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ORIGINAL ARTICLE

Perceived Diabetes Task Competence Mediates the Relationship of both Negative and Positive Affect with Blood Glucose in Adolescents with Type 1 Diabetes

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Abstract

Background Adolescents dealing with type 1 diabetes experience disruptions in affect and diabetes management that may influence their blood glucose.

Purpose A daily diary format examined whether daily fluctuations in both negative and positive affect were associated with adolescents' perceived diabetes task competence (DTC) and blood glucose, and whether perceived DTC mediated the relationship between daily affect and blood glucose.

Methods Sixty-two adolescents with type 1 diabetes completed a 2-week daily diary, which included daily measures of affect and perceived DTC, then recorded their blood glucose readings at the end of the day. We utilized hierarchical linear modeling to examine whether daily perceived DTC mediated the relationship between daily emotion and blood glucose.

Results Daily perceived DTC mediated the relationship of both negative and positive affect with daily blood glucose.

Conclusions This study suggests that within the ongoing process of self-regulation, daily affect may be associated with blood glucose by influencing adolescents' perception of competence on daily diabetes tasks.

Keywords Adolescence · Daily affect · Blood glucose · Diabetes management · Diary

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Introduction

Type 1 diabetes is one of the most common childhood chronic illnesses in the United States [1]. It has an extremely complex treatment regimen [2] involving the coordination of multiple daily blood glucose tests, multiple daily insulin injections or insulin provided through a pump, and monitoring diet and daily exercise levels in order to normalize blood glucose levels [3]. Adequate diabetes management during adolescence is often a struggle, with adherence and blood glucose control commonly decreasing during this developmental period [4], raising the potential of serious long-term complications [5]. The greater negative affect and affect lability that occurs during adolescence [6, 7] may present additional challenges for the adolescent, as negative affect may derail both diabetes management [8] and blood glucose control [9]. In this study, we sought to examine whether adolescents' perceptions of how well they managed their diabetes on a given day—which we label perceived diabetes task competence (DTC)—mediated the relationship between daily affect and blood glucose levels.

Overwhelming evidence utilizing a variety of measures of negative affect points to the strong influences of negative emotions on health and health outcomes [10–12]. This relation is particularly relevant for adolescents with diabetes, who report negative emotions to be a common diabetes-related stressor [13]. Wiebe and colleagues found trait anxiety among adolescents with diabetes was associated with several self-regulatory processes that undermined glycemic control [14]. Consistent relationships between depressive symptoms and poorer metabolic control have been reported in both adult [15, 16] and adolescent samples [17]. The adult literature also suggests an association between blood glucose and daily stress, which may relate to increased negative emotion. In adults with type 1 diabetes,

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higher daily stress was associated with higher daily blood glucose levels [16] as well as with higher glycosylated hemoglobin levels following the study [18]. Gonder-Frederick and colleagues [19] also found that higher daily levels of blood glucose in a sample of adults with Type 1 diabetes was associated with negative affect, specifically anger and sadness.

The link between emotions and glycemic control in adolescents may occur through adolescents' perceptions of competence at dealing with daily diabetes management tasks, which may be affected by negative or positive affect. These perceptions of competence may reflect a combination of actual diabetes management behaviors and adolescents' developing perceptions of the effectiveness of those behaviors. Negative emotions are associated with adolescent reports of poorer diabetes management across a number of studies [20, 21]. In a sample of adolescents with type 1 diabetes, Stewart and colleagues found evidence supporting a pathway leading from overall emotional distress to poorer glycemic control via lower self-efficacy and reports of poorer diabetes management [22], and this pathway was supported longitudinally in a 1- to 2-year follow-up [23]. Little is understood, however, about how adolescents' negative affect, perceptions of competence with respect to diabetes tasks, and blood glucose may play out in the day-to-day life of adolescents coping with diabetes, which is likely to be important because management of diabetes occurs at an ongoing daily level. An important contribution of the present study was to examine daily associations between emotions and blood glucose and to examine whether perceived DTC mediated the associations.

Less is known about how the experience of positive emotions relates to perceptions of diabetes competence in adolescents. Research suggests that positive and negative emotions are conceptually distinct, as opposed to opposite ends of a single spectrum [24] and recent theory and research suggest positive affect has unique associations with self-regulation and coping [25, 26]. For example, higher levels of positive affect are associated with higher self-efficacy for successful behavior in areas such as college class performance [27] and smoking abstinence [28]. Among adolescents with diabetes, positive emotions may serve to enhance blood glucose control by improving adolescents' perceived ability to cope with challenges and hassles.

Objectives

The goal of this study was to explore whether the daily relationship between affect and blood glucose in adolescents with type 1 diabetes was mediated by daily perceived DTC. Adolescents reported on their daily affect, perceived competence regarding daily diabetes tasks, and blood glucose levels for 14 days. Utilizing a daily diary approach with adolescents with diabetes allowed for the examination of day-to-day associations among variables of interest, as opposed to more global, aggregated reports [29]. We expected that such day-to-day associations would elucidate the ongoing process of self-regulation whereby positive and negative affect are associated with blood glucose by affecting adolescents' perceived diabetes task competence.

Method

Participants

Adolescents with type 1 diabetes and their mothers were recruited for a 2-week daily diary study through patient registries at an outpatient pediatric endocrinology clinic. Participants were recruited in the context of two ongoing projects, but procedures were identical for all participants. Twenty-seven adolescents were recruited as part of a previous study of adolescents with diabetes [30]. Adolescents and their mothers were mailed letters introducing the study and were then contacted by phone to invite them to participate in a daily diary study. Of the 42 dyads contacted, 30 participated in the study and 27 successfully completed all of the materials. The remaining adolescents were recruited as part of a separate study where participants who matched the illness and demographic characteristics of the ongoing study were mailed letters inviting them to participate in a daily diary study and recruited during clinic appointments. Of 49 dyads approached, 41 participated in the study and 37 successfully completed all materials. Across both studies, eligibility criteria included: adolescent age between 11 and 17, diagnosed with diabetes for at least 1 year, adolescent living with mother, and ability to read and write English. These criteria were selected to ensure that participants were capable of completing the study and were dealing with similar problems in diabetes management during the adolescent developmental period.

Therefore, a total of 64 children (30 females and 34 males) 11.6 to 16.3 years of age (M=14.1, SD=1.20) with a diagnosis of type 1 diabetes of at least 1-year duration (mean illness duration=4.6 years, SD=2.87) and their mothers participated in the study. The majority of mothers identified themselves as Caucasian (91.9%), having either some college or a college degree, and a relatively high household annual income with 75% of the sample earning over $50,000 a year.

This study was approved by the appropriate Institutional Review Board. Adolescents gave written assent and the adolescents' mothers gave written informed consent and parental permission.

Procedure

Participants were scheduled for a 1-h training session where they individually completed a questionnaire packet (a subset of which was used in this study) and were trained for completion of a 14-day daily diary. This 2-week time period was chosen to maximize the measurement of problematic diabetes episodes, without jeopardizing participant compliance. Participants were instructed to complete their diaries at the end of each day and return them the next day in separate postage-paid envelopes. Participants received phone calls by research assistants at least every other day to encourage participation, address questions, and resolve problems in the completion of received diaries. Participants were paid $10 each for completing the questionnaire packet and $3 for each daily diary form returned. Of the 64 participants, 29 returned all 14 diaries fully completed, and 35 missed between 1 and 10 days (M=3 days). To be included in the analyses, dyads must have completed at least three consecutive daily diaries. On average, mothers completed 13 and teens completed 12 out of 14 diaries. Participants who completed all 14 diary days did not differ from those who missed diary days based on household income, child age or gender, or length of time diagnosed with diabetes (ts([62]<1.7, ps>0.10).

Daily Diary Measures

Perceived Diabetes Task Competence

To measure the adolescent's perceived competence in managing daily diabetes tasks, adolescents initially completed a brief checklist indicating how well they handled each of ten challenging aspects of diabetes management (e.g., glucose testing, administering correct insulin dose, eating appropriate foods at the proper times, eating regular snacks, avoiding high blood glucose). Participants rated how well each task was performed that day using a 1 (did not do well) to 5 (did very well) scale. Items were generated from the Self-Care Inventory [31], diabetes treatment recommendations [32], and the common diabetes problems that children and mothers reported in a preliminary study [13]. To examine stability in perceived DTC across days, we used the Spearman-Brown prediction formula [33] which corrects for changes in reliability with repeated administrations of a measure. This indicated a within-person test–retest reliability of 0.77, suggesting that individuals were moderately consistent across days around their own mean. Please see Table 1 for means and standard deviations of all key variables. Means for daily variables are provided across days and subjects.

Table 1 Means and standard deviations of key variables

	Mean	SD	Range
Perceived DTC	4.05	0.63	2.1–5.0
Positive affect	2.66	0.95	1–5
Negative affect	1.62	0.59	1–4.5
Daily blood glucose	190.97	72.69	31–528
Daily diabetes confidence	3.93	1.00	1–5
Daily diabetes control	3.86	0.94	1–5
Depression	5.08	4.21	0–22
Diabetes self-efficacy	5.29	3.08	3.08–6.0
Perceived adherence	3.88	0.52	2.36–4.86

Daily Affect

At the end of each daily diary, adolescents reported their daily mood using the Positive and Negative Affect Schedule [34]. This measure consists of ten positive emotions (e.g., alert, interested, enthusiastic) and ten negative emotions (e.g., anxious, angry, distressed) rated on a 1 (slightly) to 5 (extremely) scale to describe how much the adolescent experienced each emotion on each day. The Spearman–Brown prediction formula indicated within-person test–retest reliability was quite consistent across the 14 days, with reliabilities for positive and negative affect of 0.84 and 0.64, respectively.

Daily Average Blood Glucose

At the end of the daily diary, adolescents were asked to record each blood glucose reading taken off their glucometers at the end of each day and the average blood glucose level for each day was computed. Adolescents recorded between 1 and 6 blood glucose readings per day (average of 3.4; SD=1.8), with considerable variability across days (Spearman–Brown corrected reliability of 0.49). It should be noted that the average blood glucose level of 190.97 (SD=72.69) is above the 180 mg/dl level considered hyperglycemic [35].

Single-Item Daily Variables

At the end of each daily diary, adolescents were asked several questions to gain a better understanding of daily perceptions of their diabetes management and to validate the interpretation of the perceived DTC variable. These included confidence related to diabetes management ("How confident were you in your ability to manage diabetes?") and diabetes-related control ("Overall, how much control did you have over your diabetes management today?").

These items were rated on a 1 (strongly disagree) to 5 (strongly agree) scale.

Questionnaire Measures

Demographic and Illness Information

Mothers completed a demographics questionnaire that included personal and family information (child's age and sex, ethnicity, household income, parental marital status, parental education, and religious affiliation) as well as illness information (duration of illness, age at diagnosis).

Diabetes Self-Efficacy

The following two measures were included to examine the convergent validity of the perceived DTC variable. The Self-Efficacy for Diabetes Management Scale [36] assessed adolescents' perceptions of their ability to manage diabetes across 35 problematic situations on a 1 (very sure I can't) to 6 (very sure I can) scale. We reduced the scale to 12 items in order to minimize redundancy and update content. In our sample, this scale had good internal consistency (alpha=0.89).

Perceived Adherence

Adolescents completed the 14-item Self Care Inventory [31] to assess adherence to various aspects of the diabetes regimen over the preceding month (e.g., "Over the past month, how well have you followed recommendations for glucose testing?"). Adolescents rated their adherence on a 1 (never) to 5 (always) scale. Total scores on this scale have adequate internal consistency (alphas>0.76; [30, 37]) and correlate well with more time-intensive interview methods for measuring adherence [38]. Within this sample, alpha=0.82.

Statistical Model and Analyses

The diary design provided 14 daily reports of negative and positive affect, perceived diabetes task competence, and blood glucose. Hierarchical linear analyses were used [39] to conduct the analyses in two phases. First, we examined the convergent validity of the perceived DTC variable by examining associations with additional variables pertaining to adolescents' perceptions of diabetes management. Second, we examine the associations of negative affect and positive affect with blood glucose, and whether perceived DTC mediated those associations. This procedure interpolates the missing data under the assumption that it is missing at random (MAR) [40]. These models were based on a multilevel data array of *i* adolescents on *j* days. Two models like those depicted in Fig. 1 were calculated, one for positive and one for negative affect [41] depicting the total effect of affect on blood glucose as $c = c' + ab$.

Consistent with mediational analyses [41], we began by establishing that within person across day fluctuations in negative affect (NA), positive affect (PA), and perceived DTC were associated with within person, across day fluctuations in average blood glucose. NA, PA, and perceived DTC were all centered at the group mean (i.e., within person). The day the

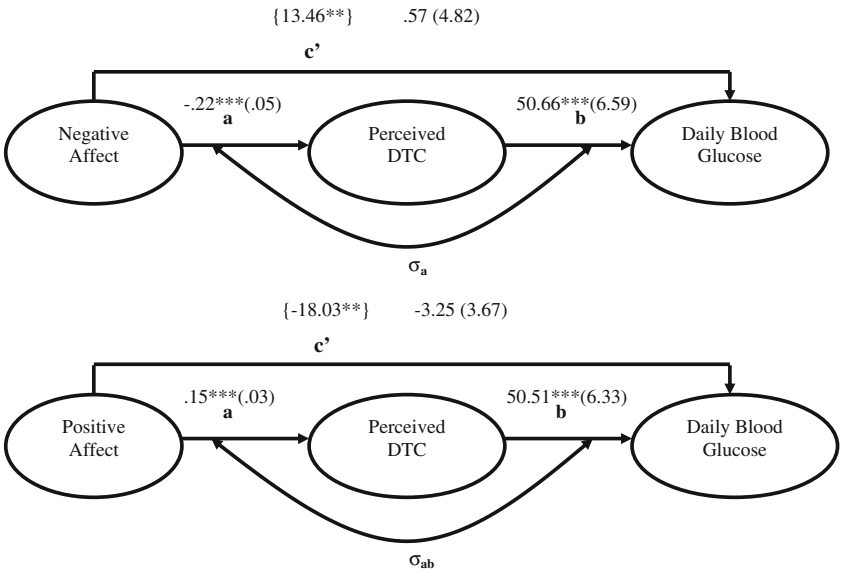

Fig. 1 Perceived DTC mediates the relationships of both PA and NA with blood glucose

Note: Bracketed coefficients represent coefficients from the original level 1 equations that do not include pathways a and b simultaneously in the model. All other coefficients are from the complete stacked model. Standard errors of the coefficients are in parentheses. $c = c' + ab + \sigma_{ab}$ where the average mediation effect is $ab + \sigma_{ab}$. Day was included as a covariate in the model but pathways were nonsignificant and thus it is not depicted in the figure.
***p < .001 **p < .01; *p < .05.

measure was completed (day 0, day 1, day 2 where 0 was the first day) and was used as a covariate to remove linear trends in blood glucose. The equations listed below illustrate these three separate analyses:

Level 1 Blood Glucose$_{ij}$=B_{0i}+B_{1i} (Day$_{ij}$)+B_{2i} (NA$_{ij}$)+r_{ij}

Level 1 Blood Glucose$_{ij}$=B_{0i}+B_{1i} (Day$_{ij}$)+B_{2i} (PA$_{ij}$)+r_{ij}

Level 1 Blood Glucose$_{ij}$=B_{0i}+B_{1i} (Day$_{ij}$)+B_{2i} (perceived DTC$_{ij}$)+r_{ij}

In these equations, mean blood glucose levels for participant i for day j are predicted by variables B_{0i}, which represents the blood glucose level for a participant when the variable in the equation (e.g., NA) is 0 on the first day (when day is 0), B_{1i} represents the relationship between diary day and blood glucose level for subject i across days, B_{2i} represents the relation between NA (or in the subsequent models, PA or perceived DTC) and blood glucose means across days for each subject, and r represents variation in blood glucose due to measurement error.

Mediation models examining whether the quality of perceived DTC-mediated relationships between daily affect (negative and positive) and daily average blood glucose levels were tested using a procedure that controls for covariance between the indirect mediation paths [42]. This is necessary because when analyzing mediation using random effects models, the average fixed effects are biased to the extent that there is covariance between the two mediation components (e.g., if there is covariance between the weights for the negative affect—perceived DTC path and the perceived DTC-blood glucose path [42, 43]) .To address this bias, we followed the procedures outlined by Bauer and colleagues [42]. This involved simultaneously modeling the regression predicting the mediator (how affect predicts perceived DTC) and the outcome (how affect and perceived DTC predict blood glucose levels). The full model with all covariates for the HLM analyses establishing the relationship between perceived DTC and NA can be expressed in the following Level 1 equation. The analyses for PA are similar in structure and are not illustrated:

Level 1 Z_{ij}=B_{1i} (OI$_{ij}$)+B_{2i} (OI$_{ij}$*NA$_{ij}$)+B_{3i} (OI$_{ij}$* perceived DTC$_{ij}$) + $\underline{B}_{ij}$ (MI$_{ij}$) + B_{ij} (MI$_{ij}$*NA$_{ij}$) + B_{ij} (MI$_{ij}$*Day$_{ij}$) + B_{ij} (OI$_{ij}$*Day$_{ij}$) + r_{ij}

In these equations, mediator indicators (MI) and outcome indicators (OI) represent redundant dummy codes (when one is zero the other is one) and Z represents a stacked variable that reflects average daily blood glucose when the dummy coded OI is 1 and perceived DTC when OI is 0 for participant i on day j. All predictors were grand centered (at the sample mean) to facilitate interpretation in the mediation context. Inclusion of a heterogeneous error structure allowed separate error variances for the mediator as DV and outcome as DV. We present a confidence interval method to establish the significance of the mediation (outlined in [42]).

Results

Convergent Validity of Perceived DTC

In order to better understand the perceived DTC variable, comparisons were made with additional variables examining adolescents' perceptions of their diabetes management on both daily and global levels. First, comparisons were made with the single-item variables examining daily perceptions of diabetes-related control and confidence. Using the single-item variables as the dependent variable in separate HLM analyses, perceived DTC was associated with more daily perceived diabetes-related control (B=1.18 [SE=0.09], p<0.001), and more daily confidence in handling diabetes (B=0.86 [SE=0.09], p<0.001). Second, to examine associations with global perceptions of adherence and diabetes self-efficacy, separate analyses were conducted with perceived DTC as the dependent variable to ascertain the influence of global variables on the intercept. Perceived DTC was positively associated with both perceived adherence (B=0.54 [SE=0.09], p<0.001), and diabetes self-efficacy (B=0.52 [SE=0.16], p<0.001). That is, individuals who reported higher adherence and diabetes self-efficacy also reported higher DTC on average across the 14 days. These findings are similar to those we have found using a parallel measure of perceived DTC in a separate sample [44]. The associations of perceived DTC with variables that were developed to reflect both cognitive perceptions of competence, as well as frequency of diabetes management behaviors, suggests perceived DTC taps into aspects of both diabetes management behaviors and self-efficacy beliefs regarding ability to sustain those behaviors.

Perceived DTC Mediates the Daily Associations Between Affect and Blood Glucose

In Table 2, the results of the three Level 1 HLM analyses are presented. For the model predicting blood glucose from NA (top panel), NA was associated with higher (less healthy) same day blood glucose. For the model predicting blood glucose from PA (middle panel), PA was associated with lower (healthier levels of) same day blood glucose. For the model predicting BG from perceived DTC (bottom panel), perceived DTC was associated with lower (healthier levels of) same day blood glucose. Day was not a significant predictor of blood glucose in any model, nor was day a predictor of perceived DTC.

As shown in Fig. 1 pathway c', reports of NA did not significantly predict blood glucose once perceived DTC was included in the model, indicating that the relationship between NA and blood glucose was explained by the relationship between NA and poorer perceived DTC. The results of the parallel model examining PA indicated that

Table 2 Associations of daily negative affect, positive affect, and perceived DTC with blood glucose

Coefficient (SE)		
MODEL blood glucose predicted from negative affect		
Intercept	193.17*	7.09
Day	−0.20	0.53
Negative affect	13.46**	5.44
MODEL blood glucose predicted from positive emotion		
Intercept	194.53*	7.02
Day	0.43	0.54
Positive affect	−18.03*	6.34
MODEL blood glucose predicted from perceived DTC		
Intercept	193.15*	7.54
Day	–0.15	0.50
Diabetes Task Management	–0.53.16*	7.03

*$p<0.01$; **$p<0.05$

reports of PA did not significantly predict daily blood glucose once perceived DTC was included in the model. The relationship between PA and blood glucose was explained by better perceived DTC when higher levels of PA were reported. Thus, on a daily basis, perceived DTC mediates the association of both NA and PA with daily blood glucose.

We constructed 95% confidence intervals of the mediation effect taking σ_{ab} into account [41]. This replaces the Sobel test when σ_{ab} is non-zero, as was the case here (σ_{ab} for NA=3.11, Z=39.29, $p<0.01$; σ_{ab} for PA=−5.85, Z=234.00, $p<0.01$). Specifically, having zero fall within the confidence interval would indicate a pattern inconsistent with mediation—that the population mediation effect could be zero. The results of the confidence interval test indicated that significant mediation was present. For the NA model, CI 95% $11.25 \leq 19.24 \leq 27.23$, and for the PA model, CI 95% $-19.55 \leq -12.95 \leq -6.34$. Once the relationship between perceived DTC and blood glucose was included in the model, the relationships between NA and blood glucose, and PA and blood glucose, respectively, were no longer significant, indicating significant mediation.

To examine whether there was a lagged association between affect and perceived DTC or between affect and blood glucose (i.e., whether affect on Day t predicts perceived DTC/blood glucose on Day $t+1$), the models displayed above were extended so that next day perceived DTC (or blood glucose) was predicted from previous days' affect (NA or PA) while controlling for previous days' perceived DTC (or blood glucose). No significant effect of NA or PA was found for either next day perceived DTC or next day blood glucose (Bs<0.10, ps>0.10). Lag analyses were repeated examining the reverse pathway, to determine whether next days' affect (NA or PA) was predicted from previous days' perceived DTC (or blood glucose) while controlling for previous days' affect. Again, no significant effect of perceived DTC or blood glucose was found for either next day NA or PA (Bs<0.01, ps>0.10). Therefore, lagged analyses were unable to provide evidence for supporting causality in either direction.

Finally, to examine whether the associations of PA and NA were independent when both were included in the model, we also tested each model including both PA and NA and the pattern of results remained the same. There was no significant interaction between PA and NA for either perceived DTC (B=−0.05 [SE=0.06], p=0.39) or blood glucose (B=5.68 [SE=10.84], p=0.60) as the outcome. This analysis supported the idea that PA and NA are best considered as having independent associations with perceived DTC and blood glucose.

Discussion

The goal of this study was to examine self-regulatory processes in blood glucose control involving affect and perceptions of competence in managing diabetes problems. Both theory [45, 46] and research [47, 48] reveal the importance of emotion in illness-related perceptions and outcomes. This study provides evidence that emotion may disrupt or facilitate management of healthy blood glucose levels in adolescents with diabetes. Emotion regulation and perceptions of competence and self-efficacy in management are especially important during adolescence, and may partially explain the poorer metabolic control seen in adolescents with diabetes [4, 49]. Our results indicate that daily perceived DTC mediated the same-day relationship of both negative affect and positive affect with daily average blood glucose. The daily diary format is a unique method of capturing everyday life experiences [50], which may be particularly relevant in an illness requiring ongoing daily management such as diabetes.

The proposed pathway from emotions to blood glucose via perceived DTC is consistent with evidence that emotions can both impair and facilitate self-regulation. Negative emotions may influence appraisal processes that are important for behavioral self-regulation. It is feasible that a broader tendency to report negative affect could explain the relationship between daily affective experiences and perceived DTC. For example, some adolescents might tend to report both negative affect and negative perceived DTC due to an underlying trait, such as neuroticism. Intraindividual fluctuations in affect and behavior are thought to be influenced by trait-like characteristics [51]. Study of these intraindividual fluctuations across days and times indicates that the degree of within-person fluctuation in both affect and behavior is high, and likely reflects

situation-based factors [51, 52]. The link between positive affect and behavior is unlikely to be explained by underlying neuroticism, but may reflect an underlying trait related to positive affect, such as extraversion. Although it is plausible for our data to be explained, in part, by underlying trait-influenced processes, it is unlikely for the overall pattern of findings to be explained by any single trait.

Baumeister and colleagues [47] suggest that the presence of negative emotions may limit resources in adolescents, leading to more difficulty in managing problems related to illness. Future research should examine whether this relationship between negative emotion and illness-related problem solving found by Baumeister is related to perceived competence in illness management. Adolescents especially may be thwarted by negative emotions because they reason more poorly on emotionally salient problems than do adults [53]. Furthermore, negative emotions may become a focus of regulatory efforts, which could undermine self-management. The presence of negative emotions may lead adolescents to focus on the short-term goal of feeling better emotionally, rather than on long-term illness management [54].

A key finding is that positive affect is related to daily blood glucose via perceived DTC. Individuals who report positive affect in the context of difficult circumstances [55] appraise circumstances positively and engage in self-regulatory behavior. Furthermore, positive emotion associated with a certain health behavior is associated with greater tendency to engage in that behavior [48]. It is possible therefore that positive affect could increase the resources of adolescents coping with diabetes, and enhance perceptions of their ability to competently address difficulties in management. The processes by which this relationship may occur require further examination. It is worth noting that positive and negative affect showed independent effects in our study, pointing to the likelihood of unique associations of different affects with self-regulatory processes.

Limitations

Several limitations of the study should be noted. First, although longitudinal data supports the hypothesis that daily emotions influence blood glucose via daily illness management [23, 56], our results are unable to demonstrate directionality. An equally plausible explanation for the current findings is that adolescents may have received poor blood glucose readings during the day, leading them to perceive their diabetes management efforts for the day as bad and to feel more negative and less positive emotion (e.g., [57]), consistent with theories that negative emotions provide information that the self-regulatory system requires adjustment (e.g., [58]). Our explanation, however, is consistent with evidence suggesting that manipulating negative emotion (i.e., inducing fear) can undermine important self-regulatory processes [59]. Furthermore, an alternative model of mediation, in which daily affect mediated the relationships between perceived DTC and blood glucose, was not supported by our results. Next-day lag effects, which may have been helpful in elucidating questions of causality, were not found for either of these directions. The lack of lag effects may be related to the timing of our daily diary measures as affect fluctuates more rapidly than on a 24-h cycle [7] and perceived DTC and blood glucose fluctuate throughout the day. Monitoring affect and perceived DTC more frequently throughout the day may provide a clearer understanding of the directionality of the mediation pathway.

Our measure of perceived DTC, although derived from a well-validated and commonly used measure, could be considered fairly multifaceted, capturing an adolescent's overall views of how well they manage their diabetes as well as their actual diabetes management behaviors. This measure fluctuated on a daily basis with adolescents' confidence and perceptions of control in managing diabetes. Furthermore, adolescents who reported higher self-efficacy beliefs and adherence also perceived higher DTC on average across the 2-week diary. Perceived DTC may thus reflect adolescents' perceptions of their own behaviors and capabilities. Finally, our method of capturing daily blood glucose by averaging across measures within days does not capture the nuances of blood glucose fluctuations [60] and our reliance on the adolescent's self-report of their emotions, competence, and of the blood glucose levels may be problematic.

Future Directions

In this study, only adolescent emotions and perceptions of competence were examined. However, adolescent diabetes care takes place within the broader family context and extensive research shows a complex and bi-directional relationship among family factors and diabetes in youth. Parenting a child with diabetes impacts both mothers and fathers emotionally [61, 62], while higher perceived parental burden is associated with poorer levels of HbA1c in youth with type 1 diabetes [63]. Furthermore, family emotion management is prospectively associated with change in disease management in patients with type 2 diabetes [64]. In our lab, we have shown that parents' emotions are associated not only with parents' perceptions of diabetes competence, but also with the adolescents' self-perceptions [65].

Conclusion

This study emphasizes the dual challenge faced by adolescents of simultaneously managing their emotions

and maintaining their perceptions of competence in the context of a complicated medical regimen. Managing an illness in the presence of emotional changes is a challenge that adolescents will face throughout their lives, and adolescents develop views of their competence that remain influential throughout adulthood. Learning to manage illness behaviors in the presence of negative emotions, and learning to recognize and harness positive emotions for optimal diabetes management, are skills that may have implications for maintaining long-term health when living with diabetes. It will be important to understand factors that may help adolescents to regulate their behavior in the context of emotions as well as to understand what leads adolescents to experience more positive or negative emotions in the context of diabetes. Helping adolescents to optimally manage their emotions in the context of diabetes may have important implications for clinical interventions and lifelong diabetes control.

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