Predictors of Youth Diabetes Care Behaviors and Metabolic Control: A Structural Equation Modeling Approach

Clarissa S. Holmes,[1,2] PhD, Rusan Chen,[2] PhD, Randi Streisand,[3] PhD, Donna E. Marschall,[3] PhD, Sari Souter,[1] PhD, Erika E. Swift,[2] PhD, and Catherine C. Peterson,[4] PhD

[1]Department of Psychology, Virginia Commonwealth University, [2]Department of Psychiatry, Georgetown University, [3]Department of Psychology, Children's National Medical Center, and [4]Department of Psychology, Case Western Reserve University

Objective To empirically test a biopsychosocial model of predictors of youth diabetes care behaviors and metabolic control. **Methods** A cross-sectional multisite study of youths (N = 222) with T1D (mean age = 12.6) used structural equation modeling to examine interrelations among predictors, with follow-up analyses of covariance (ANCOVAs). **Results** Youths' memory skills related to diabetes knowledge which, along with self-efficacy and age, was associated with greater youth responsibility that in turn predicted poorer self-care behaviors. Less frequent/briefer exercise and less frequent blood glucose monitoring/eating were found; the latter directly related to poorer metabolic control. Behavior problems also were associated directly with poorer metabolic control. A parsimonious model found memory directly related to blood glucose testing. **Conclusions** Continued parental supervision of adolescents, along with monitoring diabetes knowledge and efficacy, may help optimize transfer of diabetes care from parents to youths. Behavior problems warrant immediate attention because of their direct and adverse relation to metabolic control.

Key words diabetes; self-care; metabolic control.

Over the last two decades, researchers have investigated a range of factors related to the diabetes treatment regimen in an attempt to identify determinants of poorer health status in adolescents who are at greatest risk for later disease complications (Cox & Gonder-Frederick, 1992; Gonder-Frederick, Cox, & Ritterband, 2002). Identification of pertinent risk factors should lead to development of risk management strategies to enhance metabolic control and to reduce disease complications (Diabetes Control & Complications Trial Research Group, 1994). However, these efforts may be hampered by overly simplistic portrayals of one or two relevant disease care factors in isolation, such as youth diabetes knowledge or the family environment, or even a handful of attributes that can not realistically reflect the myriad of factors that may contribute to poorer self-care behaviors and metabolic control. Although many studies have evaluated a diverse range of parent/child factors related to disease outcomes, no study has evaluated all these factors simultaneously despite their established empirical associations. Only by simultaneously weighing all of these factors and their interrelations can a more comprehensive picture begin to emerge of the convergence of youth, parental, and familial attributes that more accurately portray the complexity of factors that contribute to daily self-care behaviors, and ultimately to metabolic control.

Establishing the ecological validity or accuracy of a model with multiple contributors will be a challenging task in light of the array of pertinent factors involved and the complexity of their probable interrelations. Patient demographic features [i.e., socioeconomic status

All correspondence concerning this article should be addressed to Clarissa S. Holmes, PhD, Department of Psychology, Pediatrics, and Psychiatry PO Box 842018, Virginia Commonwealth University, Richmond, VA 23284-2018. E mail: cholmes@richmond.edu.

Journal of Pediatric Psychology 31(8) pp. 770–784, 2006
doi:10.1093/jpepsy/jsj083
Advance Access publication October 12, 2005

(SES) and age] and disease factors (i.e., disease duration) are important correlates of daily disease care behaviors and metabolic control. Typically, poorer self-care behaviors and metabolic control are found in association with lower family SES (Adler et al., 1994; Auslander, Thompson, Dreitzer, White, & Santiago, 1997; Charron-Prochownick, Kovacs, Obrosky, & Stiffler, 1994; Frindik, Williams, Johnson, & Dykman, 2002; Overstreet, Holmes, Dunlap, & Frentz, 1997). Age also is important, with adolescence being a time of striking deterioration in metabolic control, in part due to poorer self-care behaviors and to hormonal fluctuations (Johnson et al., 1992; La Greca, Follansbee, & Skyler, 1990). Further, adolescence is often associated with longer disease duration in pediatric populations which is another risk factor for both poorer self-care and metabolic control (Johnson, Perwien, & Silverstein, 2000).

A more comprehensive model of adolescent diabetes care needs to include psychosocial variables that encompass the family environment, youth stress, and behavior problems all of which are interrelated to one another and individually associated with poorer disease management and metabolic control. Disruptive family environments, particularly those higher in family conflict and lower in cohesion, are frequently associated with poorer disease outcomes in youth, although the finding is not universal (Anderson, Auslander, Jung, Miller, & Santiago, 1990; Hanson, DeGuire, Schinkel, & Kolterman, 1995; Jacobson et al., 1994; Miller-Johnson et al., 1994; Overstreet et al., 1995). Children's stress, quantified as negative life events, also is linked directly to poorer metabolic control (Goldston, Kovacs, Obrosky, & Iyengar, 1995; Holmes, Yu, & Frentz, 1999) and to more behavior problems (Holmes et al., 1999). Further, a significant proportion of youth with diabetes have a higher prevalence of internalizing and externalizing behavioral difficulties compared to unaffected peers (Goldston et al., 1995; Kovacs et al., 1990) which are related to poorer metabolic control.

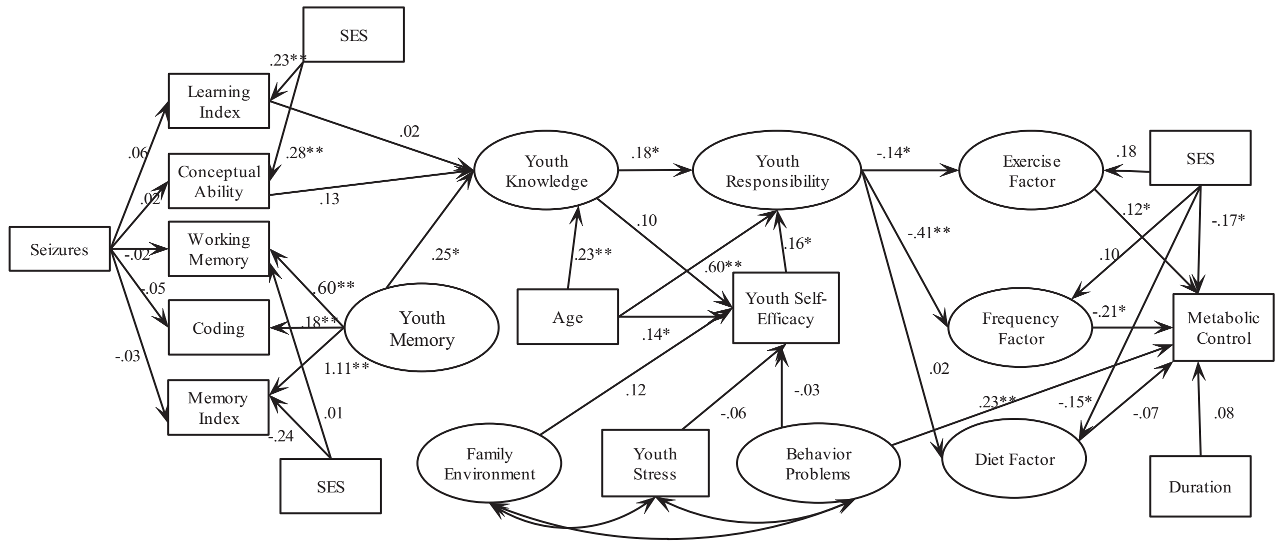
Youth attitudes also weigh in the constellation of factors to be considered in a more comprehensive model of disease care. Self-efficacy, or the belief in one's ability to successfully perform specific behaviors that will have positive health benefits is related to better diabetes self-care behaviors (Kappen, van der Bijl, & Vaccaro-Olko, 2001; Shortridge-Baggett, 2001). These beliefs, coupled with diabetes knowledge, are key considerations for parents to weigh before they allocate more self-care responsibility to their adolescents. However, parents undoubtedly also weigh their adolescents' cognitive capabilities to learn and remember daily self-care behaviors, although surprisingly, memory and learning skills have not been evaluated before in relation to disease knowledge or to metabolic control.

An Integrated Self-Care Model

Johnson (1995b) proposed a theoretically integrated model of metabolic control in childhood diabetes, but it was never empirically tested nor did it include information about attitudes or disease knowledge. A more comprehensive biopsychosocial model (Schwartz, 1982) of diabetes self-care behaviors is proposed and tested in this study, a model increasingly embraced by pediatricians to better understand children's health care (Wertlieb, 2003). The biopsychosocial model proposed focuses on individual ontogenic development within the family microsystem (Belsky, 1980) that includes biological indices of a youth's medical condition, as well as components of individual psychological functioning, and the familial social environment for youth. Because of the relative complexity of the model, and to account for simultaneous additive and/or interactive effects of these factors, structural equation modeling is utilized to describe the interplay of diverse intra- and interindividual factors. The model adopts a youth's perspective during a transitional high-risk time of adolescence and therefore relies on youths' skills and attitudes as correlates of their self-care, but combines data from parents where appropriate to increase the veridical accuracy of the data (e.g., youth behavior problems and levels of self-care responsibility). The following interrelated hypotheses are evaluated:

Hypotheses (Fig. 1)

1. Better youth cognitive skills (memory, learning, conceptual ability) should be interrelated and linked to SES and should be associated with fewer hypoglycemic seizures. Better memory and learning skills should predict more youth diabetes knowledge, and ultimately, better metabolic control.
2. Greater youth diabetes knowledge should predict greater youth self-efficacy.
3. More favorable psychosocial factors [i.e., better family social environment for youth, fewer negative life events (stress), and better youth behavior] should be interrelated and predict greater youth self-efficacy.
4. Greater youth diabetes knowledge and self-efficacy should predict more child self-care



χ^2 (241) = 323.25, $p < 0.05$, CFI = 0.946, TLI = 0.930, RMSEA = 0.039.

Note: * inidicates p < 0.05, ** indicates < 0.01. Path loadings are standardized coefficients.

Figure 1. A priori biopsychosocial model of diabetes disease care in adolescents. $\chi^2(241) = 323.25$, $p < 0.05$; Comparative Fit Index (CFI), 0.946; Tucker Lewis Index (TLI), 0.930; root mean square error of approximation (RMSEA), 0.039. *$p < .05$. **$p < .01$. Path loadings are standardized coefficients.

responsibility. These attributes represent the confluence of favorable cognitive skills and health beliefs which parents ideally consider when they transfer diabetes care responsibility to youngsters.

5. Greater youth self-responsibility, conferred subsequent to these favorable prerequisites, should predict better self-care behaviors (i.e., greater exercise duration and intensity, more frequent blood glucose testing and meals/snacks), and better diet composition (i.e., greater percent of calories from carbohydrates, lower percent of calories from fat).
6. Better youth self-care behaviors may relate to better metabolic control, although longer disease duration and physiologic factors related to adolescence may obscure this relation.

Method

Participants

Participants in this study were 222 youths (53% males) from 9 to 16 years of age (*M* = 12.8 years, *SD* = 1.9) consecutively seen for diabetes outpatient services from one of two metropolitan children's hospitals who also had complete data on all measures. One parent of each youth (81% mothers) also participated in the study. All children had type 1 diabetes for at least 6 months (average duration = 4.0 years; average HbA1c = 8.4%) and were free of other chronic medical conditions, had not experienced head trauma requiring medical attention and were not taking medications that affected the central nervous system.

Most of the sample was from middle-class families, with a Hollingshead index ranging from 11.5 to 70.0 (*M* = 45.8). The racial distribution was 76.1% Caucasian, 20.3% African American, and 3.2% Hispanic/other; similar to other reports of metropolitan diabetes clinics (Glasgow et al., 1991). See Table I for the demographic information about participants. Although 250 youths received the cognitive portion of the evaluation, 27 had incomplete child or parent questionnaire data, and one child was over the age of 17 (i.e., 17.8 years), and this information could not be included in this study. Descriptive analyses indicated that participants with incomplete versus complete psychosocial questionnaire data did not differ in familial SES (*M* SES = 46.3 vs. 45.8, respectively) but were significantly more likely to be of minority ethnicity (63% minority) than participants with complete data (25% minority). No age differences were found between groups.

Procedure

Following approval from appropriate Institutional Review Boards, a letter informed families about the study. Next, a follow-up telephone call identified interested participants, and an evaluation was scheduled, usually on the day of a child's medical appointment.

Table I. Means and Standard Deviations (SDs) of the Demographic and Disease Characteristics of the Children with Insulin-Dependent Diabetes Mellitus ($N = 222$)

	Number	Percent	
Male	118	53	
Caucasian	166	75	
Socioeconomic status category[a]			
I (upper)	27	13	
II (upper middle)	69	33	
III (middle)	97	46	
IV (lower middle)	17	8	
V (lower)	1	0.5	
Hypoglycemic seizures[b]	58	26.6	
Biological two-parent families	189	85	
	M	*SD*	Range
Age (years)	12.8	1.8	9–17
Socioeconomic status score[a]	45.8	11.2	11–70
Average[c] HbA1c (%)[d]	8.3	1.5	5.2–15
Age of disease onset (years)	8.8	3.8	0.06–15.7
Disease duration (years)	4.2	3.3	0.05–13.25
Hypoglycemic seizures[b]	.4	1.1	0–6

[a]Based on the Hollingshead (1975) Four-Factor Index of Social Status.
[b]Average number of hypoglycemic seizures based on lifetime prevalence from parent report.
[c]Average of three readings: at time of testing, 3 and 6 months before testing.
[d]Based on the glycosylated hemoglobin assay, nondiabetes range = 4.0 through 6.0%.

Approximately, 15% of families declined participation, primarily citing time demands or lack of interest in the recurring longitudinal study requirements. Evidence from at least one study (Riekert & Drotar, 1999) found diabetes participants and nonconcenters (i.e., those who did not enroll in the study) did not differ on any of the disease features gathered from the children's medical charts, including disease duration, number of hospitalizations, or most recent HbA1c.

After informed parental consent and child assent were obtained, trained psychological examiners individually administered cognitive tests to youths, while parents completed questionnaires. After the cognitive assessment, diabetes care behaviors were elicited with one set of parent/child 24-h Diabetes Care Interviews (Johnson, Silverstein, Rosenbloom, Carter, & Cunningham, 1986). When possible, child self-report questionnaires also were completed in the clinic, otherwise they were returned by mail. A follow-up telephone call, usually within 2 weeks of the initial assessment, elicited a second set of 24-h diabetes interviews. Children were paid $25 for their participation in the study.

Measures

Demographic and Disease Information

SES Parents reported demographic information, including highest education level attained and occupation for each parent. The Hollingshead Four Factor Index (Hollingshead, 1975) was used to calculate SES scores, with higher scores indicating higher status.

Disease Duration Disease duration was calculated in months based on youngsters' chronological age at study enrollment minus their age of disease onset/diagnosis.

Hypoglycemic Seizures Number of episodes of hypoglycemic seizures ($X = .4$; $SD = 1.1$) was reported by parents over the duration of their youngster's disease (i.e., lifetime prevalence) with corroboration by medical charts when possible. Hypoglycemic seizures were recorded, because they are observable events that are more likely to be accurately detected and recalled.

Metabolic Control Medical records provided glycosylated hemoglobin (HbA1c) values as a measure of metabolic control over the previous 2–3 months (Blanc, Barnett, Gleason, Dunn, & Soeldner, 1981). The DCA 2000 analyzer (Bayer HealthCare, Tarrytown, NY) measured glycosylated hemoglobin values at both sites. With a normal reference range of 4–6%, higher scores reflect poorer metabolic control. Three readings were combined to derive an average rate of metabolic control over the previous 6 months to avoid transient factors (i.e., illness, vacation) which could disrupt the results of any single assay.

Psychosocial Variables

Family Environment The perceived family environment was assessed with parent- and child-completed conflict and cohesion subscales of the Family Environment Scale (FES; Moos & Moos, 1986). Parent and child scores for these scales were averaged separately to provide aggregated measures of each aspect of the family environment.

Child Stress and Behaviors The child-completed Life Events Checklist (LEC; Johnson & McCutcheon, 1980) measured life events over the previous 12 months. Only negative life events were utilized in the study as an indicator of youth-reported stress.

Parents completed the Child Behavior Checklist (CBCL; Achenbach, 1991a) and children completed the Youth Self Report (YSR; Achenbach, 1991b) to provide parallel assessments of youth adjustment/behavior problems. Parent and child scores were averaged for the internalizing and externalizing domains separately to yield two aggregated scores.

Diabetes Health Control Beliefs The beliefs youths have about their ability to execute different aspects of the diabetes regimen were measured using the Self-efficacy for Diabetes Scale (SED; Grossman, Brink, & Hauser, 1987). The SED asks children to rate their level of proficiency at specific diabetes tasks, such as recognizing low blood glucose levels or adjusting insulin doses based on exercise.

Cognitive Variables

Diabetes Knowledge Youths completed the Test of Diabetes Knowledge (TDK; Johnson et al., 1982), which measures diabetes general information and problem solving ability. The general information (α = .71) and problem solving (α = .80) subscales have good internal consistency.

Memory and Learning The Wide Range Assessment of Memory and Learning (WRAML; Sheslow & Adams, 1990) assessed youths' memory and learning skills. Two pertinent indices were utilized. The General Memory Index has good reliability which has a coefficient alpha of .96 and the Learning index which also has good reliability with a coefficient alpha of .91 (Sheslow & Adams, 1990).

Subtests from the Wechsler Intelligence Scale for Children—Third Edition (WISC-III; Wechsler, 1991) provided ancillary measures of youth attention/memory (coding), verbal working memory (arithmetic), and verbal conceptual ability (similarities). The subtests have appropriate reliability, with split-half coefficients of .79, .78, and .81, respectively (Wechsler, 1991).

Diabetes Care Measures

Perceptions of Youth Self-Care Behavior

Responsibility Parents and children completed the Diabetes Family Responsibility Questionnaire (DFRQ; Auslander, Anderson, Bubib, Jung, & Santiago, 1990), which measures an individual's perceptions of who (parent or child) has responsibility for different diabetes care behaviors or if responsibility is shared. Parent and child scores were averaged, with higher scores indicating more youth responsibility. Internal consistency reported in the literature is good (.71 to .86; Auslander et al., 1990).

Diabetes Care Behaviors. The 24-h diabetes interview technique (Johnson et al., 1986) was utilized to document diabetes care behaviors. Parent/youth pairs were interviewed separately to ascertain diet, exercise, blood glucose testing, and insulin injection behaviors over the previous 24 h beginning with awakening and progressing chronologically through the day. Utilization of parent and youth report reduces the likelihood of systematic "halo" and source error effects. Interviews were conducted on two separate occasions, and data were combined with decision rules described in Johnson et al. (1986). Because a depiction of diabetes management behaviors was the focus of evaluation and not "ideal" behaviors as defined by deviation from a prescribed treatment regimen, diabetes care behaviors were reported descriptively rather than calibrated according to an ideal standard (Johnson et al., 1986). No hypotheses regarding insulin injections were included because of the highly individualized insulin regimens involved (i.e., two or three injections vs. insulin pump), and previous research has failed to detect significant intersubject variability on this factor such that it does not necessarily discriminate between youths in better or poorer metabolic control (i.e., Johnson et al., 1986, 1992).

Data Analysis Overview

Before testing the proposed biopsychosocial model with the MPlus program (Muthen & Muthen, 2002), data were screened for systematic missing values as well as outliers. Table II summarizes the means, standard deviations, and intercorrelations for the 26 observed measures utilized in the final model.

As suggested by Anderson and Gerbin (1988), confirmatory factor analysis (CFA) models were tested first, followed by a fit of the structural models to explore the hypothesized relations among the variables of interest. Table III summarizes the obtained factors with their indicators as found by the measurement part of the CFA. In the structural models, there were four observed variables with one indicator available for each theoretical construct of verbal conceptual ability, child stress, child self-efficacy and learning, although the Learning Index score was comprised of scores from its three subtests. Use of both factors and observed measures in structural modeling is a routine practice (Bentler, 1995).

The Maximum Likelihood method was used to estimate the fit of a model, and standardized path coefficients (spc) and their statistical significance are presented. Several fit indices for the overall models are reported, including the conventional chi-square statistics and related *p* values, the Tucker Lewis Index (TLI), the Comparative Fit Index (CFI) and The root mean square error of approximation (RMSEA). Traditionally, models with TLI and CFI indices greater than 0.9 are considered to have a relatively good fit of the data (Hoyle & Panter, 1995) and a RMSEA of less than 0.05 indicates a good fit with a value above 0.10 indicating a poor fit of the data (Browne & Cudeck, 1993). The standardized estimates of the path coefficients from the hypothesized apriori model were used to test the individual study hypotheses. A second, more parsimonious, model also was tested that deleted the nonsignificant paths from the apriori model to better highlight and test the strength of the active ingredients from the original apriori model. Finally, several analyses of covariance (ANCOVAs), with age and SES as covariates, were conducted to evaluate the self-care behaviors of youths who had more self-care responsibility based on a median split. Favorable attributes of more disease knowledge and more self-efficacy were evaluated as independent variables in the ANCOVAs after their dichotomization with a median split procedure.

Table II. Means, Standard Deviations (SDs), and Correlation Matrix Among Observed Measures

Measures	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Age	12.81	1.84																										
Socioeconomic status	45.82	11.18	.03																									
Learning Index	105.2	17.11	.06	**.23**																								
Similarities	11.15	2.59	.03	**.23**	**.38**																							
Arithmetic	10.74	3.57	−.07	**.33**	**.41**	**.51**																						
Coding	9.81	3.09	−.09	.05	.13	**.25**	**.29**																					
Memory Index	100.5	13.31	**.15**	**.38**	**.73**	**.55**	**.58**	**.19**																				
General diabetes knowledge	71.64	13.97	**.15**	**.16**	**.12**	**.17**	**.18**	.01	**.19**																			
Duration of problem solving	70.36	12.45	**.25**	**.20**	**.25**	**.26**	**.28**	.12	**.33**	**.60**																		
Youth responsibility	11.96	1.82	**.50**	.07	.08	.13	.00	.05	**.17**	.11	**.19**																	
Injection responsibility	8.58	1.89	.50	.10	.07	**.14**	**.16**	.09	**.20**	**.28**	**.31**	**.59**																
Family cohesion	3.22	1.66	.02	−.06	−.04	.04	.03	−.02	−.02	−.08	−.03	.08	.06															
Family conflict	2.86	1.55	.07	.08	.02	.01	.04	−.08	.06	.00	.09	−.05	.00	**.37**														
Internalizing behavior problems	9.38	7.09	−.09	−.12	−.01	−.11	−.07	−.03	−.07	−.08	−.05	−.05	−.10	**.24**	**.27**													
Externalizing behavior problems	8.90	6.68	−.04	−.12	−.02	−.13	−.11	−.05	−.07	−.09	−.13	.01	−.01	**.19**	**.31**	**.64**												
Negative life events/ youth stress	3.64	3.62	.11	−.13	.10	−.05	−.04	−.07	.03	−.07	−.07	.07	.02	**.15**	**.16**	**.17**	**.22**											
Diabetes self–efficacy	92.31	**12.00**	**.17**	.05	.06	.09	.11	.06	.11	.10	**.14**	**.23**	**.20**	.11	.01	−.04	−.09	−.05										
Exercise frequency	1.35	.78	**−.20**	.12	.04	−.00	.12	−.03	.01	−.01	−.05	−.09	**−.14**	−.06	.07	−.03	−.01	−.08	−.04									
Exercise duration	75.08	61.13	**−.15**	**.18**	.12	.07	.01	−.10	.02	.05	−.02	−.10	−.06	−.04	.15	.03	.07	−.18	−.05	**.54**								
Glucose testing	3.17	.98	**−.23**	**.19**	.11	**.14**	**.20**	−.05	**.19**	.12	−.01	−.05	.00	**−.15**	−.02	−.01	−.04	**−.14**	−.01	**.16**	**.15**							
Eating frequency	4.32	1.05	**−.32**	.02	−.01	.01	.07	.09	−.04	.02	.12	**−.20**	**−.24**	−.10	−.09	−.01	−.07	**−.18**	**−.14**	**.27**	.10	**.30**						
% fat	35.39	7.08	−.07	**−.18**	−.10	−.02	−.12	.09	−.11	−.10	**−.14**	.05	−.06	.12	.03	**.16**	.09	−.01	−.02	−.07	−.06	−.02	**.14**					
% carbohydrates	48.96	7.94	.02	**.17**	.12	−.02	.13	−.08	.09	.11	.11	−.10	.05	−.11	−.07	**−.18**	−.12	−.01	.00	.08	.07	.04	−.10	**−.90**				
Average HbA1c	8.32	1.46	−.03	−.07	−.07	−.11	**−.17**	−.05	−.14	−.05	−.08	−.05	.03	.12	.08	**.20**	**.18**	.04	−.01	−.07	.10	−.02	**−.17**	.01	−.03			
Seizures	.44	1.06	.04	−.00	.06	.01	.04	.07	.09	.09	.02	.01	.03	.11	.09	−.03	.14	.01	.00	−.01	.11	.05	−.07	−.07	−.13	−.04		
Duration	4.2	3.3	−.05	.10	−.00	−.06	−.00	−.11	−.02	**−.14**	−.11	−.10	−.01	.01	.04	−.11	.07	−.07	−.09	.06	**.16**	.09	−.03	**−.13**	**−.20**	.08	**.22**	

$r \geq .13$, $p < .05$. $r \geq .17$, $p < .01$.

Table III. Variables and Factors with their Factor Loadings on Study Measures and Their Source [Child (C), Parent (P)]

Variables/factors	Measures[a] C/P completed	Factor loadings
Cognitive variables		
Learning	WRAML Learning Index: C	–
Conceptual Ability	WISC-III Similarities Subtest: C	–
Memory Factor	WISC-III Arithmetic Scaled Score: C	0.60
	WISC-III Coding Scaled Score: C	0.18
	WRAML General Memory Index: C	1.11
Psychosocial variables		
Family Environment Factor	FES Cohesion raw score[b]: C/P	0.53
	FES Conflict raw score: C/P	0.70
Youth stress	LEC Negative events: C	–
Behavior Problems Factor	YSR/CBCL Internalizing Problems raw score: C/P	0.81
	YSR/CBCL Externalizing Problems raw score: C/P	0.79
Youth Self-Efficacy	Self-efficacy for diabetes: C	–
Youth Diabetes Knowledge Factor	Test of Diabetes Knowledge (TDK general information: C/P)	0.64
	TDK problem solving: C/P	0.93
Youth Diabetes Responsibility Factor	DFRQ general responsibility: C/P	0.74
	DFRQ injection responsibility: C/P	0.77
Diabetes care variables		
Exercise[c] Factor	Exercise frequency per day (number): C/P	0.47
	Exercise duration per day (min): C/P	1.10
Frequency[c] Factor	Number of glucose tests per day (number): C/P	0.35
	Number of meals/snacks per day: C/P	0.83
Diet[d] Factor	% of calories from fat: C/P	1.03
	% of calories from carbohydrates[e]: C/P	0.85
Disease and demographic variables		
Average HbA1c	Average HbA1c from three assessments: medical records	–
Disease duration	Time since diagnosis: P	–
Hypoglycemic seizures	Lifetime prevalence of seizures: P	–
Age	In years: P	–
Socioeconomic status	Hollingshead Four Factor Index: P	–

CBCL, Child Behavior Checklist; DFRQ, Diabetes Family Responsibility Questionnaire; FES, Family Environment Scale; LEC, Life Events Checklist; WISC-III, Wechsler Intelligence Scale for Children–Third Edition; WRAML, Wide Range Assessment of Memory and Learning; YSR, Youth Self Report.

All factor loadings standardized coefficients and are significant at p <.01.

[a]See *Methods* section for full test measure names.

[b]Cohesion scores were inverted so that lower scores represent more cohesive families.

[c]Higher scores indicate better self-care according to American Diabetes Association (ADA) guideline (ADA, 2002).

[d]Lower scores indicate better self-care behaviors according to ADA guidelines (ADA, 2002).

[e]% Carbohydrate scores were inverted so that lower scores represent a higher percentage of carbohydrate consumption.

Results

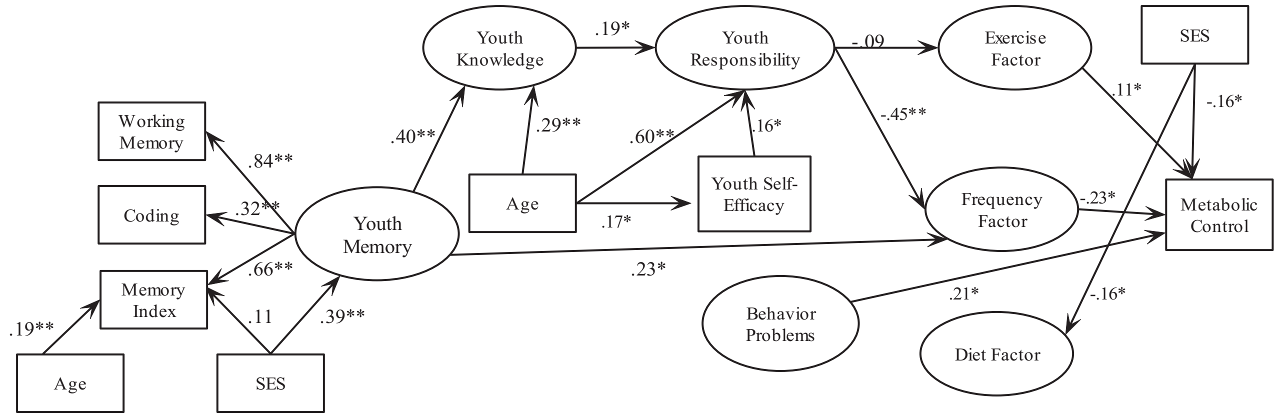
Tests of the Structural Models: An Overview

A Priori Model

The original structural model posited in Fig. 1, fit the data well, $\chi^2(241) = 323.25$, $p <0.05$; TLI = 0.93; CFI = 0.946; and RMSEA = 0.039. In addition to a good fit of the data, the fit indices reveal that the chosen indicators were valid measures of the factors in the model (Table III). Only one path, between behavior problems and metabolic control, was added to the original model post hoc to improve the model fit as suggested by the modification index in Mplus. This significant path (*spc* = 0.23) indicated an association between youth behavior problems and metabolic control, and had the highest *spc* of all of the significant predictors of metabolic control in this model. The final structural model in Fig. 1 reveals that many of the estimated coefficients were in the predicted direction and many were statistically significant.

Parsimonious Model

Utilizing the a priori model (Fig. 1), all significant paths were retained and all nonsignificant paths/variables were deleted to create a more parsimonious model of children's diabetes management behaviors and metabolic control. The parsimonious model also fit the data well, $\chi^2(137) = 159.68$, $p <.05$; TLI = 0.975; CFI = 0.980; and RMSEA = 0.027. See Fig. 2 for the final figure of the



χ^2 (137) = 159.68, $p < 0.05$; CFI = 0.980; TLI = 0.975; RMSEA = 0.027.

Note: * inidicates p < 0.05, ** indicates < 0.01. Path loadings are standardized coefficients.

Figure 2. Parsimonious biopsychosocial model of diabetes disease care in adolescents. $\chi^2(137) = 159.68$, $p < 0.05$; Comparative Fit Index (CFI), 0.980; Tucker Lewis Index (TLI), 0.975; root mean square error of approximation (RMSEA), 0.027. *$p < 0.05$. **$p < 0.01$. Path loadings are standardized coefficients.

parsimonious model. Based on the MPlus modification index, one additional *primary* path was added *post hoc* to the parsimonious model between the primary predictor of Youth Memory and the Frequency Factor, *spc* = .23, *p* <.05, *indicating that better memory was directly associated with more frequent blood glucose monitoring and eating*. However, memory appeared more related to blood glucose monitoring than eating frequency based on the simple correlations (Table II) in which two of the three memory components of the Youth Memory latent variable were significantly correlated only with blood glucose testing. Based on the MPlus modification indices to improve the parsimonious model fit, two other paths between *secondary* or "control" variables also were added for age (to Memory Index, *spc* = .19, *p* <.01) and SES (to Youth Memory, *spc* = .39, *p* <.01).

Comparison of the A Priori and Parsimonious Models

The relative fits of the a priori model and its nested parsimonious model were compared with the Likelihood Ratio Test. This test uses the differences of the chi-square values and of the degrees of freedom from the two models for statistical comparison. Specifically, the chi-square degrees of freedom and value of the parsimonious model, $\chi^2(137) = 159.68$, was compared to the degrees of freedom and chi-square value for the original apriori model, $\chi^2(241) = 323.25$. The result was a significant chi-square difference value, $\chi^2(104) = 163.57$, $p < 0.05$, that indicates the fit of the parsimonious model was significantly better than the fit of the a priori model (Fig. 2).

Tests of Specific A Priori Hypotheses

Specific model hypotheses were tested using the standardized estimates from the Maximum Likelihood estimation method from the a priori structural equation model. Although a similar pattern of results was obtained with the parsimonious model, some of the *spc*'s varied slightly between the two models.

Hypothesis 1: Better youth cognitive skills should be linked to higher SES and fewer hypoglycemic seizures. Better memory skills should predict more youth diabetes knowledge.

As shown in Fig. 1, the secondary or control variable of SES was significantly related to the Learning Index and Conceptual Ability, *spc*'s = .23 and .28, respectively but not to the memory variables. Hypoglycemic seizures also were not linked significantly to the cognitive variables. However, as shown in Fig. 1, better youth memory significantly related to more youth diabetes knowledge (*spc* = .25), as predicted, even after partialling out the effect of Verbal Conceptual Ability (*spc* = .13) to control for overall intellectual capacity. However, better learning skills did *not* relate to more youth diabetes knowledge (*spc* = .02), although this relation became significant when the Seizure variable was deleted (*spc* = .16) as did the path between Verbal Conceptual Ability and diabetes knowledge (*spc* = .20). However, these changes did not improve the fit indices, so hypoglycemic seizures were retained in the original model for the sake of comprehensiveness. In the parsimonious model, the association between youth memory and youth knowledge also was significant and stronger, *spc* = .40, p <0.01, when the two nonsignificant paths from the Learning Index and Conceptual Ability were excluded (Fig. 2).

Hypothesis 2: More youth diabetes knowledge should significantly predict greater youth self-efficacy.

As shown in Fig. 2, the standardized estimate between Youth Knowledge of diabetes and Youth Self-efficacy was positive (.10), indicating a trend for more diabetes knowledge to relate to more self-efficacy. Although self-efficacy was not significantly related to General Diabetes Knowledge, it was significantly correlated with its diabetes Problem Solving subscale (r = 0.14, p <.05), as Table II reveals, indicating that better diabetes problem solving was related to greater self-efficacy. Hypothesis 2 was partially supported. Finally, to examine the bi-directional relation between youth knowledge and youth self-efficacy, a path from youth self-efficacy to youth knowledge was added to determine whether self-efficacy also predicts disease Knowledge, within the recognized limits of the cross-sectional nature of the data. A significant, but counterintuitive, *spc* of –.13 (p <.05) indicated that *greater* self-efficacy predicted *less* disease knowledge, suggesting that high beliefs in self-efficacy that are not based on more disease knowledge in fact may be detrimental, and related to *less* disease knowledge, although this causal inference requires documentation longitudinally. In the parsimonious model, the nonsignificant path between knowledge and self-efficacy was removed.

Hypothesis 3: More favorable psychosocial factors (i.e., better family environment, less stress, and better youth behavior) should be interrelated, and should predict greater youth self-efficacy.

With lower scores indicating more favorable conditions, the simple intercorrelations in Table II revealed that psychosocial factors of family environment, behavior problems, and less child stress were positively interrelated as hypothesized. However, as seen in Fig. 1, Family Environment, Youth Stress, and Behavior Problems were not significantly associated with youth self-efficacy. This latter part of the hypothesis was not supported. In the parsimonious model, the nonsignificant psychosocial variables of family climate and youth stress were removed; behavior problems were retained because of their significant relation to metabolic control based on the modification index.

Hypotheses 4 and 5: Ideally, the confluence of more favorable youth prerequisites of greater youth diabetes knowledge and self-efficacy should predict more child self-care responsibility. In turn, greater youth self-care responsibility under these favorable conditions should predict better self-care behaviors and diet composition.

Figure 1 shows that more youth diabetes Knowledge and higher Self-efficacy significantly predicted more child self-care Responsibility (*spc* = 0.18, p <0.05, and *spc* = 0.16, p <0.01, respectively). Hypothesis 4 was supported in the a priori as well as the parsimonious model; the latter model had *spc's* of .19 and .16, p <.05, respectively. However, another strong predictor of Youth Responsibility was Age (*spc* = .60), which unfortunately, when not linked to youth knowledge and self-efficacy, was related to poorer self-care behaviors. The path from youth responsibility to the Exercise Factor had a standardized estimate of –0.14 (p <.05); suggesting that more youth responsibility was related to less frequent, shorter exercise periods. Similarly, a significant and negative association also was found between more Youth Responsibility and lower Frequency Factor scores (*spc* = –0.41, p <.01). Hypothesis 5 was not supported in the absence of favorable youth prerequisites for the transfer of self-care responsibility.

In detail, more Youth Responsibility was related to the Frequency Factor composite of fewer daily blood glucose tests and fewer meals/snacks. The simple correlations in Table II, however, suggest that this effect may be due primarily to less frequent eating which was associated with more youth responsibility (eating frequency and responsibility r = –.20, p <.05). In contrast, the simple correlation between responsibility and blood glucose monitoring was not significant. Finally in the structural model, the path coefficient between Youth Responsibility and the Diet Factor was nonsignificant, indicating a weak relation between youth self-care responsibility and dietary composition.

Together, results suggest that most parents do not appear to weigh favorable prerequisites of youth knowledge and efficacy for optimal self-care before giving their children more disease management responsibility. Youth age alone appears to be the primary determinant of this transfer of responsibility. Under these *un*favorable conditions, greater youth responsibility was related to less frequent and briefer exercise as well as to less frequent meals/snacks. Youth responsibility was unrelated to dietary composition, suggesting parents likely retain control over this facet of daily care longer.

In the parsimonious model, the negative relation between Youth Responsibility and the Frequency Factor also was significant, *spc* = –0.45, p <.01. However, the *spc* from Youth Responsibility to the Exercise Factor was no longer significant in the parsimonious model.

ANCOVAs were performed on the self-care behaviors of youths with more self-care responsibility to determine whether more favorable youth attributes, that is, more knowledge and more self-efficacy, based on a median split procedure (N = 103), were related to better care. SES and age served as covariates to control their well-known effects on self-care behaviors. There were no main effects of either Knowledge or self-efficacy upon the self-care behaviors, however, there was a significant interaction of these factors for percentage of calories consumed from carbohydrates, $F(1,98) = 4.33$, $p = .04$. Adjusted means from the ANCOVAs revealed that youth with more knowledge and greater self-efficacy showed better dietary self-care, with consumption of a higher percentage of calories from carbohydrates than other groups, and a trend toward consumption of a smaller percentage of calories from fat, $F(1,98) = 3.55$, $p = .06$. Hypothesis 5 received support in the ANCOVAs under the conditions of the favorable prerequisites delineated.

Hypothesis 6: Better youth self-care skills may relate to better metabolic control.

Only the Frequency Factor was significantly related to metabolic control over the previous 6 months ($spc = -0.21$, $p < 0.05$). Less frequent blood glucose monitoring and fewer daily meals/snacks significantly predicted higher glycosylated hemoglobin values, that is, poorer metabolic control. Conversely, those youths who tested blood glucose levels and ate more frequently had lower glycosylated hemoglobin values, that is, better metabolic control. Hypothesis 6 was supported. In the parsimonious model, the significant relation between more frequent blood glucose monitoring/eating and better metabolic control remained significant, $spc = -.23$, $p < 0.05$.

Discussion

A complex model of biopsychosocial predictors of adolescent self-care behaviors and metabolic control was examined which included key behavioral medicine concepts from a quarter century of diabetes management research (Cox & Gonder-Frederick, 1992; Gonder-Frederick et al., 2002). In addition to studying more established links among psychosocial variables and self-care behaviors, this study also examined previously unexplored memory skills which underlie pediatric diabetes knowledge, a necessary prerequisite of good disease management along with self-efficacy beliefs (Holmes, Overstreet, & Greer, 1997; Johnson, 1995a). Adolescents have increasing responsibility for their own diabetes management (Drotar & Ievers, 1994; La Greca et al., 1990; Wysocki, Meinhold et al., 1992; Wysocki, Meinhold, Cox, & Clarke, 1990), and the current model approaches diabetes care from the perspective of youths. However, parent-reported data also were included, where relevant, to corroborate youths' reports or to achieve a more comprehensive and accurate assessment of factors related to pediatric self-care. Finally, a more parsimonious *post hoc* biopsychosocial model also was evaluated based on significant path relations retained from the a priori model.

As Fig. 1 shows, the relations portrayed among the latent factors and measured variables provide a good statistical fit of the a priori biopsychosocial model. For the first time, the cognitive underpinning of youth diabetes knowledge is described and localized to memory, not learning. The relation between memory and diabetes knowledge occurred independently of general conceptual intellectual ability, learning, hypoglycemic seizure history, and the well-known effects of SES (Adler et al., 1994). Of concern though is the cognitive literature which reports that with longer disease duration a subtle decline in verbal memory can occur (Fox, Chen, & Holmes, 2003; Northam et al., 1998, 2001) such that description of memory in addition to psychosocial antecedents of disease care and disease sequelae is necessary to achieve a fuller understanding of the likely dynamic interplay between disease processes and self-care behaviors (Holmes, 1987). Memory related to diabetes self-care indirectly through more disease knowledge, although hypoglycemic seizures did not relate to memory as found by others (Hershey, Craft, Bhargava, & White, 1997), perhaps because of its relatively low incidence (26%) in this sample. However, its moderate relation with longer disease duration ($r = -.20$) indicates that seizures are a significant aspect of living with diabetes for some adolescents that should be considered in developing a comprehensive treatment plan to facilitate youth self-care behaviors. Accordingly, seizures were retained in the a priori final model, even though they were nonsignificant.

Although more disease knowledge was not significantly related to greater self-efficacy, as expected, hypothesis 2 was partially supported in that the problem solving subscale from the TDK was significantly correlated with self-efficacy scores ($r = .14$; Table I). Problem solving may prove to be the more stringent test of this relation than general diabetes knowledge, because it is a more demanding skill that requires the adaptation of rote information to novel or difficult situations. Further evaluation of this possibility in future research appears warranted. The converse of this relation that more youth self-efficacy might predict more disease knowledge, perhaps by promoting information-seeking behavior in youth, was not supported on the basis of the negative path coefficient obtained when the direction of the relation was reversed.

Youth knowledge, along with youth self-efficacy and older age all predicted youth responsibility for more disease management, as explicated in hypothesis 4. Ideally, disease knowledge alone is not sufficient for parents to entrust greater disease management skills to youth. Optimally, parents also should evaluate youths' self-efficacy beliefs about their ability to effectively self-manage their illness and consider a child's age as well. In fact, this model indicates that youth self-efficacy and diabetes knowledge almost equally predicted more self-care responsibility. Together, these factors represent the confluence of favorable cognitive and attitudinal prerequisites for greater youth diabetes management responsibility as postulated in the proposed model, and when high levels of both were present, youths ate more carbohydrates and tended to consume less dietary fat, as recommended by the American Diabetes Association (ADA). However, outweighing these favorable predictors of more youth responsibility (*spc*'s = .16 and .18, respectively) by a three to one margin was youth chronologic age (*spc* = .60) as a predictor of more self-care responsibility. It appears that more weight is given by parents to age alone than to these other favorable youth attributes when disease management responsibility is relinquished to youth. The heavy reliance on chronologic age as a primary determinant of youth responsibility in this predominantly middle-class sample is troublesome, particularly in light of the poorer disease care outcomes that are associated with this practice.

The literature consistently has indicated that more youth disease care responsibility is associated with poorer self-care (Gowers, Jones, Kiana, North, & Price, 1995; La Greca et al., 1990; Wysocki et al., 1996; Wysocki, Hough, Ward, & Green, 1992). This study also demonstrated that greater youth responsibility, when allocated primarily on the basis of age, was associated with poorer self-care behaviors and subsequent poorer metabolic control. Specifically, more youth responsibility predicted less frequent and shorter duration exercise. More youth responsibility also was related to lower Frequency Factor scores (less blood glucose monitoring and fewer meals/snacks), which were related to poorer metabolic control, even after considering the well-established effect of SES. In their longitudinal structural equation model of disease factors related to self-care, Johnson et al. (1992) also found that reduced frequency of blood glucose monitoring and eating predicted poorer metabolic control, both initially and 1.7 years later. However, youth responsibility, demographic, cognitive and psychosocial factors were not assessed. As can be seen in Table III, when the effect of SES and other psychosocial factors simultaneously are considered in the present CFA, the Frequency Factor was related more to reduced number of meals/snacks than to less frequent blood glucose monitoring. The simple correlations further support this relation, at least in this predominantly middle-class sample (Table II). With a mean of 3.2 blood glucose tests per day, this sample was on target with ADA guidelines of three tests/day; but the sample's average of 4.3 meals/snacks/day was below the recommended six [American Diabetes Association (ADA), 2002]. However, it is easy to imagine that in a lower SES sample, restricted access and affordability of blood glucose monitoring equipment may be a greater issue than eating frequency in predicting poorer metabolic control. Even with youngsters from relatively more advantaged middle-class families who are older and may *appear* developmentally capable of more self-care responsibility, continued parental monitoring and supervision, particularly of eating frequency, remains crucial to avoid poorer self-care behaviors and poorer metabolic control. Alternatively, post hoc results suggest if parents evaluate and weigh their children's disease knowledge and self-efficacy before allocating disease care responsibility to them, better outcomes may result. Future research should seek to replicate these findings.

In contrast, results suggest that parents in this middle-class sample retained more responsibility for dietary composition, consistent with the literature (Wysocki et al., 1990; Wysocki, Meinhold et al., 1992). Parents usually plan and prepare meals in the home, purchase groceries, and approve of food consumption outside of the family home, either directly or indirectly through their financial support. In this study, greater parental dietary responsibility may be protective for health status, because diet composition was not related to poorer metabolic control. Alternatively, dietary behaviors simply may be less powerfully related to metabolic control than either blood glucose testing or eating frequency (Johnson et al., 1992) and/or may require more statistical power to detect a relation than was available in this study (Delahanty & Halford, 1993).

A direct, and relatively strong association, was found *post hoc* between more behavior problems and poorer metabolic control (Fig. 1). Behavior problems had been hypothesized to exert an indirect effect on self-care, along with the other psychosocial constructs of disruptive home environments and life stressors, via lower self-efficacy and possibly premature greater youth self-care responsibility. However, these mediational paths were not supported. Instead, it appears that it is not the presence of disruptive psychosocial factors *per se* that relate to poorer metabolic control, ultimately, it is youth's response to their psychosocial/familial climate, as reflected in behavior problems, which directly relates to metabolic control. Overt behavioral disobedience and a lack of cooperation with the diabetes regimen could explain this direct link. However, this connection also may be explained by stress hormones (e.g., epinephrine, cortisol, growth hormone) and their disruptive effect on metabolic control via increased insulin resistance (Moberg, Kollind, Lins, & Adamson, 1994; Sachs et al., 1993), although individuals differ in their catecholamine responsiveness to stress (Kramer, Ledolter, Manos, & Bayless, 2000). The simple correlations revealed that both externalizing and internalizing behavior problems each was related directly to poorer metabolic control (Table II). Internalizing behavior problems also were correlated significantly with higher fat and lower carbohydrate consumption, suggesting another possible mediational link with poorer metabolic control. Children with more anxious/depressed symptomatology in this study deviated more from the prescribed ADA diet, perhaps using food to "self-medicate" their symptoms. Alternatively, depressed adults with diabetes have been shown to hypersecrete cortisol compared to nondepressed diabetic adults and depressed controls, supporting the hypothesis of possible catecholamine-induced insulin resistance (Sachs et al., 1993), although stress-related biochemical studies have yet to be done with children.

Children vary widely in their coping skills and resilience to psychosocial stressors (Goldston et al., 1995; Holmes et al., 1999), such that the link between behavior problems and metabolic control may have two broad implications. First, a child's behavior may be both the single best, and the most easily assessed, correlate of metabolic control and child behavior is a logical place to begin assessment of poorer pediatric glycemic status. Second, a child's behavior problems also may be the most effective target for intervention, at least initially, to improve poorer metabolic control. However, because the family environment and/or life stresses likely serve to initiate or to maintain behavior problems, even though the present psychosocial/environmental factors did not have a significant effect on self-care behaviors or metabolic control, these psychosocial factors nevertheless will be important considerations in a successful treatment plan. This supposition is supported by the moderate correlations between more behavior problems and more negative family environments (r's = .19–.31). Clinical intervention aimed at ameliorating disruptive home environments also can benefit other children in the family. Further, intervention that teaches children to cope adaptively with life stressors may yield future benefits by providing a level of stress inoculation or buffering.

As Fig. 2 illustrates, the parsimonious model tested more succinctly the important relations that were empirically supported from the a priori biopsychosocial model from Fig. 1. Although the fit indices of both models were good, the fit of the parsimonious model was significantly better. Generally slight variations occurred among the standardized path coefficients of the two models, but the pattern of associations among the variables remained similar. In addition to its brevity and focus on important relations, the parsimonious model also underscores the potential utility of memory as a significant cognitive variable, independent of the effects of general conceptual ability and SES, to weigh in future descriptions of diabetes self-care management in youth. Beyond the significant indirect role of memory in disease knowledge and self-care in both models, the parsimonious model also indicated a unique new, and direct, link between Youth Memory and the Frequency Factor (*spc* = .23). Better youth memory was directly related to more frequent blood glucose testing and eating, the components of the Frequency Factor. However, the simple correlations reveal the memory variables were significantly correlated only with blood glucose testing and not eating frequency. Together with the Youth Responsibility/Frequency Factor path, which the simple correlations related primarily to eating frequency, different factors appear to differentially relate to each aspect of the self-care frequency factor. Better Youth Memory primarily relates to more blood glucose monitoring and in contrast, premature Youth Responsibility allocated primarily on the basis of age appears predominantly related to less frequent youth eating. If replicated in future work, these differential findings begin to provide a more specific decision tree for clinicians to follow when evaluating the self-care ramifications of poorer youth memory and premature and/or unsupervised youth responsibility in middle-class samples of children. Youths who are relatively unsupervised by parents warrant clinician attention to their eating frequently as a possible mechanism of poorer metabolic control. Alternatively, youths with infrequent blood glucose monitoring could have their memory skills assessed to rule out this factor as a part of the problem. Assistive memory devices, such as wrist watches with alarms, may prove useful for youth with relatively poorer memory skills (Soutor, Chen, Streisand, Kaplowitz, & Holmes, 2004), and continued parental supervision, particularly of eating frequency, remains important despite the apparent skill levels of adolescents.

Although far from all-encompassing, the present model provides a step toward a more comprehensive depiction of the putative interconnections of a range of biopsychosocial predictors, including novel cognitive factors, of diabetes care in adolescents. However, longitudinal replication is required. Although 25% of the sample was of minority ethnicity, because minorities were disproportionately represented in the 10% of participants who failed to return questionnaire data and were excluded from the present report, the generalizability of these findings is reduced accordingly. Nevertheless, results provide primary evidence that structural equation modeling has potential as a tool to evaluate the comparative strength and relative fit of theoretical interrelations among precursors of better disease care behaviors and biomedical outcomes. The resultant information could be a prelude toward optimization of treatment interventions by providing a better approximation of the complexity of factors that contribute to adolescent self-care behavior than is possible with univariate or multivariate descriptions. Future structural equation modeling may benefit from assessing coping styles that may moderate the effects of behavior problems to obtain a fuller picture of individual risk and resistance in the face of psychosocial disruption. It also would be beneficial in additional inquiry to assess the pubertal status of youths to better predict metabolic control (Amiel, Sherwin, Simonson, Lauritano, & Tamborlane, 1986; Cruickshanks, Orchard, & Becker, 1985) and to strengthen the biological component of a biopsychosocial model. Clinical research also should continue the search for additional or better measures of favorable adolescent prerequisites of "readiness" for self-care that may prove fruitful in identifying those youths that can better manage their diabetes care more independently and/or those prerequisite attributes/knowledge that must be better instilled and taught.

Acknowledgment

This work is supported in part by NIH grant DK56975, awarded to Clarissa S. Holmes.

Received March 4, 2004; revisions received July 19, 2004 and September 1, 2005; accepted September 12, 2005

References

Achenbach, T. M. (1991a). *Manual for the child behavior checklist/4–18 and 1991 profile*. Burlington, VT: Department of Psychiatry, University of Vermont.

Achenbach, T. M. (1991b). *Manual for the youth self-report and 1991 profile*. Burlington, VT: Department of Psychiatry, University of Vermont.

Adler, N. E., Boyce, T., Chesney, M. A., Cohen, S., Folkman, S., Kahn, R. L., et al. (1994). Socioeconomic status and health: The challenge of the gradient. *American Psychologist, 49*, 15–24.

American Diabetes Association. (2002). Standards of medical care for patients with diabetes mellitus (position statement). *Diabetes Care, 25*, 213–229.

Amiel, S. A., Sherwin, R. S., Simonson, D. C., Lauritano, A. A., & Tamborlane, W. V. (1986). Impaired insulin action in puberty: A contributing factor to poor glycemic control with diabetes. *New England Journal of Medicine, 314*, 215–219.

Anderson, B. J., Auslander, W. F., Jung, K. C., Miller, J. P., & Santiago, J. V. (1990). Assessing family sharing of diabetes responsibilities. *Journal of Pediatric Psychology, 15*, 477–492.

Anderson, J., & Gerbin, D. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*, 411–423.

Auslander, W. F., Anderson, B. J., Bubb, J., Jung, K. C., & Santiago, J. V. (1990). Risk factors to health in diabetic children: A prospective study from diagnosis. *Health and Social Work, 15*, 133–142.

Auslander, W. F., Thompson, S., Dreitzer, D., White, N. H., & Santiago, J. V. (1997). Disparity in glycemic control and adherence between African-American and Caucasian youths with diabetes. *Diabetes Care, 20*, 1569–1575.

Belsky, J. (1980). Child maltreatment: An ecological integration. *American Psychologist, 35*, 320–335.

Bentler, P. M. (1995). *EQS structural equations program manual*. Encino, CA: Multivariate Software.

Blanc, M. H., Barnett, D. M., Gleason, R. E., Dunn, P. J., & Soeldner, J. S. (1981). Hemoglobin A1c compared with three conventional measures of diabetes control. *Diabetes Care, 14*, 20–25.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing Structural Equation Models* (pp. 136–162). Newbury Park, CA: Sage.

Charron-Prochownick, D., Kovacs, M., Obrosky, D. S., & Stiffler, L. (1994). Biomedical and psychosocial predictors of early rehospitalization among children with insulin-dependent diabetes mellitus: A longitudinal study. *Diabetic Medicine, 11*, 372–377.

Cox, D. J., & Gonder-Frederick, L. (1992). Major developments in the behavioral diabetes research. *Journal of Consulting and Clinical Psychology, 60*, 628–638.

Cruickshanks, K. J., Orchard, T. J., & Becker, D. J. (1985). The cardiovascular risk profile of adolescents with insulin-dependent diabetes mellitus. *Diabetes Care, 8*, 118–124.

Delahanty, L. M., & Halford, B. N. (1993). The role of diet behaviors in achieving improved glycemic control in intensively treated patients in the Diabetes Control and Complications Trial. *Diabetes Care, 16*, 1453–1458.

Diabetes Control and Complications Trial Research Group. (1994). Effect of intensive diabetes treatment on the development and progression of long-term complications in adolescents with insulin-dependent mellitus: Diabetes Control and Complications Trial. *Journal of Pediatrics, 125*, 177–188.

Drotar, D., & Ievers, C. (1994). Age differences in parent and child responsibilities for management of cystic fibrosis and insulin-dependent diabetes mellitus. *Developmental and Behavioral Pediatrics, 4*, 265–272.

Fox, M. A., Chen, R. S., & Holmes, C. S. (2003). Gender differences in memory and learning in children with insulin-dependent diabetes mellitus (IDDM) over a four-year follow-up interval. *Journal of Pediatric Psychology, 28*, 569–577.

Frindik, J. P., Williams, J. P., Johnson, R. L., & Dykman, R. A. (2002). Parental perception and factors associated with glycemic control in pediatric patients with type 1 diabetes. *Endocrinology Practice, 8*, 105–108.

Glasgow, A. M., Weissberg-Benchell, J., Tynan, W. D., Epstein, S., Driscoll, C., & Turek, J. (1991). Readmission of children with diabetes mellitus to a children's hospital. *Pediatrics, 88*, 98–104.

Goldston, D. B., Kovacs, M., Obrosky, D. S., & Iyengar, S. (1995). A longitudinal study of life events and metabolic control among youths with insulin-dependent diabetes mellitus. *Health Psychology, 14*, 409–414.

Gonder-Frederick, L. A., Cox, D. J., & Ritterband, L. M. (2002). Diabetes and behavioral medicine: The second decade. *Journal of Consulting and Clinical Psychology, 70*, 611–625.

Gowers, S. G., Jones, J. C., Kiana, S., North, C. D., & Price, D. A. (1995). Family functioning: A correlate of diabetic control? *Journal of Child Psychology and Psychiatry and Applied Disciplines, 36*, 993–1001.

Grossman, H. Y., Brink, S., & Hauser, S. T. (1987). Self-efficacy in adolescent girls and boys with insulin-dependent diabetes mellitus. *Diabetes Care, 10*, 324–329.

Hanson, C. L., DeGuire, M. J., Schinkel, A. M., & Kolterman, O. G. (1995). Empirical validation for a family-centered model of care. *Diabetes Care, 18*, 1347–1356.

Hershey, T., Craft, S., Bhargava, N., & White, N. (1997). Memory and insulin dependent diabetes mellitus (IDDM): Effects of childhood onset and severe hypoglycemia. *Journal of the International Neuropsychological Society, 3*, 509–520.

Hollingshead, A. B. (1975). *Four factor index of social status*. New Haven, CT: Department of Sociology, Yale University.

Holmes, C. S., Yu, Z., & Frentz, J. (1999). Chronic and discrete stress as predictors of children's adjustment. *Journal of Consulting and Clinical Psychology, 67*, 411–419.

Holmes, C. S. (1987). Cognitive functioning and diabetes: Broadening the paradigm for behavioral and health psychology? *Diabetes Care, 10*, 135–136.

Holmes, C. S., Overstreet, S., & Greer, T. (1997). Cognitive predictors of self-care behaviors 3 years later in youths with IDDM. *Diabetes, 46*, *Supp. 1*, 263A.

Hoyle, R. H., & Panter, A. T. (1995). Writing about structural equation models. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp. 158–176). Thousand Oaks, CA: Sage.

Jacobson, A. M., Hauser, S. T., Lavori, P., Willett, J. B., Cole, C. F., Wolfsdorf, J. I., et al. (1994). Family environment and glycemic control: A four-year prospective study of children and adolescents with insulin-dependent diabetes mellitus. *Psychosomatic Medicine, 56*, 401–409.

Johnson, S. B. (1995a). Insulin-dependent diabetes mellitus in childhood. In M. C. Roberts (Ed.), *Handbook of pediatric psychology* (pp. 263–285). New York: Guilford Press.

Johnson, S. B. (1995b). Managing insulin-dependent diabetes mellitus: A developmental perspective. In J. Wallander & L. Siegel (Eds.), *Adolescent health problems: Behavioral perspectives* (pp. 265–288). New York: Guilford Press.

Johnson, S. B., Kelly, M., Henretta, J. C., Cunningham, W. R., Tomer, A., & Silverstein, J. H. (1992). A longitudinal analysis of adherence and health status in childhood diabetes. *Journal of Pediatric Psychology, 17*, 537–553.

Johnson, J. H., & McCutcheon, S. M. (1980). Assessing life stress in older children and adolescents: Preliminary findings with the Life Events Checklist. In I. G. Sarason & C. D. Spielberger (Eds.), *Stress and anxiety* (pp. 111–125). Washington, DC: Hemisphere.

Johnson, S. B., Perwien, A. R., & Silverstein, J. H. (2000). Response to hypo- and hyperglycemia in adolescents with type I diabetes. *Journal of Pediatric Psychology, 25*, 171–178.

Johnson, S. B., Pollack, T., Silverstein, J. H., Rosenbloom, A. L., Spillar, R., McCallum, M., et al. (1982). Cognitive and behavioral knowledge about insulin-dependent diabetes among children and parents. *Pediatrics, 69*, 708–713.

Johnson, S. B., Silverstein, J., Rosenbloom, A., Carter, R., & Cunningham, W. (1986). Assessing daily management in childhood diabetes. *Health Psychology, 5*, 545–564.

Kappen, M. J., van der Bijl, J. J., & Vaccaro-Olko, M. J. (2001). Self-efficacy in children with diabetes mellitus: Testing of a measurement instrument. *Scholarly Inquiry for Nursing Practice, 15*, 209–221.

Kovacs, M., Iyengar, S., Goldston, D., Stewart, J., Obrosky, D. S., & Marsh, J. (1990). Psychological functioning of children with insulin-dependent diabetes mellitus: A longitudinal study. *Journal of Pediatric Psychology, 15*, 619–632.

Kramer, J. R., Ledolter, J., Manos, G. N., & Bayless, M. L. (2000). Stress and metabolic control in diabetes mellitus: Methodological issues and an illustrative analysis. *Annuals of Behavioral Medicine, 22*, 17–28.

La Greca, A. M., Follansbee, D., & Skyler, J. S. (1990). Developmental and behavioral aspects of diabetes management in youngsters. *Children's Health Care, 19*, 132–139.

Miller-Johnson, S., Emery, R. E., Marvin, R. S., Clarke, W., Lovinger, R., & Martin, M. (1994). Parent-child relationships and the management of insulin-dependent diabetes mellitus. *Journal of Consulting and Clinical Psychology, 52*, 603–610.

Moberg, E., Kollind, M., Lins, P. E., & Adamson, U. (1994). Acute mental stress impairs insulin sensitivity in IDDM patients. *Diabetologia, 37*, 247–251.

Moos, R., & Moos, B. (1986). *Family environment scale manual* (2nd ed.). Palo Alto, CA: Consulting Psychologists Press.

Muthen, L. K., & Muthen, B. O. (2002). *Mplus user's guide*. Los Angeles, CA: Muthen & Muthen.

Northam, E. A., Anderson, P. J., Jacobs, R., Hughes, M., Warner, G. L., & Werther, G. A. (2001). Neuropsychological profiles of children with type 1 diabetes 6 years after disease onset. *Diabetes Care, 24*, 1541–1546.

Northam, E. A., Anderson, P. J., Werther, G. A., Warne, G. L., Adler, R. G., & Andrews, D. (1998). Neuropsychological complications of IDDM in children 2 years after disease onset. *Diabetes Care, 21*, 379–384.

Overstreet, S., Goins, J., Chen, R. S., Holmes, C. S., Greer, T., Dunlap, W. P., et al. (1995). Family environment and the interaction of family structure, child behavior, and metabolic control for children with diabetes. *Journal of Pediatric Psychology, 20*, 435–447.

Overstreet, S., Holmes, C. S., Dunlap, W. P., & Frentz, J. (1997). Sociodemographic risk factors to disease control in children with diabetes. *Diabetic Medicine, 14*, 153–157.

Riekert, K. A. & Drotar, D. (1999). Who participates in research on adherence to treatment in insulin-dependent diabetes mellitus? Implications and recommendations for research. *Journal of Pediatric Psychology, 24*, 253–258.

Sachs, G., Spiess, K., Moser, G., Kantzky, A., Luger, A., Pietschmann, P., et al. (1993). Hormonal and blood glucose responsiveness as an indicator of specific emotional arousal in type 1 diabetics. *Journal of Psychosomatic Research, 37*, 831–841.

Schwartz, G. E. (1982). Testing the biopsychosocial model: The ultimate challenge facing behavioral medicine? *Journal of Consulting and Clinical Psychology, 50*, 1040–1053.

Sheslow, D., & Adams, W. (1990). *Manual for the WRAML*. Wilmington, DE: Jastak Associates.

Shortridge-Baggett, L. M. (2001). Self-efficacy: Measurement and intervention in nursing. *Scholarly Inquiry for Nursing Practice, 15*, 183–188.

Soutor, S., Chen, R. S., Streisand, R., Kaplowitz, P., & Holmes, C. S. (2004). Memory matters: Developmental differences in predictors of diabetes care behaviors. *Journal of Pediatric Psychology, 29*, 493–505.

Wechsler, D. (1991). *Manual for the WISC-III*. New York: Psychological Corporation.

Wertlieb, D. (2003). Converging trends in family research and pediatrics: Recent findings for the American Academy of Pediatrics Task Force on the Family. *Pediatrics, 111*, 1572–1587.

Wysocki, T., Hough, B. S., Ward, K. M., & Green, L. B. (1992). Diabetes mellitus in the transition to adulthood: Adjustment, self-care, and health status. *Journal of Developmental and Behavioral Pediatrics, 13*, 194–201.

Wysocki, T., Meinhold, P. A., Abrams, K. C., Barnard, M. U., Clarke, W. L., Bellando, B. J., et al. (1992). Parental and professional estimates of self-care independence of children and adolescents with IDDM. *Diabetes Care, 15*, 43–52.

Wysocki, T., Meinhold, P., Cox, D. J., & Clarke, W. L. (1990). Survey of diabetes professionals regarding developmental changes in diabetes self-care. *Diabetes Care, 13*, 65–68.

Wysocki, T., Taylor, A., Hough, B. S., Linscheid, T. R., Yeates, K. O., & Nagliere, J. A. (1996). Deviation from developmentally appropriate self-care autonomy. *Diabetes Care, 19*, 119–125.