

Depressive Symptoms and Glycemic Control in Adolescents with Type 1 Diabetes: Mediational Role of Blood Glucose Monitoring

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Objective – Determine if the association between depressive symptoms and glycemic control is mediated by blood glucose monitoring (BGM).

Research Design and Methods – 276 adolescents with type 1 diabetes (age=15.6±1.4 years) completed a measure of depressive symptoms. Sociodemographic and family characteristics were obtained from caregivers. BGM frequency and glycemic control were obtained at a clinic visit.

Results – Separate regression analyses revealed that depressive symptoms ($B=-0.03$, $p=0.04$) were associated with lower BGM frequency; depressive symptoms were associated with higher A1c ($B=0.03$, $p=0.05$); and lower BGM frequency ($B=-0.39$, $p<0.001$) was associated with higher A1c. With depressive symptoms and BGM frequency included together, only BGM frequency was associated with A1c and depressive symptoms became nonsignificant ($B=0.02$, $p=0.19$). The Sobel test was significant, $z=1.96$, $p<0.05$, and showed that 38% of the depression-A1c link can be explained by BGM.

Conclusions – BGM is a mediator between depressive symptoms and glycemic control in adolescents with type 1 diabetes.

Adolescents with type 1 diabetes have elevated risk for poor blood glucose monitoring (BGM) adherence and suboptimal glycemic control (1; 2). Adolescents also experience increased risk for depressive symptoms (3-5), which are associated with higher A1c values (4; 5). Although BGM nonadherence and depressive symptoms both contribute to higher A1c values, little is known about their collective association with glycemic control. Prior studies in adults have tested the mediational role of adherence (6). We aimed to evaluate whether the depressive symptoms–glycemic control link is mediated by BGM.

RESEARCH DESIGN AND METHODS

Adolescents with type 1 diabetes were eligible for this study if they did not have a major psychiatric/neurocognitive disorder that would inhibit ability to participate; a significant medical disease other than type 1 diabetes; or the inability to read or understand English. At the Northeastern clinical site, 173 eligible adolescents were approached; 126 participated. At the Midwestern site, 166 eligible adolescents were approached; 150 participated. All study procedures were approved by the Institutional Review Board at each site. Written informed consent from caregivers and consent/assent from adolescents were obtained.

Measures Youth depressive symptoms were assessed using the Children’s Depression Inventory (CDI)(7), a self-report questionnaire consisting of 27 items. Higher scores indicate more depressive symptomatology (4; 7). There was a high degree of internal consistency in this sample (coefficient $\alpha=0.86$).

BGM frequency was obtained via meter download or self-report. Of the 276 adolescents, 158 provided meters for downloading; their daily BGM frequency was correlated with ($r=0.66$, $p<0.0001$) and similar to their self-report (daily meter mean 4.15; self-report mean 4.26). Because of this self-report inflation, the 118 adolescents with only self-report data had their values adjusted by multiplying by 0.97 (4.15/4.26). There were no differences between adolescents with and without meter download on A1c or CDI scores ($ps>0.05$).

Adolescents at the Northeastern clinical site had their A1c determined by high-performance liquid chromatography (reference range 4.0-6.0%, Tosoh 2.2; Foster City,CA). Adolescents at the Midwestern clinical site had their A1c measured by DCA 2000+ (reference range 4.3-5.7%, Bayer Inc.; Tarrytown,NY). A1c values obtained from the laboratory and DCA 2000+ have shown high agreement (8).

Duration of diabetes and mode of insulin administration were obtained from chart review. Family demographic data were obtained from the caregiver.

Statistical Analyses We conducted multivariate analyses (9) using general linear modeling to test the hypothesis that BGM would mediate the depressive symptoms–glycemic control link. First, the effect of depressive symptoms on BGM frequency was tested. Second, the effect of depressive symptoms on A1c values was tested. Third, BGM frequency was added to test its mediational role. The Sobel test examined the significance of the mediational effect and a post-hoc model of interactions was tested. Covariates (age, gender, ethnicity, diabetes duration, mode of insulin delivery; caregiver

education level, insurance status, marital status; site; and availability of meter download) were included in all models. Analyses were conducted in SAS v9.1 (SAS Institute, Cary,NC).

RESULTS

Table 1 displays characteristics of the total sample and by site. The first model (depressive symptoms+covariates → BGM) was significant. Lower levels of BGM frequency were associated with more depressive symptoms ($B=-0.03, p=0.02$), insulin delivery via injections ($B=0.85, p<0.001$), less caregiver education ($B=-0.53, p=0.01$), participation at the Midwestern site ($B=0.85, p=0.005$), and older age ($B=-0.34, p<0.001$).

The second model (depressive symptoms+covariates → glycemic control) was significant. Higher A1c values were associated with more depressive symptoms ($B=0.03, p=0.05$), longer diabetes duration ($B=0.07, p=0.007$), insulin delivery via injections ($B=0.74, p=0.001$), and single caregiver marital status ($B=0.63, p=0.02$).

The third model (depressive symptoms+BGM frequency+covariates → glycemic control) was significant; however, with depressive symptoms and BGM frequency in the model, the effect of depressive symptoms became nonsignificant ($B=0.02, p=0.19$). Higher A1c values were associated with lower levels of BGM frequency ($B=-0.39, p<0.001$), longer duration of diabetes ($B=0.05, p=0.03$), single caregiver status ($B=0.58, p=0.02$), and participation at the Northeastern site ($B=0.61, p=0.05$). The Sobel test, evaluating the magnitude of mediation, was significant, $z=1.96, p<0.05$; 37.5% of the depressive symptoms–glycemic control link was explained by BGM. A post-hoc model

included interactions between significant covariates and BGM frequency; however, none were significant, indicating covariates were directly associated with glycemic control.

DISCUSSION

Results from this cross-sectional analysis indicate that the depressive symptoms–glycemic control link is partially explained by BGM. Prior research highlights that depressive symptoms are associated with lower self-efficacy, negative attributions, and diminished ability to concentrate (10; 11). Adolescents with type 1 diabetes and elevated depressive symptoms may have trouble initiating tasks for diabetes management, carrying them out, and believing they will be effective.

The primary implication is that careful monitoring of depressive symptoms is warranted. This recommendation has been advocated previously in individual studies (4; 5) and by an ADA task force (12); however, these findings highlight the potential for negative consequences on diabetes management and outcomes when elevated depressive symptoms exist. Second, once identified, depressive symptoms need to be treated. There is strong empirical evidence that cognitive-behavioral treatments are effective in reducing depressive symptoms in adolescents (13), so this appears to be a viable option, especially if the diabetes-specific context is considered. Third, straightforward attempts to promote BGM adherence may prove ineffective. Phased interventions may be most appropriate; attempt to reduce depressive symptoms before attempting to promote BGM adherence.

Limitations include the inability to rule out bi-directional relationships

between depressive symptoms and glycemic control in these cross-sectional data. Depressive symptoms were measured by self-report with the CDI, providing an indication of “clinically significant” levels of depressive symptoms and not a diagnosis. Adolescents were predominantly white with married caregivers; findings may not generalize to more diverse families. Finally, we only examined BGM adherence. While previous studies highlight the importance of BGM frequency as an indicator of overall adherence and glycemic outcomes (14; 15), future studies should examine multiple dimensions of adherence.

In sum, adolescents with type 1 diabetes who experience elevated depressive symptoms are also likely to experience problems with BGM. When that occurs, suboptimal glycemic control likely results. Continued surveillance of depressive symptoms is suggested and targeted interventions for these adolescents within a diabetes-specific framework appear warranted.

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Table 1. Participant Characteristics

Characteristic	Total Sample <i>n</i> = 276	Northeast <i>n</i> = 126	Midwest <i>n</i> = 150
Age (years)	15.6 ± 1.4	15.8 ± 1.4	15.5 ± 1.4
Gender (% female)	47.5%	42.9%	51.3%
Ethnicity (% white, not of Hispanic origin)	87.3%	88.9%	86.0%
Caregiver marital status (% married)	80.4%	84.1%	77.3%
Primary caregiver (% mother)	82.6%	77.8%	86.7%
Education level of primary caregiver (% with at least a college degree)	54.0%	62.7%	46.7%
Insurance Status (% private)	84.4%	85.7%	83.3%
Type 1 diabetes duration (years)	6.6 ± 1.81	7.3 ± 4.0	6.0 ± 3.9
Hemoglobin A1c (%)	8.9 ± 1.8	9.0 ± 1.7	8.8 ± 1.9
Blood glucose monitoring frequency (times daily)	3.83 ± 1.45	4.08 ± 1.38	3.61 ± 1.48
Method of insulin delivery			
Multiple daily injections (%)	44.9%	54.8%	36.7%
CSII (%)	55.1%	45.2%	63.3%
CDI score	7.3 ± 6.4	6.5 ± 5.4	8.0 ± 7.1

Note. Scores are shown as mean ± SD. CSII – Continuous subcutaneous insulin infusion. CDI – Childhood Depression Inventory.