

Diabetes Problem Solving by Youths with Type 1 Diabetes and their Caregivers: Measurement, Validation, and Longitudinal Associations with Glycemic Control

Tim Wysocki,¹ PhD, Ronald Iannotti,² PhD, Jill Weissberg-Benchell,³ PhD, Lori Laffel,⁴ MD, Korey Hood,⁴ PhD, Barbara Anderson,⁵ PhD, Rusan Chen,⁶ PhD, for the Family Management of Childhood Diabetes Steering Committee

¹Nemours Children's Clinic, ²National Institute of Child Health and Human Development, ³Children's Memorial Hospital, ⁴Joslin Diabetes Center, ⁵Texas Children's Hospital, and ⁶Georgetown University

Objectives This article introduces a new measure of problem-solving skills of youths with type 1 diabetes (T1DM) and adult caregivers in correcting glycemic fluctuations. **Methods** The Diabetes Problem Solving Interview (DPSI), a structured interview, was validated during a pilot study of a behavioral intervention. DPSI data and measures of diabetes management were obtained at baseline from 114 youths (ages 9–14.5) and 109 caregivers. Glycosylated hemoglobin (HbA_{1c}) was measured quarterly over 9 months. **Results** Results confirmed the psychometric adequacy of the DPSI. For caregivers, but not youths, low DPSI scores (indicating poor problem-solving skills) were significantly associated with worse HbA_{1c} over 9 months. **Conclusions** The DPSI has clinical and research utility as a measure of diabetes problem-solving skills. Identification and targeted remediation of caregivers' deficient diabetes problem-solving skills or promotion of youths' utilization of these skills could possibly enhance glycemic control in youths with T1DM.

Key words adolescents; children; diabetes; problem solving.

Introduction

Youths with type 1 diabetes mellitus (T1DM) who can successfully optimize daily blood glucose control can enjoy a more flexible lifestyle, while minimizing their risks of serious long-term complications (Diabetes Control and Complications Trial Research Group, 1994). Living with T1DM requires youths and their parents/caregivers to recognize unwanted fluctuations in blood glucose levels and to respond promptly and effectively to these events (Chase, 2006). Chronically, high blood glucose (hyperglycemia) raises the risk of both short-term complications (e.g., diabetic ketoacidosis) and long-term complications (e.g., cardiovascular disease, retinopathy, nephropathy, and neuropathy). Episodes of low blood glucose (hypoglycemia) may be associated with cognitive decrements (Hershey, Lillie, Sadler, & White, 2002),

increased risk of injury, embarrassment, and disruption of normal activities. The extent to which extreme excursions of blood glucose can be either prevented or corrected promptly may be a key factor affecting emotional adjustment to diabetes, self-efficacy about its management, family conflict and symptoms of depression, and anxiety among these youths (Kuttner, Delamater, & Santiago, 1990). Consequently, the proficiency of youths and parents in responding to unwanted blood glucose fluctuations is likely to be a critical determinant not only of medical outcomes of diabetes, but also of its psychosocial outcomes. Experience gained in the Diabetes Control and Complications Trial (DCCT; Diabetes Control & Complications Trial Research Group, 1993) suggests anecdotally that patients who acquired strong diabetes problem-solving skills tended to report

All correspondence concerning this article should be addressed to Tim Wysocki, PhD, Center for Pediatric Psychology Research, Nemours Children's Clinic, 807 Children's Way, Jacksonville, FL 32207-8426, USA.
E-mail: twysocki@nemours.org

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more flexible lifestyles and more favorable diabetes-related quality of life compared with patients who lacked these skills. The American Diabetes Association (Mensing et al., 2005) includes diabetes problem-solving skills among its required curricular elements in its standards for recognition of diabetes education programs.

Problem solving is an element of executive functioning and requires analysis of the problem, generation of possible solutions, evaluation of the risks and benefits of those solutions, and analysis of the outcomes (Bagner, Williams, Geffken, Silverstein, & Storch, 2007; Cook, Alkens, Berry, & McNabb, 2001). Reliable and valid measurement of these skills is a prerequisite to conducting sound research on this topic and to applying that research to clinical practice (Johnson, 1984, 1995). There have been several tests of diabetes knowledge for youths and parents published in the past (Eastman, Johnson, Silverstein, Spillar, & McCallum, 1983; Harkavy, et al., 1983; Johnson, et al., 1982; La Greca, Follansbee, & Skyler, 1990; Wysocki, et al., 1996), but these instruments typically demand relatively low levels of cognitive operations such as recognition or recall of facts, rather than more sophisticated cognitive skills such as application, analysis, synthesis, or evaluation (Bloom, 1984; Wysocki, 2000). Effective diabetes problem solving may be mediated by these higher cognitive functions.

We are aware of only three such tools that have been developed and validated: Johnson's Test of Diabetes Knowledge (Johnson et al., 1982), the Diabetes Awareness and Reasoning Test developed by Heidgerken et al. (2007), and the Diabetes Problem-Solving Measure for Adolescents (Cook et al., 2001). The first two instruments included several diabetes problem-solving scenarios in which children and parents are asked to identify which of several alternative solutions is most appropriate in each situation. The Test of Diabetes Knowledge predated the widespread use of self-monitoring of blood glucose, the use of insulin pumps, the recent introduction of new insulin types, and the intensification of diabetes management subsequent to the DCCT and so its applicability to modern therapy for T1DM is limited. The Diabetes Awareness and Reasoning Test includes modern diabetes regimens but requires recognition of a correct solution rather than generating appropriate solutions or providing a rationale for selection of the most appropriate solution. These problem-solving items do not represent a unique construct; they have the same psychometric properties as the knowledge items and have been incorporated into a single total score along with items assessing general knowledge about insulin,

nutrition, hyperglycemia/hypoglycemia, pump use, and school issues. The Diabetes Problem-Solving Measure for Adolescents most closely meets the criteria for a problem-solving task (vignettes are presented and solutions are spontaneously generated by the respondent), but it was developed and validated with a cross-sectional sample of older adolescents (ages 13–17). Consequently, the primary purpose of this article is to introduce a new measure of diabetes problem-solving skills suitable for preadolescents and early adolescents and their adult caregivers, and to present information on its psychometric properties using longitudinal data.

Presumably, possession of adequate diabetes problem-solving skills should equip caregivers and youths to achieve and maintain acceptable glycemic control, while deficiencies in those skills should be predictive of inadequate glycemic control. Another purpose of the work reported here was to evaluate the extent to which baseline measurements of adult caregivers' and youths' diabetes problem-solving skills were associated with glycosylated hemoglobin levels measured prospectively over 9 months.

Methods

Participants

Participants in this study were enrolled in a multi-site pilot and feasibility study that was preliminary to a larger randomized controlled trial of a clinic-based, family-focused intervention designed to optimize family adaptation to childhood diabetes during late childhood and early adolescence. Primary objectives of the pilot and feasibility study were to evaluate the feasibility and acceptability of the measurement and intervention protocols and to refine those protocols for the larger randomized controlled trial to follow. All parents or other legal caregivers had signed institutionally approved informed consent or parental permission forms and all youths had assented to participation in the study using each center's approved procedures for doing so. Eligibility criteria for children and adolescents were: age 9.0 through 14.5 years; duration of T1DM of 12 months or longer; established diabetes care at the enrolling center; absence of other chronic systemic diseases; grade-appropriate reading skills in English; not enrolled in self-contained special education; and no history of psychiatric hospitalization within the prior 6 months. Enrollment criteria for parents/caregivers and families included at least 5th grade reading fluency in English; absence of diagnosis of psychosis, substance use disorder, major depression, or bipolar disorder; no history of

Table I. Demographic Characteristics of Parents ($n = 109$) and Youths ($n = 114$) who Contributed Data for this Report

| Youths | <i>M</i> | <i>SD</i> |
|-------------------------------------|----------|-----------|
| Age (Years) | 12.1 | 1.6 |
| Duration of diabetes (Years) | 5.8 | 3.1 |
| HbA _{1C} (%) | 8.4 | 1.4 |
| Race/Ethnicity (%) | | |
| Caucasian | 71 | |
| African-American | 12 | |
| Hispanic | 10 | |
| Other/multiple | 7 | |
| Gender (%) | | |
| Male | 49 | |
| Female | 51 | |
| Parents/Caregivers (%) | | |
| Relationship to child with diabetes | | |
| Mother/stepmother | 92 | |
| Father/stepfather | 7 | |
| Other | 1 | |
| Household annual income (%) | | |
| <\$30,000 | 13 | |
| \$30,000–50,000 | 9 | |
| \$50,000–100,000 | 40 | |
| >\$100,000 | 37 | |
| Highest educational level (%) | | |
| <High school | 4 | |
| High school graduate | 15 | |
| Some college | 35 | |
| College graduate | 32 | |
| Advanced degree | 14 | |

psychiatric hospitalization in prior 6 months; and working telephone service.

The full sample for the pilot and feasibility study included 122 children with T1DM and their caregivers, of whom 114 youths and 109 adult caregivers were interviewed using the DPSI as described subsequently. Missing data were attributable primarily to malfunctions of the recording equipment or to inaudible recordings that could not be transcribed satisfactorily. Demographic characteristics of the 114 youths and 109 parents whose data were analyzed for this article are summarized in Table I. There were no statistically significant differences at baseline between the intervention and control groups on these demographic characteristics.

Setting

Families enrolled at one of four pediatric diabetes centers located in the Northeastern, Southeastern, Southwestern, and Midwestern United States. Participants were enrolled in a pilot randomized trial designed to establish the

feasibility of the intervention and measurement protocols prior to a larger randomized controlled trial (Nansel et al., manuscript under review). Families were randomly assigned, stratified by age (<12 or ≥12-years old) and most recent glycosylated hemoglobin level (<8.3 or ≥8.3%), to either the Intervention or Control conditions. All study families received the same medical care for diabetes during the study that they would have received if not enrolled in the study. At all sites this consisted of clinic visits approximately once each 3 months with a pediatric endocrinologist and a diabetes nurse and, as needed, a dietitian, social worker, or psychologist. Diabetes regimens at baseline were: 44 youths (36%) on insulin pumps, 32 (26%) on “basal-bolus” multiple daily injection regimens and 46 (38%) on conventional, fixed-dose insulin injection regimens with no differences between the Intervention and Control groups. Self-management education was strongly emphasized and targets of treatment were to maintain HbA_{1C} as close to normal as possible, while minimizing the occurrence of severe or symptomatic hypoglycemia. Intervention families received up to three sessions ($M = 2.85$) of a family-focused, low-intensity behavioral intervention delivered during quarterly routine diabetes clinic visits over a 6-month study period. Intervention families were taught by a specially trained Health Advisor (with a BA or MA in a behavioral science or related field) to apply a basic problem-solving strategy to daily problems in family management of childhood diabetes. Families received education, assistance with negotiation of an intervention plan, and supplemental handouts. Clinic encounters were followed by telephone follow-ups to evaluate and refine the intervention plan and to prepare for the subsequent clinic visit. These circumstances were maintained for a period encompassing three successive diabetes clinic visits for each study family, or ~6 months. Each family also had one follow-up visit ~9 months after randomization, at which time the final blood sample for a glycosylated hemoglobin assay was collected. Although treatment outcome measures were obtained, demonstration of a treatment effect favoring the experimental intervention was not expected during the pilot and feasibility study because of its relatively short duration, low intervention dosage, modest sample size, and preliminary intervention content and materials.

Measures

Biomedical data were collected by medical record review during or just after diabetes clinic visits. All questionnaires and interviews were collected at assessments

conducted in the home by field interviewers who were unaware of the participants' group assignments or of the adequacy of the child's diabetes management. The measures described subsequently were collected at baseline prior to the family's randomization and following the last clinic visit during the study period. Measures beyond those described here were administered, but only those listed below were analyzed for the purposes of the present article.

Diabetes Family Responsibility Questionnaire (DFRQ)

This is a 17-item questionnaire on which caregivers or children with T1DM rated the degree to which responsibility for each diabetes management task is a Parent Responsibility, a Shared Responsibility, or a Child Responsibility (Anderson, Auslander, Jung, Miller, & Santiago, 1990). Higher scores indicate increasing levels of child responsibility for diabetes management. Acceptable internal consistency, test-retest reliability and parent-child agreement have been reported consistently in a number of studies that have used this instrument. Greater parent-child discordance in scores on this measure has been associated with higher HbA_{1C} levels. Alpha coefficient for the present sample was .67 for caregivers and .73 for youths.

Diabetes Self Management Profile (DSMP)

This is a 24-item structured interview for the assessment of diabetes treatment adherence and self-management designed for administration to caregivers or youths ≥ 11 years of age (Diabetes Research in Children Network, 2005; Harris et al., 2000). Separate forms have been validated for patients treated on conventional, fixed-dose insulin regimens and for patients on flexible insulin regimens (i.e., insulin pumps or "basal-bolus" injection regimens) in which insulin bolus doses are adjusted proactively based on carbohydrate counting and dosage correction factors that account for prevailing glucose levels. Internal consistency (α -coefficients) for the present sample's total scores was .66 for the Youth Conventional Regimen form, .67 for the Youth Flexible Regimen form, .71 for the Parent Conventional Regimen form, and .76 for the Parent Flexible Regimen form. The caregivers' total score correlated significantly with youths' HbA_{1C} levels ($r = -.33$; $p < .01$).

Glycosylated Hemoglobin (HbA_{1C})

This blood test estimates average glycemic concentration over the prior 2–3 months (Chase, 2006). Blood samples were obtained quarterly by fingerstick and shipped to Joslin Diabetes Center for processing using the Tosoh

High Performance Liquid Chromatography method. This schedule yielded three HbA_{1C} measurements during the 6-month intervention phase of the study and one follow-up measurement at 9 months.

DPSI

An initial version of the DPSI consisted of separate structured interviews of parents/caregivers and children in which they were faced with four realistic diabetes vignettes. A collection of 12 vignettes was developed in consultation with pediatric endocrinologists and diabetes educators at each study center. Each interview addressed four vignettes, one each concerned with Prevention of Hypoglycemia, Prevention of Hyperglycemia, Correction of Hypoglycemia, and Correction of Hyperglycemia. In order to minimize observational reactivity, parents and youths were administered different randomly selected sets of vignettes at each evaluation. Participants were also administered different sets of vignettes at each successive evaluation to minimize practice effects. Participants were asked this series of questions about each vignette:

- What is the diabetes problem here?
- Why is this a problem? What would happen if he/she did nothing?
- Tell me all the ways this problem could be fixed.
- How would you fix this problem?
- How would that solution work?
- How would you know if you really fixed the problem?

Interviews were audio-recorded and subsequently transcribed verbatim for coding. Raters who were blind to the intervention assignment and demographic characteristics of the study families scored each transcript using detailed vignette-specific coding rules (available from the first author). Each response to a given question was rated as a "0" if a respondent offered no answer or gave an incorrect response (e.g., "I don't know") a "1" if a respondent offered a partially correct or incomplete response (e.g., the respondent would treat a presumed low blood glucose without first completing a blood glucose check) or a "2" if a respondent gave a correct response with supporting details or evidence of metacognition (e.g., "After taking extra insulin, I would re-check my blood glucose about once an hour until I was sure it was back to normal"). All transcribed interviews were rated independently by two raters to permit assessment of inter-rater agreement (see Results section).

After completion of interviews with the first 67 families who entered the study, concern about the overall

Table II. Vignettes Utilized in the DPSI

Correction of low blood sugar (Hypoglycemia) (CL) vignettes:

Tim played basketball before lunch at school. Later he was waiting in line for lunch. He started feeling dizzy, hot, and shaky.

Colin is at school and starts to feel shaky and weak in the middle of math class.

Lori had played soccer all morning. Just after she ate a big lunch, she started feeling really shaky, sweaty, hot, and like she might faint.

Correction of high blood sugar (Hyperglycemia) (CH) vignettes:

Amanda was supposed to go to soccer practice after school, but the coach cancelled it at the last minute. She ate lunch, but didn't take any insulin because she thought she would be playing soccer for about 2 hrs.

Emma was at dinner at her great aunt's house. Before dinner, she guessed that she would be eating 75 g of carbohydrates and she took her premeal insulin based on that guess. On the way home, she asked her parents about this and they thought she had eaten more like 100 g of carbs.

Mary Ann went to the pool with her friends. She thought she was going to be swimming so she took less insulin than usual before her lunch. But, when she arrived at the pool, it was closed.

length of the baseline assessment, which included collection of multiple measures, led to a careful evaluation of the need to administer all four types of scenarios at each interview. The interviewers reported that engagement of many children and some caregivers tended to wane when four scenarios were presented. There were also a number of instances in which both caregivers and children had difficulty discerning the diabetes problem that was implicit in the "Prevention" vignettes. Consequently, in addition to dropping certain other measures from the assessment protocol, a decision was made to delete the two "Prevention" vignettes, and to retain the two "Correction" vignettes from the DPSI. The remaining 47 caregiver-child dyads who were interviewed at baseline, and all interview participants at End of Study, were presented with two vignettes, consisting of one Correction of Hypoglycemia and one Correction of Hyperglycemia vignette for their analysis and resolution; for all participants, only scores on these two types of vignettes were analyzed and reported in this paper. A DPSI total score, consisting of the number of points credited for each of the six structured questions (maximum of 12 points) averaged across the two vignettes (possible range 0–12), was generated for each participant. Caregivers and children were always interviewed in separate rooms about different vignettes to minimize potential reactivity. Table II shows the three Correction of Hypoglycemia and three Correction of Hyperglycemia vignettes that were utilized in this study.

Since the various DPSI vignettes differed in mean scores following the baseline administration of the interview, it was decided to devise a weighted scoring procedure to equate the difficulty levels of the various scenarios. Weights were calculated separately for children and caregivers. First, mean scores for each vignette were calculated using both baseline and end of study data. A mean for each type of vignette (correction of low and

correction of high) was then calculated using all six vignettes within that type. The ratio of the mean score of each vignette within that type to the mean for that type of vignette was then calculated. The inverse of this ratio was used to correct individual scores on the corresponding vignette. All DPSI scores entering the analyses reported below were adjusted using this method.

Statistical Analyses

Various statistical analyses permitted evaluation of the measurement properties of the DPSI. These included calculation of descriptive statistics for each vignette separately for caregivers and youths at baseline and end of study; internal consistency for each vignette and for the DPSI total scale at baseline and end of study; associations between demographic variables and caregiver and child DPSI total scores at baseline and end of study; comparison of and associations between caregiver and child DPSI total scores at baseline and end of study; inter-rater agreement at baseline and end of study; and convergent validity as measured by associations with other pertinent measures of family diabetes management and diabetes outcomes. Between-group effects on DPSI scores were examined by comparing change in DPSI total scores from baseline to end of study for the intervention group and the control group. Finally, Mixed Effects models (Hedeker & Gibbons, 2006) were used to examine the longitudinal association between DPSI scores and glycemic control with repeated HbA_{1C} levels as the outcome variable. Compared with conventional repeated measures analyses of variance (RM-ANOVA), the mixed effects models approach confers several statistical and interpretive advantages. These advantages include the capacity to control simultaneously for possible effects of intervention groups and clinical sites on HbA_{1C}, quantitative representation of the longitudinal

relationship among DPSI and HbA_{1C} during the entire period of observation rather than comparisons at discrete time points, the use of DPSI raw scores rather than derived cutoff scores as is implicit in RM-ANOVA, and the capacity to retain cases for analysis if there are missing HbA_{1C} values instead of excluding those cases as in RM-ANOVA. All available HbA_{1C} values at 0, 3, 6, and 9 months were included in the analysis. Average DPSI scores were used as a between-subject predictor in the model. Intervention effect (coded 1 and 0 for treatment and control groups, respectively) and site (as a random effect) were included in the model for controlling possible intervention and between-site effects on HbA_{1C}.

Results

Intervention Outcomes

The Intervention and Control groups did not differ significantly in mean HbA_{1C}, or total scores on the Diabetes Self Management Profile, Diabetes Family Responsibility Questionnaire, or DPSI at any measurement point. Since there was no treatment effect on DPSI scores or the primary diabetes outcomes that were measured, the Intervention and Control groups were combined for the descriptive analyses reported subsequently.

DPSI Descriptive Statistics

Mean \pm SD caregiver scores on the DPSI (maximum = 12) at baseline were 7.1 ± 1.7 and child scores were 6.5 ± 1.7 , a statistically significant difference (paired samples $t = 3.19$; $p < .01$). At baseline, there were no significant differences in DPSI total scores for either parents or youths who were administered four vignettes versus those who were administered two vignettes. At 6 months, the mean score for caregivers increased to 7.6 ± 1.4 ($t = 2.25$; $p < .05$), while that for youths increased to 7.0 ± 1.5 ($t = 2.92$; $p < .01$). The statistically significant difference between caregiver and child scores persisted at 6 months ($t = -3.60$; $p < .001$).

DPSI Reliability

Internal consistency of the DPSI (Cronbach's α -coefficient) was .59 for caregivers and .67 for children at baseline and .53 and .51, respectively, at 6 months. Item-total correlations were uniformly positive for both caregivers and children at baseline ($M = .44$; range = .19–.54) and 6 months ($M = .36$; range = .13–.45) and statistically significant. Stability of DPSI scores over time was modest, with Pearson correlations between

baseline and 6 months of .33 ($p < .001$) for children and .35 ($p < .001$) for caregivers. Caregiver scores were not significantly correlated with child scores at baseline ($r = .17$) or at 6 months ($r = .17$). Intra-class correlations were calculated to assess inter-rater reliability. Based on independent coding of all vignettes, the intra-class correlation was .82 for the baseline assessments and .80 for the 6-month assessments.

DPSI Validity

At baseline, children's scores correlated significantly with child age ($r = .18$; $p < .05$) but not with duration of diabetes. Caregivers' scores correlated significantly with HbA_{1C} ($r = -.31$; $p < .002$), while youths' scores did not. With child age controlled statistically, caregiver DPSI scores correlated significantly with degree of child responsibility for diabetes management (DFRQ) ($r = .23$; $p < .05$), and level of diabetic control ($r = -.31$; $p < .002$). Higher parental DPSI scores predicted more child responsibility and lower baseline HbA_{1C}.

Longitudinal Associations between DPSI Scores and Glycosylated Hemoglobin

Two mixed effects models were used to evaluate the association between DPSI scores and HbA_{1C}, one for parent and one for child DPSI scores, respectively. In both models, the effect for treatment group was not a significant predictor of HbA_{1C}. To facilitate graphical presentation of the longitudinal effects of interest, participants were divided into categories based on whether their baseline DPSI scores fell into the lowest, (Low), middle (Medium), or highest (High) third of the DPSI score distribution. Figure 1 shows that parent DPSI scores were significantly associated with HbA_{1C} across time [$F(1, 537) = 11.55$, $p < 0.001$], with weaker parental problem-solving skills related to poorer glycemic control in youths ($b = -0.25$).

Figure 2 shows the corresponding results for youths in the Low, Medium, and High DPSI groups. In contrast to the findings for caregivers, youths with High DPSI scores appeared to have slightly higher mean HbA_{1C} (range 8.8–9.0%) during the study than those in the Medium and Low DPSI groups. However, the child DPSI scores were not statistically associated with HbA_{1C} levels across time [$F(1, 547) = 0.41$, $p = 0.52$]. Further analysis showed that this latter finding was evident for both the younger and older halves of the sample and that these sub-groups did not differ significantly from each other.

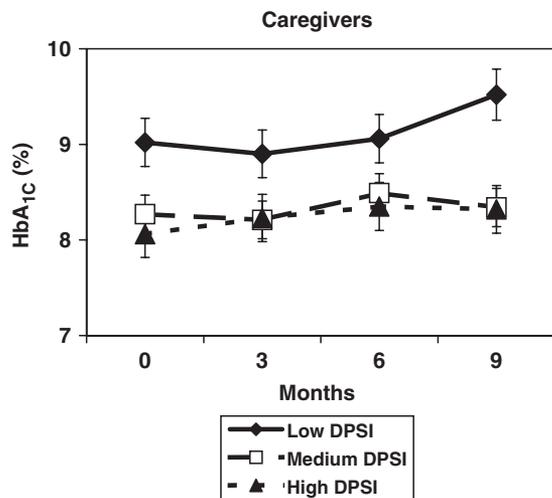


Figure 1. Youths' mean (± 1 SEM) HbA_{1C} (%) and caregivers' mean scores on the DPSI.

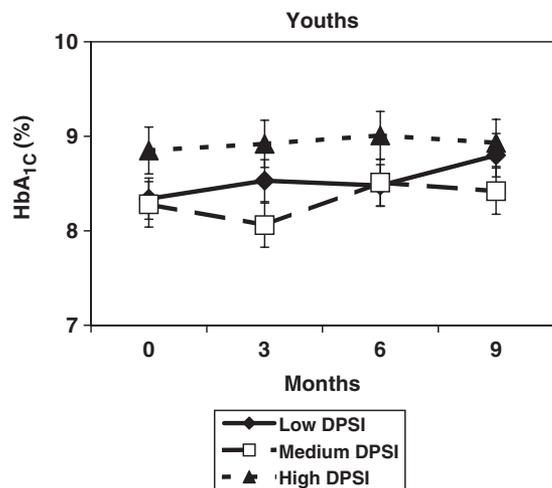


Figure 2. Youths' mean (± 1 SEM) HbA_{1C} (%) and youths' mean scores on the DPSI.

Discussion

This article introduced the DPSI and provided an evaluation of several psychometric properties of this measure. These contributions begin to fill a gap in the available measurement tools that have been validated for use in this clinical population by providing a method of quantifying skills of youths with T1DM and their adult caregivers in responding to unwanted glycemic fluctuations. To the extent that these skills may represent a key mediator of behavioral effects on diabetes outcomes, the DPSI provides a valuable tool for further research on these relationships. The measure yielded approximately

normal score distributions for both caregivers and youths, and demonstrated sufficient variability to enable analyses of the measure's statistical associations with other variables of interest. The reliability of the measure, as assessed by indices of internal consistency, item-total correlations, inter-rater agreement, and test-retest reliability, was marginally acceptable. Since the DPSI items targeting correction of hypoglycemia and hyperglycemia focus on distinct diabetes management skills, it is not surprising that the resulting estimates of internal consistency and item-total correlations were not particularly high. Evidence of the validity of the DPSI was provided by significant correlations between youths' age and DPSI scores, between caregivers' DPSI scores and concurrent HbA_{1C} measurements, and, with youths' age controlled, scores on the DFRQ.

While the analyses that were performed yielded only modest support for the psychometric properties of this structured interview, the mixed effects modeling analyses that were completed suggest that this is a promising direction for psychological assessment in pediatric T1DM and that further refinement of the instrument is certainly warranted. Specifically, the mixed effects modeling analysis showed that low DPSI scores among caregivers were particularly predictive of poor glycemic control over the ensuing 9 months. Thus, families in which caregivers lack sufficient skill for responding to and managing blood glucose fluctuations may be at special risk for unacceptable diabetes outcomes and this association was quite durable over time. This observation suggests that there may be a threshold for problem-solving skills in parents necessary for adequate diabetes management. Consequently, efforts to identify caregivers with deficient diabetes problem-solving skills and to provide them with targeted education may be particularly beneficial in terms of ultimate effects on their children's diabetes outcomes.

The corresponding relationship between youths' DPSI scores and HbA_{1C} levels revealed minimal evidence of associations similar to those found with caregivers. Youths' diabetes problem-solving skills were related to their current HbA_{1C} levels only after the contributions of pertinent parental behaviors were accounted for statistically. Youths' diabetes problem-solving skills were unrelated to their subsequent levels of glycemic control. On the surface, this effect would seem to be somewhat counter-intuitive. However, the psychological and educational research literature on pediatric diabetes is replete with reports of no relationship between diabetes knowledge or skills and measures of glycemic control or treatment adherence (see Johnson, 1984, 1995

for reviews). There are several plausible explanations for why caregivers' diabetes problem-solving skills would be more strongly associated with diabetes outcomes than would youths' skills.

Thomas, Peterson, and Goldstein (1997) reported that, although older youths demonstrated more sophisticated diabetes problem-solving skills in social situations, compared with younger children they were more likely to avoid utilization of their diabetes problem-solving skills in favor of behaviors that are perceived by them as more likely to yield peer affiliation and acceptance. Thus, adolescents who face social dilemmas pitting optimal diabetes management against peer affiliation and acceptance will tend to behave in accord with the latter priority. Similarly, Wysocki, Hough, Ward, Allen, and Murgai (1992) found that active use of self-monitored blood glucose data for treatment decisions was associated significantly with parental diabetes knowledge, but not with youth knowledge. A second possible explanation is that most youths in this age range may continue to rely heavily on parental involvement in decision making regarding treatment adjustments in response to blood glucose monitoring results. If youths do rely more heavily on their caregivers' diabetes problem-solving skills than on their own skills, it is reasonable to expect that youths' skills will account for minimal variance in diabetes outcomes and that youths whose caregivers have deficient skills will tend to struggle with diabetes management. Another possible explanation for this pattern of findings is that, since caregivers' DPSI scores were significantly higher than youths' scores, it is possible that few youths had sufficiently well-developed diabetes problem-solving skills to equip them to make active, appropriate treatment decisions in a timely manner without parental support or guidance. As with caregivers, there may be a minimum threshold for problem-solving skills to be effective. Youths with DPSI scores in the upper tertile had a mean score of 7.66, which overlaps that achieved by caregivers in the middle ($M = 6.86$) and highest ($M = 8.43$) tertiles of the caregiver distribution. Since children of these caregivers achieved similar, better HbA_{1C} levels compared to those in the lowest tertile, it seems implausible that similar DPSI scores obtained by youths would not also equip them to maintain similar levels of glycemic control. Another possible explanation might be that youths with extremely stable glycemic control may have fewer opportunities to engage in and practice problem solving than those with less stable glycemic control. If true, this could dilute a possible association between youths' problem-solving skills and indices of glycemic control.

While all of these possible interpretations of our findings are interesting and plausible, it remains for future research to determine if any are valid conceptualizations.

The present study has a number of limitations that should be taken into account when interpreting these results. Foremost among these is that several psychometric properties of the DPSI proved to be rather marginal. While the present findings reveal some promise for a measure of this type, further refinement of the measure appears warranted, perhaps including a more extensive collection of diabetes vignettes and empirically driven retention of those that prove to be most strongly associated with diabetes management behaviors and outcomes. The present study evaluated diabetes problem-solving skills in children as young as 9 years of age, but perhaps the findings suggest that these skills do not emerge until somewhat later in development. Supplementation of vocal presentation of vignettes with visual aids could possibly enhance youths' comprehension of the diabetes problems. Finally, it is possible that a revised scoring system that enables more fine-grained quantification of problem-solving skills could result in a measure that is more consistently associated with other relevant variables.

The primary clinical implication of the findings reported here is that youths with T1DM from families in which the primary diabetes caregiver has deficient diabetes problem-solving skills may be at elevated risk of poor glycemic control. If confirmed by further research, this observation implies that active efforts to identify these caregivers may be fruitful if these families can either be provided with effective remedial education targeting these specific skills or provided with additional consultation and support to enable them to compensate for these skill deficiencies. An additional clinical implication of the present findings derives from the suggestion that youths may not adequately utilize the diabetes problem-solving skills they have acquired. The absence of an association between youths' DPSI scores and either their measured adherence (DSMP scores) or glycemic control (HbA_{1C}) suggests that interventions that promote youths' utilization of problem solving skills in either naturalistic or realistically simulated circumstances (Gross, Heimann, Shapiro, & Schultz, 1983; Kaplan, Chadwick, & Schimmel, 1985) may be particularly valuable. Taken as a whole, the present findings support the targeting of diabetes problem-solving skills in behavioral and psychological interventions that seek to facilitate effective family management of pediatric T1DM.

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Conflicts of interest: None declared.

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Appendix

The following institutions and investigators comprised the steering committee of the Family Management of Diabetes multi-site trial.

National Institute of Child Health and Human Development, Bethesda, Maryland: Bruce Simons-Morton, EdD, Tonja R. Nansel, PhD, and Ronald J. Iannotti, PhD.

Joslin Diabetes Center, Boston, Massachusetts: Lori Laffel, MD MPH, Korey Hood, PhD. Contract N01-HD-4-3364.

Nemours Children's Clinic, Jacksonville, Florida: Tim Wysocki, PhD, Amanda Lochrie, PhD. Contract N01-HD-4-3361.

Texas Children's Hospital, Houston, Texas: Barbara Anderson, PhD. Contract N01-HD-4-3362.

Children's Memorial Hospital, Chicago, Illinois: Jill Weissberg-Benchell, PhD, Grayson Holmbeck, PhD. Contract N01-HD-4-3363.

James Bell Associates, Arlington, Virginia; Cheryl McDonnell, PhD, MaryAnn D'Elia, MS. Contract N01-HD-3-3360.

More detailed psychometric data are available from the first authors upon request.

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