Pediatric Diabetes

Pediatric Diabetes 2011: 12: 410–418
doi: 10.1111/j.1399-5448.2010.00692.x

Pediatric Diabetes

Original Article

Gender differences in the relationship between parental report of self-regulation skills and adolescents' management of type 1 diabetes

Graziano PA, Geffken GR, Williams LB, Lewin AB, Duke DC, Storch EA, Silverstein JH. Gender differences in the relationship between parental report of self-regulation skills and adolescents' management of type 1 diabetes. Pediatric Diabetes 2011: 12: 410–418.

Objective: To examine the extent to which self-regulation skills of adolescents with type 1 diabetes (T1D), including executive functioning and emotion regulation, relate to treatment adherence and glycemic control.
Method: Participants were 109 adolescents aged 12–18 yr with TID and their primary caregiver who attended an outpatient appointment at a pediatric endocrinology clinic. Parents and adolescents completed a measure of treatment adherence. Parents completed a self-regulation measure while a glycemic control measure [i.e., hemoglobin A1c (HbA1c)] was collected.
Results: For boys, executive functioning and emotion regulation deficits were significantly associated with worse treatment adherence and glycemic control. Further analyses indicated that emotion regulation was the primary self-regulation measure related to treatment adherence and glycemic control. No significant associations were found for girls.
Conclusion: For adolescent boys, the ability to cope with various stressors and emotions may be as important as higher-order thinking skills for maximizing treatment adherence and diabetes control. Clinical implications and potential mechanisms by which emotion regulation skills relate to adolescent boys' diabetes treatment management are discussed.

Paulo A Graziano[a], Gary R Geffken[b], Laura B Williams[c], Adam B Lewin[d], Danny C Duke[e], Eric A Storch[d] and Janet H Silverstein[f]

[a]Department of Psychiatry, University of Florida, Gainesville, FL, USA; [b]Departments of Psychiatry, Pediatrics, & Clinical & Health Psychology, University of Florida, Gainesville, FL, USA; [c]Department of Pediatrics, University of South Florida, Gainesville, FL, USA; [d]Departments of Pediatrics & Psychiatry, University of South Florida, Rothman Center for Neuropsychiatry, Tampa, FL, USA; [e]Child Development and Rehabilitation Center, Oregon Health & Science University, Portland, OR, USA; and [f]Department of Pediatrics & Community Health and Family Medicine, University of Florida, Gainesville, FL, USA

Key words: emotion regulation – glycemic control – self-regulation – treatment adherence – type 1 diabetes

Corresponding author:
Paulo Graziano, PhD, Department of Psychiatry, University of Florida, P.O. Box 100234, Gainesville, FL 32610-0165, USA.
Tel: 352-392-3611;
fax: 352-392-3614;
e-mail: pagrazia@ufl.edu

Submitted 25 January 2010. Accepted for publication 19 May 2010

Given the complexity of diabetes treatment regimens, it is not surprising that children, adolescents, and their families often have difficulty adhering to them (1). Non-adherence is not only problematic in terms of increasing an individual's risk for potentially serious medical consequences (e.g., diabetic ketoacidosis), but it also impacts society in terms of excessive healthcare costs (2). Consequently, recent research has attempted to examine predictors of treatment adherence and biological indices associated with glycemic control such as HbA1c levels.

Factors that have been shown to predict treatment compliance include demographic variables (3), medical and organizational factors (4), and psychosocial factors such as support from family and friends (5, 6). Family factors and particularly parental behaviors have been shown to be important for treatment compliance and glycemic control in children with diabetes (7–9). Although it is clear that parental factors play a significant role in children's treatment compliance and glycemic control, less research has examined the extent to which children's individual traits impact their treatment. Given the developmental shift in responsibility that occurs as children enter adolescence (10), examining individual traits may be particularly important for understanding when adolescents are ready to self-manage their treatment.

The few studies that have examined individual factors have focused on children's and adolescents' overall behavior problems (11), cognitions and perceived competence regarding diabetes care (12), and/or their motivation for treatment (13). The current study explored adolescents' self-regulation skills, including executive functioning and emotion regulation skills, as significant factors associated with treatment adherence and glycemic control.

Broadly speaking, self-regulation refers to an individual's conscious or unconscious efforts to alter his or her inner states or responses (14). Self-regulation is a multi-level construct with control efforts that may include the use of physiological, attentional, executive functioning, emotional, and behavioral processes. These processes are hierarchically organized and become more sophisticated and integrated through development (15). Individual differences in self-regulation skills are well documented along with its importance for children's adaptive functioning (16). An important aspect of self-regulation is executive functioning which refers to higher-order cognitive skills that enable the child to self-regulate or 'maintain behavior on a goal and calibrate behavior to context' (16). Among the most widely cited (17, 18), cognitive skills thought to represent executive functioning are (i) cognitive flexibility, which involves working memory processes and the ability to shift between response sets and process multiple sources of information; (ii) attentional control, which involves selective attention and inhibition and includes the capacity to sustain attention and selectively attend to specific stimuli while inhibiting prepotent responses; and (iii) goal setting, which involves planning and monitoring abilities and the ability to develop new initiatives and concepts for a future task.

A recent meta-analysis indicated that children with type 1 diabetes are at an increased risk of having mild cognitive impairments (19). Poorer neuropsychological performance in youth with type 1 diabetes relative to healthy controls has also been documented (20). However, the extent to which executive functioning abilities contribute to treatment non-adherence remains unclear. One recent study did find that children's overall executive functioning skills, as reported by parents, were related to overall behavioral adherence to type 1 diabetes treatment (21). However, biological markers for glycemic control were not collected. Given the moderate association between behavioral treatment adherence and glycemic control (22), it is important to include both measures.

Although higher-order executive functions such as planning and working memory skills may facilitate adherence to diabetes treatment regimen (e.g., remembering and organizing one's treatment regimen), other self-regulation skills such as emotion regulation may operate by controlling affective and stressful aspects of having type 1 diabetes. For example, higher levels of emotion regulation skills have been associated with decreased levels of stress (23), as well as anxiety and depressive symptoms (24). Thus, adolescents with higher levels of emotion regulation skills may be less likely to view their treatment regimen as stressful or may be able to better express their emotions associated with their treatment and be less frustrated. Better coping with these affective and stressful aspects of diabetes treatment will likely result in better behavioral adherence to the treatment regimen and subsequently better glycemic control. Support for this link has been found in the adult literature as a recent study found that a coping style that promoted better emotion regulation was associated with better glycemic control (25). However, to date, no study has examined the extent to which adolescents' emotion regulation skills relate to treatment adherence and glycemic control.

Hence, the primary goal of this study was to determine within a sample of adolescents with type 1 diabetes the extent to which self-regulation skills, including executive functioning and emotion regulation skills, relate to treatment adherence and subsequently glycemic control as measured by hemoglobin A1c test. We hypothesized that adolescents with lower levels of emotion regulation and executive functioning skills would have lower levels of treatment adherence and subsequently have poorer glycemic control compared to adolescents with higher self-regulation skills. Finally, it is important to note that numerous studies within the child development and developmental psychopathology domains have documented boys as having significant greater self-regulation deficits compared to girls (26, 27). Consequently, we expected that the link between self-regulation, treatment adherence, and glycemic control to be stronger for boys compared to girls.

Method

Participants

Participants were 109 youths with type 1 diabetes (TID) and their primary caregiver recruited from the outpatient tertiary Pediatric Endocrinology Clinic at a large university hospital in the Southeastern United States. Inclusion criteria for the study participation were (i) aged 12–18 yr, (ii) diagnosed with T1D for at least 6 months, (iii) living with and accompanied by their primary caregiver, (iv) no other chronic medical conditions (e.g., cystic fibrosis), and (v) both adolescent and primary caregiver were able to read and complete study materials. Subjects participating in the current research study may have also participated in previous studies and included in different analyses presented elsewhere (e.g., sample demographic data and associations between adherence, metabolic control, and demographics) (9, 28–31).

The sample consisted of 59 girls and 50 boys aged 12–18 yr (M = 15.23, SD = 1.81). The ethnic distribution of participants was: 72% Caucasian, 18% African American, 8% Hispanic, and 2% indicating membership in other ethnic groups. Participants were from predominantly two-parent families (68%) and the mothers were the primary caregiver respondents (72%), followed by fathers (17%) and other caregivers (11%). The median family income was $37 000 per year (range = $1200–$200 000). Youth in the study had been diagnosed with T1D for an average of 5.06 yr (SD = 3.7, range = 0.5–17).

Procedure

Participants were recruited during their regular visits to the Pediatric Endocrinology Clinic. Clinic nurses identified patients meeting inclusion criteria and eligible participants were approached in private patient waiting rooms by a trained member of the research team and provided with an introduction to the study prior to obtaining consent. The consent rate was approximately 92% which is similar to past research recruitment within this clinic (32). The study was approved by the governing Institutional Review Board and families received a $10 gift certificate for their participation. Signed informed consent was obtained from legal guardian and caregiver of all participants and adolescents provided assent. Adolescents and their caregivers were interviewed separately about T1D treatment adherence and parents completed the remaining questionnaires independently. Blood samples were obtained by nursing staff as part of the patients' regular clinic visit for the measurement of glycemic control (A1c test).

Measures

Demographic questionnaire. The participants' primary caregiver completed a basic demographic form, including information such as age, sex, socioeconomic status, duration of T1D, and family composition.

Behavior rating inventory of executive function. The behavior rating inventory of executive function (BRIEF; 33) is designed to assess executive functioning/self-regulation skills in children and adolescents. The parent version contains 86 items, which yield eight non-overlapping but correlated clinical scales (inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of materials, and monitor) and two validity scales. Parents circle 'never', 'sometimes', or 'often' to indicate whether their child has experienced problems over the last 6 months with a given behavior as described in each item. Higher scores indicate poorer executive functioning/self-regulation. The BRIEF has well-established internal consistency, reliability, and validity (33). For the purpose of this study, the total raw scores from the *Inhibit* (ability to control behavioral impulses, inhibitory control), *Shift* (ability to switch or alternate attention), *Working Memory* (ability to retain information in one's mind for the completion of a task), *Plan/Organize* (ability to anticipate future events and set goals), and *Monitor* (ability to assess one's own performance) subscales will be used to represent the three executive functioning domains discussed earlier: cognitive flexibility = working memory; attentional control = inhibit and shift; and goal setting = plan/organize and monitor. The *Emotional Control* subscale will be examined as a measure of adolescents' emotion regulation skills. Reliabilities for the BRIEF subscales in this study were excellent (α = 0.92–0.94).

Diabetes self-management profile. The diabetes self-management profile (DSMP; 34) is a structured interview that assesses T1D-specific adherence behaviors over the past 3 months. It consists of 23 questions in the areas of insulin administration/dose adjustment, blood glucose monitoring, exercise, diet, and management of hypoglycemia. The DSMP interview was conducted separately to parents and adolescents with T1D by trained research assistants and required approximately 15 min to complete. Participants' responses to each item were coded on scales ranging from 0 to 1 and 0 to 4, with higher numbers indicating better adherence. A total adherence score, ranging from 0 to 79, was then calculated from the sum of each item score. The DSMP has well-established internal consistency and inter-observer agreement (34).

Glycemic control. To obtain a biological assessment of glycemic control, the hemoglobin A1c test was conducted. Blood samples were analyzed using a Bayer DCA 2000+. The A1c test is considered the gold standard assessment and provides an estimate of metabolic/glycemic control over the previous 2–3 months with higher A1c values indicating poorer control.

Results

Preliminary analysis

Descriptive statistics. Descriptive statistics for the study variables, which were all normally distributed, are presented in Table 1. All analyses were conducted using SPSS 16.0. All available data were used for each analysis. Preliminary analyses were conducted to determine any associations between demographic and disease characteristics and any of the study's independent (i.e., self-regulation measures) and dependent (i.e., treatment adherence, glycemic control) variables. First, multivariate analyses indicated significant gender differences across multiple self-regulation variables, $F(6,102) = 3.92$, $p < 0.01$. Specifically, boys were reported as having significantly worse inhibition skills, $F(1,107) = 5.56$, $p < 0.05$, ability to shift or alternate attention, $F(1,107) = 6.60$, $p < 0.05$, working memory, $F(1,107) = 6.84$, $p < 0.05$, plan/organize, $F(1,107) = 17.34$, $p < 0.001$, and monitoring skills, $F(1,107) = 7.36$, $p < 0.01$ compared to girls. Second, correlational analyses indicated that duration of time with diabetes was significantly related to parent report of treatment adherence, $r = -0.28$, $p < 0.01$ indicating that the longer the youth had been diagnosed with diabetes the poorer the treatment adherence was according to the caregiver. Duration of time with diabetes was also related to higher A1c levels, $r = 0.28$, $p < 0.01$. As a result of these findings, duration of time with diabetes was controlled in subsequent analyses and separate analyses were conducted for boys and girls. No other demographic or disease characteristics were related to any of the study variables.

Data reduction. First, it was important to reduce the number of executive functioning variables to match the theoretical concepts of cognitive flexibility, attentional control, and goal setting. Thus, the BRIEF's inhibit and shift subscales ($r = 0.74$, $p < 0.001$) were standardized via Z scores, then the two scores were averaged and re-standardized to create a single measure of *attentional control* with higher numbers indicating poorer functioning. The BRIEF's plan/organize and monitor subscales ($r = 0.80$, $p < 0.001$) were also standardized via Z scores, then the two scores were averaged and re-standardized to create a single measure of *goal setting*. No data reduction procedures were needed for *emotion regulation* and *cognitive flexibility* as they were each represented by a single measure (emotion regulation = emotional control; cognitive flexibility = working memory), although they were also standardized via Z scores. Finally, parent and child report of treatment adherence ($r = 0.41$, $p < 0.001$) were also standardized via Z scores, then the two scores were averaged and re-standardized to create a single measure of *treatment adherence* with higher numbers indicating better adherence.

Associations between self-regulation, treatment adherence, and glycemic control

Partial correlations, controlling for duration of time with diabetes, were conducted separately for boys and girls and are presented in Table 2. For boys, all three executive functioning measures (cognitive flexibility, attentional control, and goal setting) along with emotion regulation were negatively correlated

Table 1. Descriptive statistics for study variables

	M	SD	Min	Max	N
Self-regulation measures					
BRIEF-inhibit (P)	5.83	5.35	0	20	109
BRIEF-shift (P)	5.43	4.25	0	16	109
BRIEF-working memory (P)	7.01	5.62	0	20	109
BRIEF-plan/organize (P)	9.36	6.64	0	24	109
BRIEF-monitor (P)	6.46	4.02	0	15	109
BRIEF-emotional control (P)	7.45	5.28	0	20	109
Treatment adherence measures					
DSMP-overall score (P)	55.31	11.62	22	77	100
DSMP-overall score (A)	57.37	10.15	22	77	99
Diabetes control measure					
Hemoglobin A1c test (L)	9.06	2.04	5.0	14.0	107

BRIEF, behavior rating inventory of executive function; DSMP, diabetes self-management profile.
(P) = parent report, (A) = adolescent report, (L) = laboratory measure.

Table 2. Correlations among variables

Variable	1	2	3	4	5	6
1. Cognitive flexibility (P)	—	0.79***	0.90***	0.62***	−0.12	0.02
2. Attentional control (P)	0.73***	—	0.86***	0.75***	−0.19	0.03
3. Goal setting (P)	0.86***	0.83***	—	0.75***	−0.19	−0.01
4. Emotion regulation (P)	0.70***	0.87***	0.78***	—	−0.26	0.03
5. Treatment adherence (P & A)	−0.50**	−0.46**	−0.58***	−0.47**	—	−0.60***
6. Hba1c (L)	0.47**	0.33*	0.40**	0.45**	−0.41**	—

Values above the diagonal are for girls; values below the diagonal are for boys.
All correlations controlled for duration of diabetes.
HbA1c, hemoglobin A1c.
(P) = parent report, (P & A) = combined parent and adolescent report, (L) = lab measure.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

with treatment adherence indicating that higher levels of self-regulation deficits were associated with significantly worse treatment adherence. All self-regulation measures were also positively correlated with A1c levels indicating that higher levels of self-regulation deficits were associated with significantly worse glycemic control. For girls, none of the self-regulation measures were significantly associated with either treatment adherence or glycemic control. However, treatment adherence and glycemic control were significantly and positively associated for both boys and girls. Given the lack of associations between the self-regulation measures, treatment adherence, and glycemic control, subsequent analyses focused on only boys.

Regression analyses were also conducted to determine whether all self-regulation skills (i.e., emotion regulation, cognitive flexibility, goal setting, attentional control) were uniquely associated with glycemic control or if there were particular skills that were most important in this association in boys. These analyses revealed a significant association between self-regulation skills and glycemic control, even after controlling for duration of diabetes, $F(4,39) = 3.92$, $p < 0.01$, total $R^2 = 0.42$, $\Delta R^2 = 0.23$. However, only emotion regulation was marginally related to glycemic control, $\beta = 0.49$, $p < 0.07$. Thus, adolescent boys with higher levels of emotion regulation difficulties had higher A1c levels. Attentional control ($\beta = -0.37$, $p = 0.21$), cognitive flexibility ($\beta = 0.38$, $p = 0.11$), and goal setting ($\beta = -0.03$, $p = 0.92$) were not significantly related to glycemic control.

Mediational analyses

Hiearchical regressions were conducted to examine whether treatment adherence mediates the association between self-regulation and glycemic control in boys. Mediational analyses were only conducted with emotion regulation as it was the only self-regulation measure to be marginally associated with glycemic control. To test for mediation, procedures recommended by Baron and Kenny (35) were followed. All requirements for mediation were met as emotion regulation skills, after controlling for duration of diabetes, significantly related to both treatment adherence, $F(1,41)$ change = 11.13, $p < 0.01$, total $R^2 = 0.38$, R^2 change = 0.17, $\beta = -0.41$; and glycemic control, $F(1,42)$ change = 10.55, $p < 0.01$, total $R^2 = 0.35$, R^2 change = 0.16, $\beta = 0.41$. Treatment adherence also was associated with glycemic control, $F(1,40) = 8.25$, $p < 0.01$, total $R^2 = 0.33$, R^2 change = 0.14, $\beta = -0.42$. Finally, as depicted in Table 3, we tested our mediational model by examining whether emotion regulation continued to have a significant effect on glycemic control, after controlling for both duration of diabetes and treatment adherence. Contrary to our hypothesis, treatment adherence did not mediate the relation between emotion regulation and glycemic control. The Sobel test also confirmed the lack of even a partial mediation model as there was not a significant reduction in the effect of emotion regulation on glycemic control once treatment adherence was added to the model, Sobel test = 1.50, $p = 0.13$. Thus, for boys, emotion regulation provided unique variance toward the association with glycemic control even after accounting for duration of diabetes and treatment adherence.

Table 3. Regression analyses testing treatment adherence as a mediator between the association of emotion regulation and glycemic control

		β	R^2	R^2 change	F change
Boys (n = 42)					
Step 1.	Duration of diabetes	0.34*	0.19	0.19	9.37**
Step 2.	Treatment adherence	−0.27	0.32	0.13	8.25**
Step 3.	Emotion regulation	0.29*	0.39	0.07	4.25*

*$p < 0.05$, **$p < 0.01$.

Discussion

In this study, we examined the extent to which self-regulation skills, including executive functioning and emotion regulation skills, related to treatment adherence and glycemic control in youth with type 1 diabetes. Our results generally supported our hypothesis in that for boys, all self-regulation measures (cognitive flexibility, attentional control, goal setting, and emotion regulation) were significantly associated with treatment adherence and glycemic control. Specifically, male adolescents whose parents reported them as having poorer self-regulation skills across executive functioning and emotion regulation domains were less likely to adhere to their diabetes treatment regimen as measured by both parent and adolescent report and had worse A1c compared to adolescents with better self-regulation skills. Further analyses indicated that emotion regulation was the main self-regulation measure related to treatment adherence and glycemic control. For girls, no self-regulation measures were significantly associated with treatment adherence or glycemic control.

These results provide initial support for the importance of examining male adolescents' self-regulation skills as they relate to diabetes treatment management. Past studies have demonstrated that individual factors such as children's overall behavior problems are associated with treatment adherence and diabetes control (9, 11). However, the exact mechanisms by which overall behavior problems contribute to non-adherence remained unclear. Our findings extend the literature by showing that a more specific and proximal mechanism (i.e., self-regulation) is related to both behavioral treatment adherence and glycemic control. It is important to note that while there is a significant link between behavior problems and self-regulation deficits (36), the association between self-regulation deficits and poor diabetes control may also occur independent of behavior problems (e.g., an adolescent who is forgetful but compliant).

A recent study by Bagner and colleagues (21) found that children with type 1 diabetes who had worse executive functioning skills were less likely to behaviorally adhere to their treatment. Our study not only corroborates this finding in an adolescent sample, but also extends the literature by showing that executive functioning/self-regulation skills also relate to biological indicators of diabetes control (i.e., A1c). It also extends the literature by showing the importance of examining various self-regulation/executive functioning skills as emotion regulation had the strongest association to treatment adherence and glycemic control. Thus, while a type 1 diabetes treatment regimen is complex, an adolescent's ability to cope with the various stressors and emotions may be as important as higher-order thinking skills for maximizing treatment adherence and diabetes control. The mechanism by which emotion regulation relates to glycemic control remains unclear as mediational analyses failed to support that the link between emotion regulation and glycemic control is mediated through treatment adherence. Thus, emotion regulation continued to be associated with glycemic control, even after accounting for treatment adherence.

Perhaps, a physiological mechanism can explain the link between emotion regulation and glycemic control. For example, there is some evidence suggesting that stress can contribute to metabolic instability via increased secretion of glucocorticoids such as cortisol (37, 38). Cortisol is a counter-regulatory hormone that has been shown to alter insulin sensitivity via multiple mechanisms including by impairing insulin-dependent glucose uptake, enhancing gluconeogenesis, and/or inhibiting insulin secretion from pancreatic β-cells (39). Given the well-established association between emotion regulation and the HPA axis/cortisol activity (40), it is possible that adolescents with better emotion regulation skills end up having better glycemic control via better regulation of cortisol during non-stressful and stressful events. However, given the cross-sectional nature of this study and evidence that blood glucose levels can also affect HPA axis responsiveness (41), it may also be the case that poorly controlled diabetes contributes to emotion dysregulation. To gain a better understanding on the directionality of the association between emotion regulation and glycemic control, future research needs to employ a longitudinal design with multiple measurements of emotion regulation and glycemic control to determine whether dynamic changes in one variable affects the other.

Finally, this study found a significant gender difference in the link between self-regulation and diabetes treatment management as no associations were found for girls. Past studies within the child development and developmental psychopathology domains have documented boys as having significant greater self-regulation deficits compared to girls (26, 27). Perhaps, girls' lack of self-regulation difficulties as reported by parents statistically limited its potential association with adherence measures and diabetes control. On the other hand, it may be that parents tend to be more overprotective and/or involved in the diabetes treatment of girls compared to boys. This type of parental overprotection and/or involvement may limit girls' opportunity to independently manage their diabetes treatment which would subsequently lessen the chance to observe how their self-regulation skills relate to successful diabetes treatment management. Gender differences in parental involvement have been reported in the educational literature as parents tend to be more involved in girls' education compared to boys (42). It will be important for future research to examine how parents socialize their adolescents into managing their diabetes treatment and determine whether such socialization practices differ by child gender.

The role of cortisol as a potential physiological mechanism linking emotion regulation to glycemic control may also explain the significant gender difference we found. For example, males have been found to have higher levels of stress reactivity and surges of cortisol when encountering challenging or stressful situations compared to females (43, 44). The neural pathways by which males and females react to stress have also been shown to differ. For example, Wang et al. (45) found that the neural activation pattern for males involved asymmetric prefrontal activity, whereas females had primarily limbic activation. In turn, the asymmetric prefrontal activity in males was associated with higher levels of cortisol, whereas the female limbic activation showed a lower degree of association with cortisol (45). Hence, it is possible that the link between adolescent boys' emotion dysregulation and poor glycemic control is mediated through higher cortisol levels whereas girls' lower stress reactivity would limit its association with glycemic control. Examining adolescents with type 1 diabetes' stress reactivity via cortisol levels along with measures of self-regulation skills would be an important avenue for future research to further investigate gender differences in the mechanism by which self-regulations skills relate to diabetes control.

In viewing the potential contributions of this study, limitations should be considered. First, self-regulation measures were based on parent report and tended to be highly correlated with one another calling into question the validity of separating the self-regulation domains. This may indicate a tendency on parents to generalize adolescents' self-regulation deficits across domains. It will be important for future studies to employ both parent and lab-based measures (e.g., neuropsychological tasks) to obtain a more accurate assessment of adolescents' self-regulation skills across domains. Obtaining adolescents' self-report on their self-regulation skills would also provide important information as to the extent to which they are aware of their skills, especially given the developmental shift in treatment responsibility that takes place in adolescence. Second, as mentioned earlier, this study was cross-sectional in nature; thus causal relations between self-regulation and glycemic control cannot be concluded. Finally, the mediational analysis conducted was exploratory in nature given that only a marginal association between emotion regulation and glycemic control emerged when all other self-regulation skills were included in the model. Despite these limitations, the current study demonstrates the importance of examining adolescents' self-regulation skills, in particular emotion regulation skills, as it relates to treatment adherence and diabetes control.

In terms of clinical implications, this study indicates that a general parent measure of self-regulation/executive functioning, such as the BRIEF, may be sensitive enough to identify adolescent boys who may be at risk of having treatment adherence and glycemic control difficulties. Hence, it may be important for healthcare providers to assess adolescent boys' self-regulation skills upon diagnosis and throughout treatment to identify those that may need intervention. In terms of intervention, significant efforts have been made to create clinical interventions that improve treatment adherence and diabetes control (46). The findings from this study suggest that it may be important for interventions, which have traditionally focused on the family system, to include a component in which adolescent boys' individual self-regulation skills are targeted. Specific targets of intervention could focus on helping adolescent boys improve their ability to regulate stress and negative emotions by expanding their coping strategies (e.g., relaxation/meditation strategies, positive thinking skills). Coping skills training for youth with diabetes have been found to be effective in improving glycemic control and quality of life (47). Hence, it will be important to continue to integrate such coping services in pediatric clinics as well as further assessing how to continue to improve adolescent boys' self-regulation skills as it relates to their diabetes treatment management.

References

1. Delamater AM. Improving patient adherence. Clin Diab 2006: 24: 71–77.
2. Centers for Disease Control and Prevention. National Diabetes Fact Sheet: General Information and National Estimates on Diabetes in the United States, 2007. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2008.
3. Delamater A, Jacobson A, Anderson B et al. Psychosocial therapies in diabetes: report of the Psychosocial Therapies Working Group. Diab Care 2001: 24: 1286–1292.
4. Kyngas HA. Predictors of good adherence of adolescents with diabetes (insulin-dependent diabetes mellitus). Chronic Illn 2007: 3: 20–28.
5. Ellis DA. The role of parental monitoring in adolescent health outcomes: impact on regimen adherence in youth with type 1 diabetes. J Pediatr Psychol 2007: 32: 907–917.
6. LaGreca A, Auslander W, Greco P, Spetter D, Fisher E, Santiago J. I get by with little help from my family and friends: adolescents' support for diabetes care. J Pediatr Psychol 1995: 20: 449–476.
7. Anderson B, Brackett J, Ho J, Laffel, LM. An office-based intervention to maintain parent–adolescent

teamwork in diabetes management. Impact on parent involvement, family conflict, and subsequent glycemic control. Diab Care 1999: 22: 713–721.
8. Botello-Harbaum M, Nansel T, Haynie D, Iannotti R, Simons-Morton B. Responsive parenting is associated with improved type 1 diabetes-related quality of life. Child: Care Health Dev 2008: 34: 675–681.
9. Duke DC, Geffken GR, Lewin AB, Williams LB, Storch EA, Silverstein JH. Glycemic control in youth with type 1 diabetes: family predictors and mediators. J Pediatr Psychol 2008: 33: 719–727.
10. Palmer D, Berg C, Wiebe D et al. The role of autonomy and pubertal status in understanding age differences in maternal involvement in diabetes responsibility across adolescence. J Pediatr Psychol 2004: 29: 35–46.
11. Cohen D, Lumley M, Naar-King S, Partridge T, Cakan N. Child behavior problems and family functioning as predictors of adherence and glycemic control in economically disadvantaged children with type 1 diabetes: a prospective study. J Pediatr Psychol 2004: 29: 171–184.
12. Fortenberry K, Butler J, Butner J, Berg C, Upchurch R, Wiebe D. Perceived diabetes task competence mediates the relationship of both negative and positive affect with blood glucose in adolescents with type 1 diabetes. Ann Behav Med 2009: 37: 1–9.
13. Kaar M, Akerblom H, Huttunen N, Knip M, Sakkinen K. Metabolic control in children and adolescents with insulin-dependent diabetes mellitus. Acta Paediatr 2008: 73: 102–108.
14. Baumeister R, Vohs K. Handbook of Self-regulation: Research, Theory, and Applications. New York, NY, US: Guilford Press, 2004.
15. Calkins S. The emergence of self-regulation: biological and behavioral control mechanisms supporting toddler competencies. In: Brownell C, Kopp C, eds. Socioemotional Development in the Toddler Years. New York: The Guilford Press, 2007: 261–284.
16. Pennington B, Ozonoff S. Executive functions and developmental psychopathology. J Child Psychol Psychiatr Allied Disciplines 1996: 37: 51–87.
17. Alexander M, Stuss D. Disorders of frontal lobe functioning. Semin Neurol 2000: 2: 427–437.
18. Anderson P. Assessment and development of executive function in childhood. Child Neuropsychol 2002: 8: 71–82.
19. Naguib J, Kulinskaya E, Lomax C, Garralda M. Neuro-cognitive performance in children with type 1 diabetes – a meta-analysis. J Pediatr Psychol 2009: 34: 271–282.
20. Lin A, Northam E, Rankins D, Werther G, Cameron F. Neuropsychological profiles of young people with type 1 diabetes 12 yr after disease onset. Pediatr Diab 2010: 11: 235–243.
21. Bagner D, Williams L, Geffken G, Silverstein J, Storch E. Type 1 diabetes in youth: the relationship between adherence and executive functioning. Child Health Care 2007: 36: 169–179.
22. Hood K, Peterson C, Rohan J, Drotar D. Association between adherence and glycemic control in pediatric type 1 diabetes: a meta-analysis. Pediatrics 2009: 124: e1171–e1179.
23. Bosch N, Riese H, Ormel J, Verhulst F, Oldehinkel A. Stressful life events and depressive symptoms in young adolescents: modulation by respiratory sinus arrhythmia? The TRAILS study. Biol Psychol 2009: 81: 40–47.
24. Suveg C, Hoffman B, Zeman J, Thomassin K. Common and specific emotion-related predictors of anxious and depressive symptoms in youth. Child Psychiatr Human Dev 2009: 40: 223–239.
25. Sultan S, Epel E, Sachon C, Vaillant G, Hartemann-Heurtier A. A longitudinal study of coping, anxiety and glycemic control in adults with type 1 diabetes. Psychol Health 2008: 23: 73–89.
26. Card N, Stucky B, Sawalani G, Little T. Direct and indirect aggression during childhood and adolescence: a meta-analytic review of gender differences, intercorrelations, and relations to maladjustment. Child Dev 2008: 79: 1185–1229.
27. Matthews J, Ponitz C, Morrison F. Early gender differences in self-regulation and academic achievement. J Educ Psychol 2009: 101: 689–704.
28. Lehmkuhl HD, Cammarata C, Meyer K et al. Psychometric properties of a self-report measure of adherence to the diabetes regimen. Child Health Care 2009: 38: 76–90.
29. Lewin AB, Geffken GR, Williams LB, Duke DC, Storch EA, Silverstein JH. Development of the diabetes family measure. Child Health Care 2010: 39: 15–33.
30. Lewin AB, La Greca AM, Geffken GR et al. Validity and reliability of an adolescent and parent rating scale of type 1 diabetes adherence behaviors: The Self-Care Inventory (SCI). J Pediatr Psychol 2009: 34: 999–1007.
31. Lewin AB, Storch EA, Williams LB et al. Normative data on a structured interview for diabetes adherence in childhood. J Pediatr Psychol 2010: 35: 177–182.
32. Lewin AB, Heidgerken AD, Geffken GR et al. The relation between family factors and metabolic control: the role of diabetes adherence. J Pediatr Psychol 2006: 31: 174–183.
33. Gioia GA, Isquith PK, Guy SC, Kenworthy L. BRIEF: Behavior Rating of Inventory of Executive Function. Odessa, FL: Psychological Assessment Resources, 2000.
34. Harris MA, Wysocki T, Sadler M et al. Validation of a structured interview for the assessment of diabetes self-management. Diab Care 2000: 23: 1301–1304.
35. Baron R, Kenny D. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J Pers Soc Psychol 1986: 51: 1173–1182.
36. Keenan K, Shaw DS. Exploring the etiology of antisocial behavior in the first years of life. In: Lahey BB, Moffitt TE, Caspi A, eds. Causes of Conduct Disorder and Juvenile Delinquency. New York: The Guilford Press, 2003: 153–181.
37. Aguilar-Zavala H, Garay-Sevilla M, Malacara J, Pérez-Luque E. Stress, inflammatory markers and factors associated in patients with type 2 diabetes mellitus. Stress Health: J Int Soc Invest Stress 2008: 24: 49–54.

38. Dutour A, Boiteau V, Dadoun F, Feissel A, Atlan C, Oliver C. Hormonal response to stress in brittle diabetes. Psychoneuroendocrinology 1996: 21: 525–543.
39. Andrews R, Walker B. Glucocorticoids and insulin resistance: old hormones, new targets. Clin Sci 1999: 96: 513–523.
40. Stansbury K, Gunnar M. Adrenocorticalactivity and emotion regulation. Monogr Soc Res Child Dev 1994: 59: 108–134.
41. Gonzalez-Bono E, Rohleder N, Hellhammer D, Salvador A, Kirschbaum C. Glucose but not protein or fat load amplifies the cortisol response to psychosocial stress. Horm Behav 2002: 41: 328–333.
42. Carter R, Wojtkiewicz R. Parental involvement with adolescents' education: do daughters or sons get more help? Adolescence 2000: 35: 29–44.
43. Kirschbaum C, Wust S, Hellhammer D. Consistent sex differences in cortisol responses to psychological stress. Psychosom Med 1992: 54: 648–657.
44. Kudielka B, Kirschbaum C. Sex differences in HPA axis responses to stress: a review. Biol Psychol 2005: 69: 113–132.
45. Wang J, Korczykowski M, Rao H et al. Gender differences in neural response to psychological stress. Soc Cogn Affect Neurosci 2007: 2: 227–239.
46. Plante W, Lobato D. Psychosocial group interventions for children and adolescents with type 1 diabetes: the state of the literature. Child Health Care 2008: 37: 93–111.
47. Grey M, Boland E, Davidson M, Li J, Tamborlane W. Coping skills training for youth with diabetes mellitus has long-lasting effects on metabolic control and quality of life. J Pediatr 2000: 137: 107–113.