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Associations Between Depressive Symptoms, Fear of Hypoglycemia, Adherence to Management Behaviors and Metabolic Control in Children and Adolescents with Type 1 Diabetes

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Abstract

We examined the relationship between two malleable risk factors, depressive symptoms and fear of hypoglycemia, in children and adolescents with Type 1 diabetes and their relationship to two important outcomes, adherence behaviors and metabolic control. To assess this relationship, we used a multidimensional measure of adherence, assessing frequency of both blood glucose monitoring and healthy behaviors including diet and exercise. We predicted that higher levels of depressive symptoms and higher levels of fear of hypoglycemia would be associated with worse metabolic control as mediated by poor adherence. Eighty-three children and adolescents ages 8 to 20 ($M = 13.87$, $SD 3.21$) were recruited from March 2014 to October 2014 at an outpatient diabetes clinic in a moderately sized Southeastern city within the USA. Nested models were evaluated using structural equation modeling. Adherence significantly mediated the relationship between depressive symptoms and metabolic control with more depressive symptoms leading to

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Human and Animal Rights and Informed Consent This article does not contain any studies with animals performed by any of the authors. All procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional Review Board at the Louisiana State University Health Sciences Center as well as Children's Hospital IRB and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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worse metabolic control. Adherence marginally mediated the relationship between fear of hypoglycemia and metabolic control; however, less fear of hypoglycemia was associated with worse metabolic control. In a combined model, adherence continued to significantly mediate the relationship between depressive symptoms and metabolic control, while also independently significantly mediating the relationship between fear of hypoglycemia and metabolic control. This finding was also contrary to the predicted relationship with less fear of hypoglycemia leading to worse metabolic control. The results indicate that youth with fewer depressive symptoms and more fear of hypoglycemia had better adherence to their treatment regimen, which was associated with better metabolic control. The results of this study highlight the importance of screening for depression and fear of hypoglycemia during routine clinic visits to optimize adherence and metabolic control.

Keywords

Type 1 diabetes; Treatment adherence; Metabolic control; Depressive symptoms; Fear of hypoglycemia

Introduction

Type 1 diabetes requires adherence to a strict treatment regimen to obtain optimal metabolic control and avoid severe and long-term health complications (DCCT, 1993). Adherence to the treatment regimen is difficult for many individuals with Type 1 diabetes to achieve, particularly children and adolescents (Helgeson & Palladino, 2012). Understanding modifiable factors associated with metabolic control may have important long-term impacts for children and adolescents with Type 1 diabetes.

Depressive Symptoms and Metabolic Control

Children and adolescents with Type 1 diabetes are at an elevated risk for developing major depressive disorder (MDD; Dantzer, Swendsen, Maurice-Tison, & Salamon, 2003; Hislop, Fegan, Schlaeppli, Duck, & Yeap, 2008; Silverstein et al., 2015). This is a significant concern for youth with Type 1 diabetes as depression is consistently associated with poor metabolic control and diabetes-related outcomes (Bernstein, Stockwell, Gallagher, Rosenthal, & Soren, 2013; Grey, Davidson, Boland, & Tamborlane, 2001; Grey, Whittemore, & Tamborlane, 2002; Hislop et al., 2008; Johnson, Eiser, Young, Brierley, & Heller, 2013).

The mechanism driving this relationship has yet to be determined. A primary theory proposes that depressive symptoms may interfere with daily treatment and adherence behaviors via lack of energy to maintain a healthy lifestyle and decreased motivation and attention toward diabetes-related treatment goals (Bernstein et al., 2013). Individuals struggling with depressive symptoms may have difficulty with self-care tasks, resulting in neglect of adherence behaviors, which in turn affects metabolic control. Indeed, increased depressive symptoms in youth with Type 1 diabetes have been associated with worse adherence (i.e., less frequent blood glucose monitoring [BGM]; Hood et al., 2006; Hood, Rausch, & Dolan, 2011; Korbel, Wiebe, Berg, & Palmer, 2007). Although prior work has examined the correlation between these variables, only one study to date has empirically

examined adherence as a mediator of the relationship between depressive symptoms and metabolic control in youth with Type 1 diabetes finding that adherence significantly mediated the relationship between depressive symptoms and HbA1c (McGrady, Laffel, Drotar, Repaske, & Hood, 2009).

Fear of Hypoglycemia and Metabolic Control

Hypoglycemia is a common acute complication of Type 1 diabetes with children and adolescents at an increased risk (Gonder-Frederick et al., 2008; Paquod, 2002; Shafiee, Mohakeri-Tehrani, Pajouhi, & Larijani, 2012). The physical, cognitive, and psychological symptoms of hypoglycemic events can be a source of embarrassment and worry for individuals with Type 1 diabetes (Gonder-Frederick, Clarke, & Cox, 1997). This may be worse for children and adolescents, for whom the potential social consequences, embarrassment, and physical side effects can be a major source of daily distress (Hains, Berlin, Davies, Parton, & Alemzadeh, 2006).

These negative physical, psychological, and social indications of hypoglycemia can lead to the development of a fear of hypoglycemia (FoH). FoH is common in children and adolescents with Type 1 diabetes (Al Hayek, Robert, Braham, Issa, & Al Sabaan, 2015; Driscoll, Raymond, Naranjo, & Patton, 2016; Gonder-Frederick et al. 1997; Green, Wysocki, & Reineck, 1990; White, Johnson, Wolf, & Anderson, 1989). FoH can have negative implications impacting quality of life, emotional wellbeing, diabetes management, and ultimately metabolic control and diabetes outcomes. One potential consequence of FoH is the development of avoidance behaviors as a protective factor against hypoglycemia. Avoidance behaviors include intentionally keeping blood glucose levels too high or needlessly treating suspected hypoglycemia by taking too little insulin or eating excessively (Irvine, Cox, & Gonder-Frederick, 1994; Shepard, Vajda, Nyer, Clarke, & Gonder-Frederick, 2014). While a moderate level of FoH may be beneficial when faced with an elevated risk of hypoglycemia, this FoH may become harmful in the absence risk. One possible theory suggests that higher levels of FoH in children and adolescents can lead to poor metabolic control as a result of increased avoidance behaviors (i.e., inappropriate adherence).

To date, the relationship between FoH and metabolic control remains debated in the literature with inconsistent results. For example, some studies found no association between child FoH and HbA1c levels (Gonder-Frederick et al. 2006; Viaene, Daele, Bleys, Faust, & Massa, 2017). Other studies have found a link between FoH and metabolic control with higher FoH associated with greater BG levels (Gonder-Frederick, Nyer, Shepard, Vajda, & Clarke, 2011) and higher HbA1c levels (Johnson et al., 2013). However, there is a lack of research examining the relationship between FoH, diabetes management and metabolic control. The current study is the first study to empirically test for mediation in this relationship between FoH and metabolic control through adherence to the diabetes care regimen.

Depressive Symptoms and Fear of Hypoglycemia

Increased depressive symptoms in adults with Type 1 diabetes have been associated with more severe hypoglycemic events (Gilsanz, Karter, Beeri, Quesenberry, & Whitmer, 2018). Although this relationship has not been examined in children and adolescents, it is possible that if higher depressive symptoms correlates with greater hypoglycemic events, and past hypoglycemia leads to the development of FoH, depressive symptoms would also be correlated with higher FoH. Although depressive symptoms and severe hypoglycemia are both common issues that present serious challenges for children and adolescents with Type 1 diabetes, no study to date has examined the specific relationship between depressive symptoms and FoH. The current study is the first to examine the combined effects of depressive symptoms and FoH in metabolic control through the mediator adherence.

Measurement of Adherence

Although BGM frequency has been shown to be a strong predictor of metabolic control (Hood, Peterson, Rohan, & Drotar, 2009), this approach is limited in addressing only the self-care behaviors represented by BGM frequency. However, many other self-care behaviors are essential at explaining good adherence to the treatment regimen, including exercise, diet, and insulin administration (Helgeson & Palladino, 2012). For example, a study by Helgeson, Honcharuk, Becker, Escobar, and Siminerio (2011) found that both BGM frequency and self-care indexes measuring self-reported adherence were significant, independent predictors of HbA1c. The current study extends the literature with the inclusion of a self-report measure of adherence collected from both parent and child in conjunction with an objective measure of adherence, BGM frequency, to capture all behaviors related to the diabetes care regimen. This compound measurement of adherence enhances the current literature that has already shown the individual effect of these adherence measurements to capture the overall impact of adherence on metabolic control.

Study Aims

The first goal of the study was to test whether adherence mediated the relationship between depressive symptoms and metabolic control. We predicted that higher levels of depressive symptoms would be associated with worse metabolic control as mediated by poor adherence. The second goal of the study was to test whether adherence mediated the relationship between FoH and metabolic control. We predicted that higher levels of FoH would be associated with worse metabolic control as mediated by adherence. Given that the mechanisms by which depressive symptoms and FoH affect adherence appear to be distinct, our third goal was to test adherence as a mediator of the relationship between the combined effect of depressive symptoms and FoH on metabolic control. Specifically, we predicted that higher FoH along with higher levels of depressive symptoms would be associated with worse metabolic control as mediated by poor adherence.

Materials and Methods

Participants, Recruitment, and Procedure

Youth with Type 1 diabetes were enrolled in the study at an outpatient endocrinology clinic located within a Children's Hospital in a moderately sized Southeastern city between March 2014 and October 2014. Individuals were eligible for participation if they ranged in age from 8 to 20 years old and had been diagnosed with type 1 diabetes at least 1 year before enrollment. Exclusion criteria for participation were as follows: patients with type 2 diabetes; patients under 18 without a parent or legal guardian present; patients who did not receive laboratory A1c draws that day or who received laboratory work outside of the hospital; and patients who did not have a blood glucose meter at the time of enrollment. This study received approval from the university and hospital combined IRB. Eighty-three youth were included in the analysis.

Measures

Demographic Characteristics—Demographic questionnaires provided information on age, gender, self-identified race, family make up, parental education and employment status, insurance status, and household income.

Covariates—Age, gender, race, and socioeconomic status (SES) were included as potential covariates in all models based on established associations from the literature and results of bivariate correlation analyses (Table 2) SES was a composite variable consisting of federal poverty level (FPL) and maternal education, with higher scores indicating higher SES (NCVHS, 2012). FPL was determined using calculations from the 2015 federal guidelines for poverty based on the number of individuals living in the household and household income (U.S. Department of Health and Human Services, 2015). Maternal education was expressed as a categorical variable coded from 1 to 6 with higher values representing more education.

Depressive Symptoms—All participants completed the Center for Epidemiological Studies Depression Scale for Children (CES-DC). The CES-DC is a 20-item self-report depression inventory, adapted from the Center for Epidemiological Studies Depression Scale (CES-D) for adults, to assess levels of depression in children and adolescents (Weissman, Orvaschel, & Padian, 1980). Reliability for the CES-DC in samples ranging 8 to 17 years old show acceptable internal consistency ($\alpha = .84$) as well as acceptable concurrent validity with the Children's Depression Inventory ($r = .44$; Faulstich, Carey, & Ruggiero, 1986). Internal consistency was high within the sample for the current study ($\alpha = .90$). A total depressive symptoms score was obtained by summing all items; possible total scores range from 0 to 60 with higher scores indicating more severe depressive symptoms. A cutoff score of 15 on the CES-DC indicates clinically significant levels of depression (Weissman et al., 1980).

Fear of Hypoglycemia—All participants completed the second version of the Children's Hypoglycemia Index (CHI-2). The CHI-2 is a 24-item self-report inventory developed for specific use with children and adolescents with Type 1 diabetes to assess levels of FoH

(Kamps & Varela, 2010). Reliability for the CHI-2 in samples ranging 8 to 16 years old was shown to have acceptable internal consistency for the CHI-2 total score ($\alpha = .76$) as well as acceptable concurrent validity with the Children's Hypoglycemia Fear Scale ($r = .69$). Internal consistency was high within the sample for the current study ($\alpha = .86$). A total FoH score was obtained by summing items; possible total scores range from 1 to 120 with higher scores indicating more severe FoH (Kamps & Varela, 2010).

Adherence—Two measures of adherence to Type 1 diabetes management behaviors were collected. The first measure was the Diabetes Self-Management Profile—Self-Report (DSMP-SR), designed to assess levels of adherence to the diabetes treatment regimen. The DSMP-SR is an adapted version of the diabetes self-management profile (DSMP) to be administered in situations with time restraints (Wysocki, Buckloh, Antal, Lochrie & Taylor, 2012). The DSMP-SR consists of 24 items assessing compliance with various daily adherence activities (i.e., diet, exercise, insulin administration, blood glucose monitoring). The DSMP-SR is structured in two versions, flexible regimen and conventional regimen, to accurately assess adherence for patients on all treatment methods. The flexible regimen version of the DSMP-SR was administered to all patients on insulin pump therapy, multiple daily insulin or bolus insulin injections, and the conventional version was administered to all patients receiving conventional insulin therapy with insulin injections two times a day.

The DSMP-SR consists of both parent and youth report versions. All children over the age of eleven completed the youth version of the DSMP. All parents completed the parent version of the DSMP. For children under the age of eleven, only parent report was collected. All available scores were used in the final adherence composite score. Within the current sample, the DSMP-SR showed acceptable internal consistency for parent ($\alpha = .81$) and youth ($\alpha = .78$) report with good agreement between parent and youth report ($r = .59$, $p < .001$). A total adherence score was obtained by summing items; possible scores range from 0 to 86, with higher scores indicating better adherence to type 1 care.

Second, BGM frequency was calculated as a measure of adherence through the collection of each participant's blood glucose meter printouts. Meter downloads have been found to be significantly more reliable measures of adherence among adolescents with Type 1 diabetes than both adolescent self-report of blood glucose monitoring frequency and caregiver report of blood glucose monitoring frequency (Guilfoyle, Crimmins, & Hood, 2011). Up to 10 daily blood glucose checks over the previous 3 months were collected and entered into a database. Blood glucose data were then used to calculate the average number of checks per day across all days reported representing BGM frequency. Scores on the DSMP-SR parent and child report and BGM frequency were standardized, and a composite adherence score was calculated by averaging the scores.

HbA1c—Hemoglobin A1c (HbA1c) was measured during each participant's clinic visit at the time of study enrollment by the site's laboratory using a commercial immunoassay with results reported in National Glycohemoglobin Standardization Program (NGSP) and International Federation of Clinical Chemistry (IFCC) equivalents. Subjects with HbA1c values greater than or equal to 16% (151 mmol/mol) are above the upper reporting limit of the assay and were omitted from analyses.

Missing Data—Less than one percent of data was missing on the demographic characteristics and adherence self-report measures. Mean score imputation was used to address missing data.

Statistical Analyses

First, descriptive statistics were evaluated and bivariate associations between all variables were estimated using correlations. Pearson product-moment correlations were conducted between all parametric variables derived from demographic and clinical data and variables of primary interest (i.e., depressive symptoms, FoH, adherence, HbA1c) to determine demographic variables to be used as covariates. Spearman's rho correlation was used for nonparametric variables. Models were evaluated using structural equation modeling (SEM). SEM allows multiple variables and the paths between them to be modeled simultaneously. Age, gender, race, and SES were included in initial models as covariates with the predictor(s), mediator, and outcome; covariates without significant paths were trimmed from the model to improve overall model fit. The first model included depressive symptoms predicting HbA1c through the mediator adherence. The second model included FoH predicting HbA1c through the mediator adherence. Finally, the third model included both depressive symptoms and FoH as predictors. Model fit was evaluated using the following cutoff scores: non-significant χ^2 , RMSEA < .06 [$< .05$, $< .08$], SRMR < .08, CFI > .90, and NNFI > .80 (Hooper, Coughlan, & Mullen, 2008). Mediation was evaluated using the Model Indirect command in Mplus 8.2 (Muthén & Muthén, 2019).

Results

Descriptive Statistics

Table 1 describes the demographic and clinical characteristics of the 83 participants. Overall, the study population presented in poor metabolic control with the average HbA1c (9.5%, 80 mmol/mol; SD 1.8%) of the sample meeting at-risk criteria for future diabetes-related complications (National Institute for Health and Care Excellence, 2004). Although this was a community sample, 35.4% ($n = 29$) of youth met criteria for clinical levels of depressive symptoms based on the CES-DC cutoff score of 15. Moderate levels of FoH ($M = 46.95$, SD 13.09) were reported based on averages seen in children with Type 1 diabetes. Eleven children (12.8%) were reported to have experienced an episode of severe hypoglycemia (i.e., seizure or loss of consciousness) based on parent report. Bivariate relationships between history of severe hypoglycemia and depressive symptoms, FoH, adherence, and HbA1c were examined; no statistically significant relationships emerged (all r 's < .15). Fair adherence, as interpreted based on average levels of self-reported adherence, was reported on both the parent ($M = 59.96$, SD 11.48) and child DSMP-SR ($M = 53.80$, SD 11.72; Lewin et al., 2010). The frequency of BGM per day ranged from 0 to 10 ($M = 3.73$, SD 2.66), with mean levels below the ADA recommended frequency of 4–5 BG checks per day (ADA, 2014). Table 2 provides means, standard deviations, frequencies, and simple relationships between study variables.

Aim 1: Evaluate If Adherence Mediates the Relationship Between Depressive Symptoms and HbA1c

The first goal of the study was to test whether adherence mediated the relationship between depressive symptoms and HbA1c predicting that higher levels of depressive symptoms would be associated with higher HbA1c levels as mediated by poor adherence. SES, gender, age, and race were identified as significant covariates and included in the final multivariate model. The model fits the data well, $\chi^2(3) = 0.58$, $p = .90$, RMSEA = .000, SRMR = .02, CFI = 1.0, NNFI = 1.14. In this model, adherence was a significant predictor of HbA1c, $B = -.38$, $SE = .09$, $p < .001$, while the direct effect of depressive symptoms on HbA1c was not significant, $B = .03$, $SE = .09$, $p = .75$. Instead, the indirect effect of depressive symptoms on HbA1c through adherence was statistically significant and represented a medium-sized effect, $B = .09$, $SE = .04$, $p = .02$ (Fig. 1). In line with hypotheses, the results suggest that more depressive symptoms are associated with worse adherence, and worse adherence is associated with worse metabolic control.

Aim 2: Evaluate If Adherence Mediates the Relationship Between Fear of Hypoglycemia and HbA1c

The second goal of the study was to test whether adherence mediated the relationship between FoH and HbA1c predicting that higher FoH levels would be associated with higher HbA1c levels as mediated by poor adherence. SES, race, and age were identified as significant covariates and included in the final multivariate model. The model fits the data well, $\chi^2(4) = 0.83$, $p = .93$, RMSEA = .000, SRMR = .02, CFI = 1.0, NNFI = 1.15. In this model, adherence was a significant predictor of HbA1c, $B = -.39$, $SE = .09$, $p < .001$, while the direct effect of FoH on HbA1c was not significant, $B = -.05$, $SE = .09$, $p = .60$. Instead, the indirect effect of FoH on HbA1c through adherence was marginally significant ($p < .10$), $B = -.07$, $SE = .04$, $p = .08$ (Fig. 2). Contrary to our hypothesis, the results suggest that less FoH is associated with worse adherence, and worse adherence is associated with worse metabolic control.

Aim 3: Evaluate If Adherence Mediates the Relationship Between Both Depressive Symptoms and Fear of Hypoglycemia and HbA1c

The third goal of the study was to test adherence as a mediator of the relationship between the combined effect of depressive symptoms and FoH on HbA1c with the addition of FoH predicted to increase the variance explained in the model such that higher FoH would be associated with higher HbA1c levels through the adherence pathway. The final model included SES, race, and age as covariates and fits the data moderately well, $\chi^2(5) = 7.49$, $p = .19$, RMSEA = .08, SRMR = .07, CFI = .97, NNFI = .90. In this model, adherence significantly predicted HbA1c, $B = -.37$, $SE = .10$, $p < .001$, while the direct effects of both depressive symptoms, $B = .05$, $SE = .10$, $p = .60$, and FoH, $B = -.07$, $SE = .10$, $p = .51$, on HbA1c were not statistically significant. The indirect effect of depressive symptoms on HbA1c through adherence remained significant, with a medium-sized indirect effect, $B = .10$, $SE = .04$, $p = .02$. Depressive symptoms were associated with worse adherence and worse metabolic control, as predicted. The indirect effect of FoH on HbA1c through adherence was significant, with a medium-sized indirect effect, $B = -.09$, $SE = .04$, $p = .03$.

(Fig. 3). Findings were contrary to the hypothesis. Specifically, less FoH was associated with worse adherence, which was then associated with worse metabolic control. Therefore, the results of this model did not fully support our hypothesis.

Discussion

The current study supports and expands on the results originally found by McGrady et al. (2009) identifying adherence as a mediator between depressive symptoms and metabolic control. Relying on BGM frequency alone does not provide information on the entire scope of diabetes self-care behaviors. Therefore, the additional use of the DSMP-SR strengthened the results of this study and the support for mediation. In addition, the current study expands on the current literature as the only study examining adherence as a mediator of FoH and metabolic control independently and the combined effects of FoH and depressive symptoms. The results of the study show the strongest fit to the mediation model was the inclusion of both depressive symptoms and FoH as variables associated with metabolic control. This suggests that both depressive symptoms and FoH influence metabolic control through the adherence pathway. The results of this study demonstrate that while depressive symptoms result in worse adherence and consequently worse metabolic control, FoH may be a protective factor leading to increased adherence and improved metabolic control. These results support the literature giving evidence to the relationship between increased depressive symptoms, poor adherence, and poor metabolic control and establishing the mediating role of adherence in this relationship. The results of this study also help explain the lack of relationship between FoH and metabolic control consistently found in the literature by showing adherence as a mediator of this relationship.

Limitations

Although the second objective of this study resulted in marginally significant results between FoH and metabolic control in the adherence mediation model, the small sample size most likely reduced the power of the study to detect larger effects. However, modest effect sizes were found (Cohen, 1988), therefore supporting the practical and meaningful significance of results (Kirk, 2001). The cross-sectional design of the current study limits the ability to make causal conclusions between study variables. Future longitudinal studies must be conducted to tease apart these directional relationships.

The impact of FoH on adherence and metabolic control may also be driven by a patient's history of severe hypoglycemic episodes (i.e., seizures or loss of consciousness), with previous episodes causing an increased FoH to develop (Al Hayek et al., 2015). The current study's population self-reported a small total number of history of hypoglycemic episodes making it difficult to further analyze the impact of past hypoglycemic episodes on FoH. Future studies should further analyze these differences in effects between children with and without a history of severe hypoglycemic episodes to better understand FoH as a protective or harmful factor.

Conclusion

The results of the current study found an association between depressive symptoms and FoH on metabolic control through adherence to diabetes management recommendations. Treating depressive symptoms may be one possible way to increase adherence rates and improve metabolic control. Additionally, a lack of FoH may contribute to decreased adherence and poor metabolic control. While it is not ideal to promote high levels of FoH in children and adolescents, an increased awareness of the risks of hypoglycemia may lead to a protective amount of fear. Therefore, interventions aimed to improve metabolic control through increasing adherence rates should first address depressive symptoms and FoH. Inability to do so may result in less effective interventions that do not address the entire scope of the problem. A first step in this process should be routine depression and FoH screenings during regular clinic visits. The addition of this simple step may improve diabetes-related health outcomes and quality of life among children and adolescents with Type 1 diabetes.

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Fig. 1.

Result of the mediation analysis testing adherence as a mediator of the effect of depressive symptoms on HbA1c controlling for SES, race, age, and gender. Age, gender, and race were significant covariates on adherence. The direct effect of age on adherence was $B = -.44$, $SE = .08$, $p < .001$, gender on adherence was $B = .18$, $SE = .09$, $p = .04$, and race on adherence was $B = -.29$, $SE = .09$, $p = .001$. SES and race were significant covariates on HbA1c. The direct effect of SES on HbA1c was $B = .22$, $SE = .10$, $p = .03$, and race on HbA1c was $B = .22$, $SE = .10$, $p = .04$. All coefficients are reported as standardized estimated betas with standard errors given in parentheses. The indirect effect of depressive symptoms on HbA1c through adherence was $B = .09$, $SE = .04$, $p = .02$. $*p < .05$, $**p < .01$, $***p < .001$

Fig. 2.

Result of the mediation analysis testing adherence as a mediator of the effect of FoH on HbA1c controlling for SES. SES was a significant covariate on FoH, $B = -.29$, $SE = .10$, $p = .009$. Age and race were significant covariates on adherence. The direct effect of age on adherence was $B = -.51$, $SE = .08$, $p < .001$, and race on adherence was $B = -.32$, $SE = .09$, $p < .001$. Race and SES were significant covariates on HbA1c. The direct effect of race on HbA1c was $B = .21$, $SE = .10$, $p = .04$, and SES on HbA1c was $B = -.22$, $SE = .10$, $p = .03$. All coefficients are reported as standardized estimated betas with standard errors given in parentheses. The indirect effect of FoH on depressive symptoms on HbA1c through adherence was $B = -.07$, $SE = 0.4$, $p = .08$. * $p < .10$, ** $p < .01$, *** $p < .00$

Fig. 3.

Result of the mediation analysis testing adherence as a mediator of the combined effect of depressive symptoms and fear of hypoglycemia on HbA1c controlling for SES, race, and age. SES was a significant covariate on FoH, $B = -.27$, $SE = .10$, $p = .01$. Age and race were significant covariates on adherence. The direct effect of age on adherence was $B = -.49$, $SE = .08$, $p < .001$, and race on adherence was $B = -.28$, $SE = .08$, $p = .001$. Race and SES were significant covariates on HbA1c. The direct effect of race on HbA1c was $B = .21$, $SE = .10$, $p = .04$, and SES on HbA1c was $B = -.23$, $SE = .10$, $p = .02$. All coefficients are reported as standardized estimated betas with standard errors given in parentheses. The indirect effect of depressive symptoms on HbA1c through adherence was $B = .10$, $SE = .04$, $p = .015$. The indirect effect of FoH on HbA1c through adherence was $B = -.09$, $SE = .04$, $p = .026$. $*p < .05$, $**p < .01$, $***p < .001$

Table 1Participant demographics, clinic characteristics, and study variables ($N = 83$)

Variable	Study outcomes	n^a	M	SD
Depressive symptoms		82	13.39	10.13
BGM frequency		83	3.75	2.65
Self-report adherence		64	53.80	11.72
Parent-report adherence		80	59.96	11.48
Fear of Hypoglycemia		82	46.95	13.09

Demographic and clinic characteristics				M	SD
HbA1C (% , mmol/mol)				9.5, 80	1.80
No. of people in household				4.17	1.46
Age				13.87	3.21
Gender (n , %)					
Female				41	49.40
Male				42	50.60
Race (n , %)					
African American				30	36.10
European American				53	63.90
Treatment type (n , %)					
2 daily insulin injections				26	31.30
Multiple daily injections				20	24.10
Pump				37	44.60

Household characteristics			n	%
Maternal education				
Less than high school			6	7.23
High school or vocational			23	27.71
Some college			31	37.35
College or graduate degree			21	25.30
Not answered			2	2.41
Household income (\$)				

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Household characteristics	<i>n</i>	%
Under 10,000	4	4.83
10,000–14,999	5	6.02
15,000–19,999	3	3.61
20,000–24,999	6	7.23
25,000–34,999	10	12.05
35,000–49,999	12	14.46
50,000–74,999	9	10.84
75,000–99,999	9	10.84
100,000–149,999	12	14.46
Over 150,000	10	12.05
Not answered	3	3.61
Insurance status		
Union or employer	25	30.13
Private	9	10.85
Government assistance	46	55.42
TRICARE/military	2	2.40
Other	1	1.20

BGM frequency blood glucose monitoring frequency

^a *n* for study outcomes reflect missing data

Table 2

Descriptive statistics and intercorrelations between study variables

Variable (<i>n</i> = 83) (<i>M</i> , <i>SD</i>)	1	2	3	4 ^a	5	6	7	8	9
1. HbA1c (9.5, 1.8)	–								
2. Gender (.49, .50)	.01	–							
3. Age (13.87, 3.21)	.18	–.13	–						
4. Treatment type ^a (2.13, .87)	–.37***	.09	–.03	–					
5. SES (.03, .86)	–.35***	–.12	–.05	.26*	–				
6. Race (.36, .48)	.41***	.16	–.10 [†]	–.53***	–.50***	–			
7. Depressive symptoms ^b (13.39, 10.13)	.20 [†]	.20 [†]	.13	–.01	–.07	.15	–		
8. Adherence (.02, .83)	–.47***	.15	.47***	.31**	.09	–.25*	–.31**	–	
9. Fear of hypoglycemia ^b (46.95, 13.09)	.00	.22*	.09	–.01	–.27**	.10	.29**	.09	–

Pearson's *r* and Spearman's ρ effect size interpreted as small = 0.10, medium = 0.30, large = 0.50

Standardized means and standard deviations reported for SES and adherence *M* mean, *SD* standard deviation. For gender, 0 male, 1 female. For race, 0 European American, 1 African American. For treatment type, 1 2DI, 2 MDI, 3 pump. 2DI/2 daily injections, MDI/multiple daily injections, SES socioeconomic status

[†] $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$

^a Spearman's correlation

^b $n = 83$