0.014). With respect to diabetes self-care, there were no significant HRQL differences by the percentage of diabetes self-care completed by the youth, or by HbA1c values. Exercise in the past 7 days, however, was significantly related to better emotional (p=0.012) and school functioning (p=0.047) over time.

DISCUSSION

Similar to previous studies, we found that youth with Type 1 diabetes reported higher HRQL over time on the PedsQL total and all subscales than the Type 2 participants. Female participants also generally had lower PedsQL total and subscale scores than the males over time, regardless of diabetes type.

In further examination of the effect of sex on HRQL, we observed an age by sex interaction for youth with Type 1 diabetes, with girls reporting poorer quality of life in adolescence as they grew older, whereas boys experienced improvement in quality of life as they aged. For children/adolescents with Type 2 diabetes, there was no significant sex by age interaction, although the males reported higher HRQL than the females on the total PedsQL and all subscales, except for school and social functioning. These results were similar to our prior cross-sectional analyses,[13] and reaffirm the differential effect of pediatric diabetes on the HRQL of males and females.

It is unclear why HRQL appears to be poorer for females than males. Adolescence can be a difficult stage of life for both sexes, but psychosocial and emotional concerns may pose more difficulties for girls.[25] Metabolic control may be harder to achieve during adolescence due to hormonal factors at puberty,[16] and long-term data suggests that females have higher HbA1c levels than males over time.[26–27] However, we did not find any significant differences between the male and female participants' abilities to achieve metabolic control, as measured by HbA1c levels. Mean HbA1c levels among the Type 1 participants were 7.8 for females and 7.6 for males (p=0.11). HbA1c values between the males and females with Type 2 diabetes (i.e., 7.4 for females and 6.9 for males among the Type 2 participants (p=0.06). This suggests that girls' lower HRQL during this follow-up period may be related more to social or psychological variables than to sex differences in glycemic control. We were unable to examine this more fully, however, given the lack of psychosocial variables in the SEARCH study.

Among youth with Type 1 diabetes, completing a higher percentage of their diabetes care was related to better social functioning, but not with other aspects of HRQL. There were also no significant associations between self-care and HRQL among Type 2 participants. We did, however, find a positive association between the number of days the Type 1 youth engaged in exercise over the past 7 days and better HRQL. Only the school subscale was not impacted by physical activity. For type 2 youth, more days of exercise were related to better emotional and social functioning. Exercise has been found to be an effective means of lowering and maintaining normal HbA1c levels, reducing excess body weight and the need for some diabetes medications in Type 2 youth.[28–30] Its benefits in those with Type 1 diabetes, however, are somewhat mixed.[31] There is poor evidence linking exercise to controlling blood glucose levels, and there is a risk of hypoglycemia in some individuals. Aman et al[32] reported better psychological functioning in a multi-center study of 11–18 year olds with Type 1 diabetes who reported greater physical activity, although only a weak association between exercise and glycemic control was observed. Engaging in physical activity for Type 1 participants may improve HRQL, but patient safety, including regular glucose monitoring, and insulin adjustment, if appropriate, is important to monitor depending on the type of physical activities selected by the participants.

Major strengths of the SEARCH study are the large sample size, the extensive clinical and behavioral information gathered in a standardized manner, the inclusion of youth with Type 1 and Type 2 diabetes, a multi-racial/ethnic cohort, and longitudinal data. Our ability to assess quality of life associations over time by sex, age and other demographic and clinical variables enables us to build on previous work, [1, 13, 19]. Limitations of our study data, however, include any biases from having a greater representation of younger children/ adolescents in the follow-up visits, and the lack of additional psychosocial variables that would have been useful in explaining the study results.

These study results suggest that clinicians should be mindful of the potential quality of life detriments for youth, most specifically for adolescent girls, following the diagnosis and treatment of either Type 1 or Type 2 diabetes. The daily management of the condition is impacted by the patients’ age and social environment. Implementing supports in clinical practice and in the family to assist youth to better cope with and manage their diabetes has the potential to improve HRQL in youth with diabetes. In addition, the positive association between exercise and HRQL may be a useful tool in improving HRQL among those with Type 1 diabetes.

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Appendix

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Table 1

Demographic and Clinical Characteristics of the Incident 2002–2005 SEARCH for Diabetes in Youth Study Participants at the Baseline Visit by Diabetes Type*

	Type 1: n (%)	Type 2: n (%)	p-value
Total Number	910	241	
Sex			
Male	480 (52.8%)	92 (38.2%)	p<0.001
Female	430 (47.2%)	149 (61.8%)	
Race/Ethnicity			
African American	95 (10.4%)	88 (36.5%)	
Hispanic	97 (10.7%)	56 (23.2%)	p<0.0001
Non-Hispanic White	679 (93.3%)	49 (20.3%)	
Other	39 (4.3%)	48 (19.9%)	
Age at Baseline Visit			
10–12 years	421 (46.3%)	56 (23.2%)	p<0.0001
13–15 years	463 (50.9%)	167 (69.3%)	
≥ 16 years	26 (2.9%)	18 (7.5%)	
Mean age in years (SD)	13.6 (2.4)	15.2 (2.5)	p<0.0001
Parent Education			
Less than high school graduate	39 (4.3%)	35 (14.6%)	
High school graduate	131 (14.5%)	79 (33.1%)	p<0.0001
Some college – Associate degree	319 (35.2%)	85 (35.6%)	
Bachelor’s degree or higher	416 (46.0%)	40 (16.7%)	
Health Insurance			
Private	726 (80.6%)	128 (53.3%)	
Medicaid/Other Government Program	144 (16.0%)	94 (39.2%)	p<0.0001
Other	12 (1.3%)	10 (4.2%)	
None	19 (2.1%)	8 (3.3%)	
BMI Category			
Normal weight (< 85th percentile)	586 (65.8%)	17 (7.3%)	p<0.0001
Overweight (85th – 95th percentile)	189 (21.2%)	19 (8.2%)	
Obese (> 95 th percentile)	116 (13.0%)	196 (84.5%)	
Mean BMI-z Score (SD)	0.57 (0.95)	2.10 (0.75)	p<0.0001
Mean Duration of Diabetes in Months (SD)	10.1 (6.5)	11.8 (7.3)	p=.0007
HbA1c			
< 7%	345 (40.5%)	141 (61.8%)	
7% to 8.99%	368 (43.2%)	47 (20.6%)	p<0.0001

	Type 1: n (%)	Type 2: n (%)	p-value
≥ 9%	139 (16.3%)	40 (17.5%)	
Mean HbA_{1C} Percent (SD)	7.69 (1.68)	7.21 (2.13)	P=0.0002
Treatment			
Oral or no diabetes medications	15 (1.7%)	158 (66.1%)	
Insulin < 3 times per day	348 (38.4%)	55 (23.1%)	
Insulin 3+ times per day	465 (51.4%)	26 (10.9%)	p<0.0001
Insulin pump	77 (8.5%)	0 (0.0%)	
Proportion of Self-Care Completed On Own:			
None	7 (0.8%)	10 (4.2%)	
Less than 25%	41 (4.5%)	22 (9.2%)	p<0.0001
25% – 75%	288 (31.8%)	59 (24.6%)	
More than 75%	327 (36.1%)	59 (24.6%)	
All of it	243 (26.8%)	90 (37.5%)	
Daily Blood Sugar Testing, mean (SD)	4.72 (0.68)	3.53 (1.35)	p<0.0001
Number of Days of Exercise in Past 7 Days, mean (SD)	3.54 (2.26)	2.85 (2.26)	p<0.0001
PedsQL Total Score, mean (SD)	82.5 (12.2)	75.2 (16.2)	p<0.0001
Physical Health Subscale, mean (SD)	87.2 (12.2)	80.3 (17.7)	p<0.0001
Psychosocial Subscale, mean (SD)	79.7 (13.9)	72.5 (17.6)	p<0.0001
Emotional Functioning Subscale, mean (SD)	77.0 (18.5)	69.9 (21.2)	p<0.0001
Social Functioning Subscale, mean (SD)	89.0 (14.5)	80.5 (20.1)	p<0.0001
School Functioning Subscale, mean (SD)	73.2 (18.1)	66.9 (21.2)	p<0.0001

Table 2

Means (Standard Error) of the PedsQL Total and Subscale Scores by Age, Sex, and Diabetes Type*

		Age				p-value for age trend	p-value for age by sex interaction
Type	**Sex**	**10–12**	**13–15**	**16–18**	**19+**		
PedsQL Total Score							
1	Female	83.7 (0.7)	81.6 (0.6)	80.2 (0.7)	82.8 (0.8)	0.14	< 0.001
	Male	82.5 (0.7)	83.4 (0.6)	84.0 (0.6)	85.5 (0.7)	< 0.001	
2	Female	73.2 (2.6)	73.8 (1.3)	76.2 (1.3)	77.5 (1.4)	0.032	0.54
	Male	74.7 (3.8)	78.2 (1.8)	81.2 (1.6)	84.5 (1.6)	0.005	
Physical Health Subscale							
1	Female	87.3 (0.7)	86.8 (0.6)	84.7 (0.7)	85.7 (0.9)	0.025	< 0.001
	Male	87.6 (0.7)	89.3 (0.6)	89.8 (0.6)	90.2 (0.8)	0.008	
2	Female	79.0 (2.8)	79.3 (1.5)	79.7 (1.4)	79.8 (1.6)	0.99	0.31
	Male	83.1 (3.7)	83.4 (2.0)	86.9 (1.7)	87.6 (1.7)	0.15	
Psychosocial Subscale							
1	Female	81.8 (0.8)	78.9 (0.7)	77.9 (0.8)	81.4 (0.9)	0.43	< 0.001
	Male	79.7 (0.8)	80.2 (0.7)	80.8 (0.7)	83.0 (0.8)	< 0.001	
2	Female	70.4 (2.9)	71.1 (1.4)	74.6 (1.4)	77.0 (1.6)	< 0.001	0.74
	Male	70.1 (4.2)	75.5 (1.9)	78.2 (1.8)	82.6 (1.8)	0.003	
Emotional Functioning Subscale							
1	Female	78.0 (1.1)	75.0 (0.9)	73.5 (1.0)	73.6 (1.3)	0.006	0.009
	Male	78.0 (1.1)	80.3 (0.9)	79.8 (0.9)	78.5 (1.2)	0.35	
2	Female	65.7 (3.2)	68.1 (1.8)	70.3 (1.8)	68.4 (2.2)	0.71	0.95
	Male	71.9 (4.5)	74.7 (2.5)	77.1 (2.3)	76.1 (2.6)	0.68	
Social Functioning Subscale							
1	Female	91.2 (0.8)	90.1 (0.7)	90.1 (0.7)	93.2 (0.9)	0.047	0.035
	Male	87.2 (0.9)	88.5 (0.7)	89.6 (0.7)	91.4 (0.8)	< 0.001	
2	Female	79.1 (3.4)	78.2 (1.7)	84.3 (1.7)	86.7 (1.7)	< 0.001	0.33
	Male	77.9 (4.6)	84.0 (2.3)	86.4 (2.1)	89.8 (1.9)	0.012	

		Age				p-value for age trend	p-value for age by sex interaction
Type	**Sex**	**10–12**	**13–15**	**16–18**	**19+**		
School Functioning Subscale							
1	Female	76.2 (1.0)	71.9 (0.9)	70.1 (1.1)	77.7 (1.2)	0.63	0.001
	Male	73.9 (1.0)	71.8 (0.9)	73.1 (1.0)	78.9 (1.1)	< 0.001	
2	Female	66.7 (3.4)	66.2 (1.7)	67.9 (1.7)	74.2 (2.0)	0.002	0.15
	Male	61.6 (4.8)	67.5 (2.4)	71.5 (2.2)	82.0 (2.2)	< 0.001	

*means of the PedsQL total and subscale scores by age group were calculated based on the scores reported by each participant while he/she was in that age range. If multiple scores were obtained from a participant in an age category, the mean of the multiple scores was used in these analyses.

Table 3

Mixed Model Regression Assessing the Impact of Demographic, Clinical, and Diabetes Self-Care Management Variables on the PedsQL Subscales and Total Score (Type 1)

	PedsQL SUBSCALES					PedsQL Total Score B +/− SE (p value)
	Emotional B +/− SE (p value)	Physical B +/− SE (p value)	Psychosocial B +/− SE (p value)	School (≤ 18.5 years) B +/− SE (p value)	Social B +/− SE (p value)	
Female	4.98±3.81 (0.19)	8.05±2.46 (0.0011)	9.65±2.81 (0.0006)	16.60±4.96 (0.0008)	9.99±2.92 (0.0007)	8.99±2.42 (0.0002)
Female*Age^	(0.014)	(< 0.0001)	(0.0001)	(0.0009)	(0.0059)	(< 0.0001)
M: Age	0.09±0.19 (0.64)	0.39±0.13 (0.0018)	0.46±0.14 (0.0006)	−0.04±0.25 (0.87)	0.49±0.15 (0.0012)	0.44±(0.12) (0.0001)
F: Age	−0.50±0.19 (0.0084)	−0.29±0.13 (0.024)	−0.22±0.14 (0.11)	−1.16±0.26 (< 0.0001)	−0.05±0.15 (0.74)	−0.24±0.12 (0.043)
BMI_z	−0.73±0.54 (0.17)	−0.03±0.36 (0.94)	−0.35±0.42 (0.41)	0.45±0.58 (0.43)	−0.86±0.40 (0.034)	−0.21±0.38 (0.57)
Race: Black	1.43±1.83	2.06±1.22	1.17±1.44	0.68±1.97	0.65±1.38	1.65±1.28
Hispanic	−2.80±1.70	−0.65±1.12	−1.00±1.44	−2.26±1.80	1.07±1.38	−0.97±1.19
Other	2.38±2.67	1.33±1.82	0.93±2.10	−2.11±2.91	3.09±2.05	1.27±1.88
White	0 (0.19)	0 (0.27)	0 (0.65)	0 (0.51)	0 (0.43)	0 (0.37)
Parent Education	1.28±0.67 (0.056)	1.39±0.45 (0.0019)	1.72±0.52 (0.0010)	4.00±0.72 (<0.0001)	1.05±0.50 (0.039)	1.58±0.47 (0.0007)
Health Insurance						
None	−5.77±3.49	−2.04±2.45	0.02±2.74	4.37±4.13	2.51±2.75	−0.85±2.45
Other	−0.95±4.48	−9.38±3.07	−5.03±3.50	−4.08±4.80	−12.81±3.46	−6.08±3.12
Medicaid/Care	−0.35±1.57	−1.66±1.03	−0.97±1.23	−1.09±1.66	−0.57±1.17	−1.30±1.10
Private	0 (0.43)	0 (0.0079)	0 (0.45)	0 (0.49)	0 (0.0021)	0 (0.17)
Type of Insulin Treatment	−0.77±0.77 (0.32)	−0.54±0.51 (0.29)	−0.57±0.61 (0.34)	−0.25±0.83 (0.76)	−0.50±0.58 (0.39)	−0.48±0.54 (0.37)
HbA1c	−0.91±0.31 (0.0031)	−0.71±0.21 (0.0007)	−0.92±0.24 (0.0002)	−1.22±0.34 (0.0004)	−0.68±0.24 (0.0041)	−0.85±0.22 (< 0.0001)
% of Diabetes Self- Care Completed						
None	0 (0.094)	0 (0.11)	0 (0.58)	0 (0.98)	0 (0.062)	0 (0.50)
Less than 25%	5.41±6.12	1.68±3.83	3.85±4.42	2.46±6.29	4.69±4.60	2.93±3.76
25–75%	8.79±5.84	2.85±3.65	5.38±4.21	1.80±6.01	7.00±4.39	4.22±3.58
More than 75%	9.89±5.84	3.92±3.65	5.42±4.21	1.82±6.01	7.94±4.39	4.54±3.59
All of it	9.62±5.88	3.04±3.68	5.55±4.24	2.16±6.05	8.30±4.42	4.28±3.61
Exercise in 7 Days	0.38±0.15 (0.014)	0.64±0.10 (< 0.0001)	0.26±0.11 (0.019)	0.146±0.17 (0.39)	0.31±0.12 (0.010)	0.37±0.10 (0.0001)

^Test of the difference in slopes for males and females

Table 4

Mixed Model Regression Assessing the Impact of Demographic, Clinical, and Diabetes Self-Care Management Variables on the PedsQL Subscales and Total Score (Type 2)

	PedsQL SUBSCALES					PedsQL Total Score B +/− SE (p value)
	Emotional B +/− SE (p value)	**Physical B +/− SE (p value)**	**Psychosocial B +/− SE (p value)**	**School (ages ≤ 18.5) B +/− SE (p value)**	**Social B +/− SE (p value)**	
Female	−6.76±2.47 (0.0066)	−5.86±1.89 (0.0020)	−3.86±1.94 (0.048)	−1.77±2.58 (0.49)	−2.88±2.12 (0.17)	−4.57±1.78 (0.011)
Age	−0.29±0.29 (0.32)	−0.28±0.24 (0.25)	0.58±0.23 (0.012)	0.52±0.53 (0.32)	0.90±0.27 (0.0010)	0.29±0.21 (0.18)
BMI_z	−3.05±1.63 (0.062)	−2.16±1.25 (.084)	−3.31±1.28 (0.010)	−4.50±2.12 (0.035)	−3.49±1.40 (0.013)	−2.89±1.17 (0.014)
Race: Black	3.15±3.34	5.35±2.55	3.84±2.62	6.01±3.49	3.62±2.86	4.37±2.41
Hispanic	3.50±3.71	6.24±2.83	4.10±1.91	6.83±3.87	3.27±3.18	4.83±2.67
Other	−0.51±3.96	−0.71±3.02	0.26±3.11	5.80±4.22	−2.35±3.39	−0.09±2.85
White	0 (0.55)	0 (0.016)	0 (0.27)	0 (0.17)	0 (0.16)	0 (0.082)
Parent Education	−0.60±1.33 (0.65)	0.11±1.01 (0.92)	−0.75±1.04 (0.47)	−1.50±1.46 (0.31)	−1.03±1.14 (0.36)	−0.45±0.96 (0.63)
Insurance:						
None	−18.87±6.59	−8.02±5.05	−14.08±5.18	−7.01±7.08	−17.43±5.67	−11.91±4.76
Other	−2.89±7.26	−0.31±5.51	−2.06±5.70	−7.25±9.88	−0.38±6.20	−1.52±5.23
Medicaid/Care	3.31±2.57	−3.38±1.96	0.60±2.02	−1.32±2.68	−0.67±2.20	−0.79±1.85
Private	0 (0.0080)	0 (0.19)	0 (0.044)	0 (0.69)	0 (0.024)	0 (0.10)
Type of Insulin Treatment	1.05±1.86 (0.57)	2.45±1.42 (0.086)	0.24±1.46 (0.87)	−1.09±1.92 (0.57)	−0.61±1.59 (0.70)	1.03±1.34 (0.44)
HbA1c (mean)	0.00±0.63 (1.00)	−0.03±0.48 (0.95)	−0.07±0.49 (0.89)	0.11±0.72 (0.88)	0.10±0.54 (0.85)	−0.05±0.45 (0.92)
% of Diabetes Self- Care Completed						
None	0 (0.12)	0 (0.11)	0 (0.12)	0 (0.10)	0 (0.43))	0 (0.13)
Less than 25%	−6.12±4.75	−5.34±4.10	−1.84±3.78	4.25±5.88	−0.96±5.53	−3.00±3.50
25%–75%	−3.11±4.47	−1.67±3.84	2.50±3.56	9.93±5.40	1.79±4.25	0.93±3.30
More than 75%	−1.67±4.50	1.48±3.85	2.67±3.58	8.67±5.47	4.12±4.26	2.09±3.32
All of it	1.03±4.32	3.90±3.71	4.41±3.43	11.52±5.33	3.49±4.10	2.81±3.18
Exercise in 7 Days	0.86±0.34 (0.012)	0.54±0.29 (0.061)	0.47±0.27 (0.083)	0.32±0.43 (0.45)	0.64±0.32 (0.047)	0.463±0.25 (0.064)