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Psychological screening in adolescents with type 1 diabetes predicts outcomes one year later

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Abstract

Aims—Adolescents with type 1 diabetes are at increased risk for depression and anxiety, which can adversely affect diabetes management, glycemic control, and quality of life (QOL). However, systematic psychological screening is rarely employed. We hypothesized that higher depression and anxiety screener scores would predict higher HbA1c, less frequent blood glucose monitoring (BGM), and poorer QOL one year later. Raw screener scores were expected to be more robust predictors than cutoff scores.

Methods—150 adolescents age 13–18 with type 1 diabetes completed depression and anxiety screeners. One year later, blood glucose meters were downloaded to assess BGM frequency, HbA1c values were obtained, and caregivers rated the participants' QOL. Separate regressions were conducted for each outcome, including demographic and medical covariates.

Results—Higher depression scores predicted less frequent BGM (b=−0.05, p<.05) and poorer QOL (b=−0.71, p<.01), and higher state anxiety scores predicted higher HbA1c (b=0.07, p<.05). Continuous screener scores identified risk for 12-month outcomes more robustly than clinical cut-off scores.

Conclusions—Psychological screeners predict diabetes outcomes one year later. Future clinical research studies should explore whether psychological screening and referral for appropriate intervention can prevent deteriorations in diabetes management and control commonly seen during adolescence.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Keywords

depression; anxiety; adherence; glycemic control; quality of life

Introduction

Depression and anxiety are of significant concern during adolescence [1], and teens with type 1 diabetes have at least double the risk for developing these disorders [2,3]. Psychological symptoms complicate diabetes management and detract from regular blood glucose monitoring (BGM), subsequently leading to suboptimal glycemic control [4,5,6]. Ultimately, the impact of depression and anxiety on diabetes adherence and glycemic control results in greater healthcare utilization [7] and higher medical costs [8].

Universal recommendations for routine psychological screening in adolescence [9] have been emphasized for teens with type 1 diabetes due to the elevated risks and consequences of psychological symptoms in this at-risk population [10,11,12]. However, implementation of screening in pediatric diabetes centers has lagged behind its recognized need due to significant barriers (e.g., cost, resources to respond to screening results) and lack of long-term data demonstrating its utility. Most of the research linking symptoms of depression or anxiety with diabetes outcomes has examined cross-sectional [3,4,5] or short-term associations [13] or has considered psychiatric symptoms more broadly [6]. No studies have compared screeners of anxiety and depressive symptoms as predictors of long-term glycemic control and other diabetes outcomes. Thus, the aim of this study was to investigate the ability of psychological screening to predict diabetes management and glycemic control one year later. Heath-related quality of life (QOL) was examined as an additional outcome given its associations with diabetes health behaviors and outcomes [14]. We hypothesized that higher levels of depression and anxiety would predict poorer health and QOL outcomes and that raw scores on screening measures would be more robust predictors than cutoff scores.

Subjects

As part of an ongoing, prospective, observational study, adolescents were recruited if they were between the ages of 13 and 18, had a diagnosis of type 1 diabetes according to American Diabetes Association criteria [11], were fluent in English, and did not have a severe psychiatric, neurocognitive, or other serious chronic medical condition that would make participation difficult. A convenience sample of 150 adolescents and their caregivers provided consent/assent at their regularly scheduled clinic visits, out of the 166 eligible diabetes center patients approached (90%) over a period of 6 months. Data were available from 145 dyads at 12-month follow-up (97% retention rate). Characteristics of this sample have been described at baseline [5] and short-term follow-up [13, 15].

Materials and Methods

At the baseline visit, adolescents completed two self-report psychological screeners. The Children's Depression Inventory (CDI) [16] is a widely-used measure of depressive symptoms. Across 27 items, adolescents rate their level of depression; higher scores reflect more depressive symptoms (possible range: 0–54). A clinical cutoff of 13 was used in this study, consistent with past studies [2,3,16]. Internal consistency of the CDI in this sample was excellent, α=0.90. The state scale of the State-Trait Anxiety Inventory for Children (STAIC) [17] was also completed at baseline. It is an indicator of current anxiety symptoms, includes 20 items (possible range: 0–40), and higher scores indicate more anxiety. While the

STAIC does not have a clinical cutoff, one standard deviation above the sample mean has been used to denote clinically elevated anxiety symptoms in previous research [4]. Internal consistency of the STAIC-state in this sample was excellent, α=0.87.

One component of adolescent adherence to the diabetes regimen was assessed with BGM frequency. A medical record review was conducted at baseline and 12 months by trained research assistants to obtain downloaded meter data over the previous two weeks, and the mean BGM frequency for each time point was calculated. At 12-month follow-up, BGM data were available through meter downloads for 56% of the sample. In the absence of more objective data, chart reviews reflecting clinician review of meter data or frequency assessment based on clinic visit were available for 34% and self-report was available for 10%. BGM frequency did not vary by data source, $F(2, 144) = 1.24$, $p = 0.29$.

Glycemic control was assessed using glycosylated hemoglobin A1c (HbA1c), measured with the DCA+ 2000 (reference range: 4.3–5.7%, Bayer Inc.; Tarrytown, NY, USA). HbA1c values were obtained at regular clinic visits and abstracted from the medical chart.

Parents rated their teens' health-related QOL at each time point using three subscales of the PedsQL™ Diabetes Module [18]: treatment adherence, treatment barriers, and worry. Parents rated the amount of difficulty their children have with 14 diabetes-specific behaviors or emotions, and scores are linearly transformed such that higher scores indicate better QOL. Internal consistency in this sample was adequate, α=0.73.

Demographic and medical information, including adolescent age, gender, ethnicity; caregiver marital status and education level; duration of diabetes; insulin delivery method – multiple daily injections (MDI) versus continuous subcutaneous insulin infusion (CSII); and insurance coverage (public versus private), were collected by parent-report on a background questionnaire and verified through medical chart review. The number of contacts each teen had with a mental health provider (psychology, psychiatry, social work) within the hospital between baseline and 12-month follow-up was calculated through electronic medical record review of confirmed appointments.

Statistical Analysis

First, we ran baseline correlations between the screeners (CDI, STAIC-state) and health behaviors and outcomes (BGM frequency, HbA1c, QOL). Next, we tested multivariate models (within the general linear model framework) to determine the ability of the CDI and STAIC-state scores at baseline to predict each of the three outcomes 12 months later. A separate model was tested for each dependent variable. The CDI score and STAIC-state score were simultaneously entered as predictors in each model. All measured demographic and medical covariates were included to account for the theorized associations between adolescents' demographic and medical context and the diabetes outcomes of interest. To evaluate the utility of using clinical cutoffs rather than continuous raw scores for the screening tools, we ran each model a second time using dummy-coded CDI and STAIC-state scores (0=below cut-off, 1=above cut-off), in addition to the covariates, as predictors. Statistical analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC).

Results

Univariate and Bivariate Associations

Table 1 summarizes demographic and medical characteristics, screener scores at baseline, and diabetes outcomes at baseline and 12-month follow-up. From baseline to the 12-month follow-up assessment, there was a significant decrease in BGM frequency ($t(143) = 4.56$, $p < 0.01$). HbA1c and QOL did not show statistically significantly change. At baseline, CDI

and STAIC-state scores were correlated (r=0.58, p<.0001), and higher CDI scores were correlated with higher HbA1c (r=0.22, p<.01), less frequent BGM (r=−0.22, p<.01), and lower parent-reported QOL (r=−0.33, p<.0001). Likewise, higher STAIC-state scores were correlated with higher HbA1c (r=0.30, p<.001), less frequent BGM (r=−0.19, p<.05), and lower parent-reported QOL (r =−0.18, p<.05).

Multivariate Models

Table 2 summarizes each of the models, with only significant covariates included. The left columns depict results from continuous screener scores, and the right columns depict results from cutoff scores.

The model predicting 12-month HbA1c was significant, F(11, 133)=2.59, p=0.005, R^2=0.18. In this model, CDI scores were not significant predictors of later HbA1c. However, higher STAIC-state scores (b=0.07, p<.05) were significant predictors. Based on this beta value, a 14-point increase in anxiety screener scores was associated with a clinically meaningful rise of 1% in HbA1c (e.g., from 9.0% to 10.0%). In addition, MDI versus CSII (b=0.72, p<.05), single caregiver marital status (b=1.10, p<.01), and being on private insurance (b=1.04, p<.05) significantly predicted higher HbA1c at 12 months.

The model predicting 12-month BGM frequency was also significant, F(11, 132)=2.89, p=0.0019, R^2=0.19. CDI scores trended toward significance (b=−0.05, p=.06). For every 20 point rise in CDI scores, BGM frequency decreased by one check per day. Older age (b=−0.31, p<.01) and single caregiver marital status (b=0.82, p<0.05) significantly predicted less frequent BGM. STAIC-state scores were not significant. Of note, when this model was calculated without the inclusion of mental health visit frequency, CDI was a significant predictor of 12-month BGM frequency (b= −0.05, p<.05). The model predicting 12-month QOL was significant, F(11, 121)=2.64, p=0.0046, R^2=0.19. Higher self-reported CDI scores (b=−0.71, p<.001) predicted lower parent-reported QOL scores and STAIC-state scores did not significantly predict later QOL. In the absence of an established threshold of clinically meaningful change in QOL scores, a change of 1 standard deviation around this sample's mean was used (approximately 12 points). An increase of 17 points on the depression symptoms screener was associated with a 12-point reduction in QOL.

Each of the models was re-run substituting screener cut-off scores (CDI≥13, STAIC-state≥M+1 SD) for continuous scores. Neither CDI nor STAIC-state cut-off scores significantly predicted BGM frequency. The CDI cut-off score did not predict later HbA1c, while the STAIC-state cut-off score was significant. CDI cut-off scores significantly predicted later QOL, and STAIC-state cut-off scores were not significant.

Post Hoc Analyses

In addition to comparing the ability of psychological screener scores to predict diabetes outcomes one year later, a *post hoc* examination of bivariate associations between screeners and diabetes outcomes at 12 months was also conducted. At the one-year follow-up, the mean CDI score was 5.6±5.9 and the mean STAIC-state score was 30.0±5.0. Similar to baseline associations, CDI and STAIC-state scores were correlated (r=0.67, p<.0001), and higher CDI scores were associated with higher HbA1c (r=0.21, p=.01) and lower QOL (r=−0.31, p<.001). STAIC-state scores were also correlated with higher HbA1c (r=0.25, p<.01) and lower QOL (r=−0.25, p<.01) at 12 months.

Because the significance of depression screener scores as a predictor of BGM frequency differed depending on the inclusion of mental health visits as a covariate in the regression equation, a *post hoc* analysis was conducted. CDI score quartiles were calculated and an ANOVA was conducted to determine differences in the number of mental health visits per

quartile (Table 3). The ANOVA was significant, $F(3, 146)=3.33$, $p=0.0214$, indicating more frequent mental health visits during the year following baseline for adolescents with CDI scores in the top two quartiles.

Discussion

For adolescents with type 1 diabetes, psychological screener scores are associated with diabetes-specific health behaviors and outcomes measured one year later. More anxiety symptoms predict higher HbA1c values, while depressive symptoms predict less frequent BGM and poorer QOL. Results from questionnaires that take less than ten minutes to complete can predict these outcomes, which are known to increase the risk for diabetes complications [19]. Predictions can provide a valuable index of risk up to one year in advance.

Symptoms of anxiety were associated with poorer glycemic control, and symptoms of depression were linked with lower BGM frequency and QOL. Depression can detract from BGM and other diabetes management tasks via decreased motivation and energy or declines in concentration and memory, all of which can interfere with successful completion of diabetes self-care [2,3,5, 15]. While the lack of an association between depression and HbA1c was surprising, symptoms of depression may have had an indirect impact on glycemic control through their strong association with BGM frequency, similar to prior studies [5, 15, 21]. Anxiety symptoms can mimic those related to hyper- or hypoglycemia (e.g., dizziness) and may make it difficult to accurately assess and treat blood glucose levels, subsequently impacting HbA1c values. Further, biological mechanisms related to the stress response may link anxiety and HbA1c [20]. Although depression and anxiety scores demonstrated different associations with BGM and HbA1c, it may be that they both represent a general state of psychological distress that is associated with deteriorations in diabetes management and outcomes.

Consistent with previous research [22], depressive symptoms were associated with poorer QOL, possibly reflecting common underlying features such as mood or emotional adjustment. Independent of diabetes, experiencing the unpleasant symptoms that characterize depression likely detracts from the perception of having good QOL. In addition, poorer treatment adherence is a characteristic of lower QOL [23]. Given that depression detracts from BGM frequency, depression may also be associated with QOL through poorer adherence.

Results of models contrasting continuous and cutoff screener scores highlight the relative benefit of using continuous scores for clinic-based screening. Elevated risk for later health and QOL problems, even among those adolescents at subclinical levels, are identified with continuous scores. Many at-risk teens would be missed by the screeners if cut-off scores were used. This may be of particular concern in light of potentially elevated mean scores in this population [3, 4] that could increase the clinical cut-off threshold. Identifying and preventively addressing subthreshold symptom elevations is crucial to slow or reverse deterioration in diabetes outcomes before they reach clinically significant levels.

In this sample, adolescents who received insulin via MDI versus CSII were at increased risk for poorer 12-month outcomes in all areas. This is consistent with previous research indicating a clinical benefit of CSII [24]. Parents' marital status was also associated with multiple outcomes in this study. Single parents may have fewer resources to monitor and supervise diabetes management, which can impact both BGM frequency and glycemic control. In the context of these demographic and medical covariates, CDI and STAIC-state scores were relevant but not sole predictors of glycemic control, adherence, and QOL.

A limitation of the study is that baseline levels of BGM frequency, HbA1c, and QOL were not included in the multivariate models. The auto-correlations of these variables across time would attenuate the associations with screener scores at follow-up and limit our investigation of clinically meaningful questions about psychological screeners as predictors of health outcomes. In addition, the demographic characteristics of the study sample may limit the applicability of the findings to other, more diverse populations. Finally, readers should consider that adolescents with more depressive symptoms at baseline had more visits with mental health providers over the subsequent observation period, and depression scores did not significantly predict BGM when visit frequency was included in the model. This suggests that psychological treatment may decrease depressive symptoms and thus buffer the impact on adherence.

The results of this study highlight the utility of psychological screeners to predict BGM frequency, HbA1c, and QOL measured one year later in adolescents with type 1 diabetes. Clinic-based screening for depression and anxiety symptoms will help to identify psychological concerns linked with diabetes management. Importantly, these concerns are associated with risk for rising HbA1c values, a critical diabetes outcome. Research on the implementation of such screening processes through quality improvement (QI) methodology is needed to address challenges such as time requirements, costs, and responding to elevated scores. The timeframe for this study was one year and suggested annual screening, although additional research is needed to determine the optimal frequency of screening.

Medical providers including physicians, nurse practitioners, and social workers are a primary avenue by which at-risk patients can be routed to mental health providers to address behavioral and psychological factors contributing to poor health outcomes. Evidence-based cognitive-behavioral treatments for adolescents with mood and anxiety disturbances [25] have the potential to be successfully integrated with illness-specific interventions designed to enhance adherence, glycemic control, and QOL [24,25] among adolescents at elevated risk due to mental health symptoms. A relatively large reduction in depressive and anxiety symptoms would be needed to result in the expected improvements in HbA1c, BGM frequency, and QOL, likely requiring substantial psychological intervention. Psychological screening and referral to appropriate intervention hold promise for early identification and may ultimately help prevent deteriorations in diabetes management and glycemic control.

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Table 1

Participant characteristics, screener scores, and diabetes outcomes (% or M±SD).

	Baseline	12 months
Age, years	15.5±1.4	
Gender, % female	51.3	
Ethnicity, % non-white	14.0	
Caregiver education, % college degree	46.7	
Insurance coverage, % private	84.7	
Diabetes duration, years	6.0±3.9	
Insulin regimen, % continuous subcutaneous insulin infusion (CSII)	63.3	
Children's Depression Inventory (CDI)	8.0±7.1	
State-Trait Anxiety Inventory for Children (STAIC) State scale	30.3±5.2	
Pediatric Quality of Life Inventory – Diabetes Module (PedsQL™)	68.5± 12.9	71.0±12.7
Blood Glucose Monitoring (BGM) frequency, mean checks/day	3.8±1.7	3.2±1.8
HbA1c, %	8.8±1.9	8.9±1.8

Table 2

Regression predicting 12-month outcomes.

	Continuous		Cut-offs	
Baseline predictors	**β**	***p***	**β**	***p***
Outcome: Higher HbA1c				
Insulin mode (MDI vs. CSII)	0.72	0.033	0.65	0.053
Caregiver marital status (single)	1.10	0.005	1.13	0.004
Insurance coverage (private)	1.04	0.029	-	-
CDI	−0.00	n.s.	0.44	n.s.
STAI	0.07	0.037	0.42	0.008
Outcome: Lower BGM frequency				
Predictors	β	*p*	β	*p*
Age	−0.31	0.007	−0.31	0.007
Caregiver marital status (single)	0.82	0.033	0.76	0.050
CDI	−0.05	0.064[o]	0.47	n.s.
STAI	0.05	n.s.	0.05	n.s.
Outcome: Lower QOL				
Predictors	β	*p*	β	*p*
CDI	−0.71	<0.0001	9.43	0.003
STAI	0.03	n.s.	4.65	n.s.

[o] trend toward significance

Note: All hypothesized demographic and medical covariates were included in regression equations, only significant covariates are included in the table.

Table 3

Mental health visit frequency at each CDI score quartile.

CDI Quartile	CDI Range	% of sample	Visit frequency (M±SD)
1	0–2	26.0	0.90±2.94
2	3–6	28.0	0.43±1.04
3	7–12	22.67	1.74±4.78
4	13–33	23.33	3.09±5.68