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THE EFFECTS OF TARGETING IMPROVEMENTS IN URINE GLUCOSE ON METABOLIC CONTROL IN CHILDREN WITH INSULIN DEPENDENT DIABETES

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A treatment program designed to increase the percentage of negative urine tests was implemented using a multiple-baseline across groups design in a sample of 19 families of children with insulin dependent diabetes. The treatment involved instructions in insulin adjustment, decrease in intake of simple sugars and saturated fats, and increase in exercise, along with teaching the parents to support improvements in children's self-regulatory behaviors using a point economy and praise. New proocedures designed to measure and reinforce adherence to the urine testing regimen were developed. Results showed significant increases in percentage of negative urines consistent with implementation of treatment across the three treatment groups, which were maintained over the follow-up period. Metabolic measures of control, including glycosylated hemoglobin and serum glucose did not show improvements even though the relationship between the percentage of negative urine tests and glycosylated hemoglobin was very high during treatment.

DESCRIPTORS: diabetes, urine tests, point economy, children

Insulin dependent diabetes (IDD) in children is a chronic endocrine disorder, caused by a failure of the pancreas to produce insulin. Long-term complications of insulin dependent diabetes include an increased risk of vascular disease, particularly in the forms of atherosclerosis, blindness, renal impairment and neuropathy (Drash & Becker, 1978). In addition, as in most chronic diseases of childhood, there are a variety of psychosocial problems in diabetes, including interpersonal problems with other children (Johnson, 1980), and family problems which may be brought on or exacerbated by the diabetes (Johnson, 1980; Minuchin, Baker, Rosman, Leibman, Milman, & Todd, 1975).

Treatment for diabetes is designed to normalize serum glucose by providing exogenous insulin, along with dietary regulation of simple sugars and saturated fats, and exercise (Drash & Becker, 1978). One of the major objectives in current research in diabetes is the development of devices to provide exogenous insulin in a way that may best mimic natural physiological insulin production (Maurer, 1979). Insulin requirements vary depending on growth, eating and activity patterns, illness and stress. At present the majority of children obtain insulin in an intermediate form with or without a short acting form in either one or two injections per day.

Variability in daily habits of caloric input and expenditure, as well as stress, may cause wide fluctuations in serum glucose levels. Control of serum glucose is attempted by stabilizing eating and activity patterns, with adjustments in insulin dosage during periods of illness, or as the child is growing. The majority of children and adolescents assess glucose control indirectly using urine glucose monitoring. When the renal threshold for glucose (approximately 150 mg/

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dl; Service, Molnar, & Taylor, 1972) has been exceeded, the excess glucose is excreted in urine, and this quantity of glucose can be estimated by the use of reagent tablets. Previous research has suggested that a majority of glucose determinations made by adults (Shenfield & Steel, 1977) and children (Malone, Hellrung, Malphus, Rosenbloom, Grgic, & Weber, 1976; Epstein, Coburn, Becker, Drash, & Siminerio, 1980) are inaccurate. However, the accuracy of glucose determinations can be improved by behavioral training procedures. The error rate of glucose determinations for a sample of nurses and laboratory technicians (Epstein et al., 1980) and diabetic children (Epstein, Figueroa, Farkas, & Beck, 1981) was halved following feedback training.

Although the diabetic regimen can be broken down into a series of behavioral tasks (Epstein, Coburn, Beck, & Figueroa, in press) there have been no systematic attempts to utilize behavioral technology to enhance metabolic control in diabetic children. The present study represents the initial evaluation of a behavioral treatment program designed to decrease the amount of urine glucose by regulating eating and exercise behaviors and adjusting insulin dosage in a sample of children with IDD. The goal of reducing urine glucose was chosen because urine glucose is the major source of feedback for diabetic children and their parents in controlling adherence behavior and insulin adjustment. In addition, this study represents the initial study in the diabetes literature to manipulate urine glucose systematically as the target response, and to assess related changes in other measures of metabolic control. The treatment program was designed to improve the competence of the children in self-regulating diet and exercise behaviors and urine glucose monitoring by behavioral training procedures.

METHOD

Participants and Setting

The Diabetes Clinic program at Children's Hospital of Pittsburgh provides treatment for over 600 children from infancy to 19 years of age. The standard outpatient medical management involves clinic visits at approximately 4-mo intervals for physical examination, insulin adjustment, and parental/child counseling about insulin injections, diet, and exercise.

Diabetic children and their parents were recruited from the population of Children's Hospital of Pittsburgh. Sixty families met the following criteria: (a) diabetic child between the ages of 8-12 years; (b) no metabolic problems requiring hospitalization within the last year; (c) no history of psychiatric treatment; and (d) family living within 60-mile radius of Children's Hospital.

Parents from these families were contacted by mail and then by phone to assess their interest in the program. Twenty of the families were interested and began the program. During the initial 2 wk of baseline, one child contracted chicken pox, and his data were not included. After the child had recovered he was provided treatment. The descriptive characteristics of the remaining 19 children are presented in Table 1. Fifteen of the nineteen children took one subcutaneous injection of intermediate with or without short acting insulin per day, while four children (4, 7, 11, 12) received two injections per day. At the outset, 10 of the children were self-administering insulin, and for the remaining 10, one of the parents was giving the shots.

Measurement

Daily urine testing. The method used provides a semi-quantitative estimate of urine glucose levels (Malone, Rosenbloom, Grgic, & Weber, 1976), which reflects serum glucose levels, and is used by physicians and patients both as a measure of metabolic control (Dunn, Cole, Soeldner, Gleason, Kwa, Firoozabadi, Younger, & Graham, 1979), and as a means to regulate insulin dosage. The urine testing procedure entails the collection of premeal urine specimens 3-4 times daily. Clinitest reagent tablets (Miles Laboratories, Elkhart, Indiana) are

Table 1

Descriptive Characteristics of Sample

	C #	Age (years)	Sex	Duration of Diabetes (years/months)	Regular Self-Administration of Insulin	Baseline		
						Serum Glucose (mg/dl)	% GhB	Diabetes Knowledge Score (n/40)
Group 1	1	9	F	2.7	No	234	8.3	38
	2	10	F	3.2	Yes	222	10.6	33
	3	11	F	2.10	No	297	13.4	N.A.
	4	11	F	4.10	No	261	11.3	39
	5	11	M	3.0	Yes	139	10.6	21
	6	9	F	1.0	No	279	11.3	31
Group 2	7	9	M	3.0	Yes	318	10.8	29
	8	10	F	1.9	Yes	156	9.2	30
	9	10	F	2.2	Yes	182	7.8	30
	10	11	M	5.5	Yes	156	9.2	N.A.
	11	8	F	8.0	No	57	7.6	15
	12	12	F	1.3	No	142	7.8	36
	13	12	F	4.7	No	276	12.7	37
Group 3	14	11	F	8.5	No	124	10.3	26
	15	9	M	2.11	No	314	9.0	N.A.
	16	11	F	1.0	Yes	269	10.8	30
	17	10	F	6.0	Yes	285	10.9	30
	18	11	M	7.5	Yes	168	9.8	31
	19	6	F	.9	No	345	8.7	20

Note: N.A. means not available.

added to a solution consisting of 2 drops of urine and 10 drops of water. The solution changes color depending on the amount of reducing sugars in the urine, and is then compared to a 7-step color chart with values marked 0%, trace, ½%, 1%, 2%, 3%, and 5% or more which represents 0 to >5 g of reducing sugars/100 ml of urine, respectively.

The utility of this measure is based both on the accuracy of measurement and the adherence to the measurement regimen, which was 3-4 times per day, a minimum of 21 test/wk.

The major dependent measure derived from the daily urine testing was percentage of negative tests. The presence of *any* glucose in the urine suggests that greater than normal glucose concentrations are present in the blood, and the renal threshold has been exceeded. The percentage of negatives has been previously demonstrated to be highly correlated with glycosylated hemoglobin (GHb) (Dunn et al., 1979).

Reliability. The reliability of detecting negative urine determinations, or 0% reductions, is not a problem for children with diabetes. In fact, in the assessment of urine determination accuracy in over 160 diabetic children, less than 5% made an incorrect determination when presented with 0% glucose in their urine. During baseline, all parents and children were provided our training procedures for measuring glucose concentrations (Epstein et al., in press), and were assessed for accuracy before and after treatment. No parent or child was incorrect when judging a negative sample, and no non-negative samples were rated as negative.

Assessment of the reliability of children's recordings across the range of urine glucose concentrations was also performed, though only the negative urine data were used for analyses. Parents were asked to test four urines per week, on a schedule that was determined by the experimenters. This was accomplished by having the

child set aside a urine sample each time a urine test was performed. The parent subsequently tested the sample without knowledge of the child's values. Nontested samples were thrown away by the parents. Reliability was assessed for 91% of the treatment weeks. Parents and children agreed on the glucose concentration within a one measurement interval range on each of the four reliability tests during 83% of the weeks.

Adherence. The adherence to the urine testing regimen was measured using an adaptation of the marked item technique for medicine compliance (Epstein & Masek, 1978). The marked item technique used in the present study was placebo Clinitest tablets, similar in appearance to regular Clinitest tablets, but inert when added to the urine/water solution. These tablets were provided by Dr. R. Shangraw, School of Pharmacy, University of Maryland at Baltimore. The absence of color change was readily discriminable. Predetermined quantities of placebo tablets, ranging from one to seven per week, were bottled with a greater number of the active Clinitest tablets than would be used, and distributed to children. Parents were provided a code which informed them of the correct number of placebos. At the end of each week, parents were instructed to test the remaining tablets in each bottle, and add the number they found to the number the child found. Comparison of this number to the actual number provides an objective measure of the child's adherence to the regimen for that week, because the only way the child could know the number of placebo tablets was to do the urine testing. Children were instructed to test the urine sample with a new Clinitest tablet when a marked item was found. Parents and children agreed on the number of marked items 76% of the weeks (.76 + .02, Mean ± SEM).

Glycosylated hemoglobin (GHb). Glycosylated hemoglobin measurement provides a long-term estimate of blood glucose control. The measure is based on the amount of glucose irreversibly attached to the hemoglobin in red blood cells. Because the life of a red cell is approximately 90-120 days, a measure of diabetic control over a 1- to 3-mo interval is provided. Total glycosylated hemoglobin (GHb) was measured by microcolumn chromatography using Quick-Sep columns supplied by Isolab Incorporated (Akron, Ohio). Fasting whole blood specimens were washed three times in normal saline within one half hour of venipuncture stored at 4°C for 2-5 days and run in a water bath at stable temperature 22 ± .5°C (Trivelli, Ranney, & Lai, 1971). Normal values, established for 75 nondiabetic children, were 6.1 ± .6 (Mean ± SD).

Plasma glucose. Fasting plasma glucose was measured by a glucose oxidase method using a YSI analyzer (Yellow Springs, Ohio).

Serum lipids. Fasting serum cholesterol and triglycerides were measured using enzymatic procedures described by Allain, Poon, Chan, Richmond, and Fu (1974) and Bucolo and David (1973). HDL cholesterol was measured using heparinmanganese precipitation procedures (Albers, Warnick, Wiebe, King, Steiner, Smith, Breckenridge, Chow, Kuba, Weidman, Arnett, Wood, & Shlagenhaft, 1978).

Additional measures. A test of diabetes knowledge and a diabetes attitude survey developed by Johnson, Pollack, and Silverstein (Note 1, Note 2) were given to the children pre- and posttreatment. Neither of these measures showed any change; they are discussed in greater detail in Epstein et al. (in press).

An index of consumer satisfaction was obtained as part of a posttreatment survey. Parents were asked on a 9-point scale, "How would you rate this program overall?" (1 = very poor; 9 = very good).

Experimental Design

The research design used in the present study was a multiple-baseline across groups design (Hersen & Barlow, 1976). The 19 families were randomly assigned to one of three treatment groups, which differed according to when treatment was implemented. This design provides for

analysis of the functional relationship between treatment implementation and behavioral change. In the present study, treatment was implemented at 2, 4, or 6 wk into the 12-wk program. The demonstration of treatment effect is dependent upon change in dependent variables subsequent to treatment implementation for participants in that group, with participants not in treatment showing no change.

Participants in each group were seen eight times in 1 to 1½-h sessions over the 12-wk treatment period, and at a follow-up 2 mo after the treatment was over. Meetings were generally arranged biweekly. Participants in all groups began baseline at the same time. Treatment began with the introduction to insulin adjustment, followed by training in regulating diet and exercise.

All information was presented to participants in a modular format, with one module per topic. Modules were designed in a format similar to that used by Miller (1975). Information about the topic was presented in the first section of the module. A reading quiz consisting of sentences taken from the text, with words missing followed. The module also included sample problems related to the module topic which the child could complete. Finally, five test questions were administered that covered the subject matter of the module. In order to advance to the next module, children had to score at least 80% on this test. An alternate form of the exam was available in the event the child did not pass the first test.

There were six modules which focused on programmatic ways of increasing the child's responsibility for and knowledge of his or her diabetes and the control thereof. Each child module had a matching parent module that covered the same material as well as instructed parents in the use of behavioral principles to increase the desired behaviors in the child (e.g., the use of praise plus fading to initiate insulin injections). The information presented in the modules was as follows:

Introduction/motivation, glucose and acetone monitoring. In this first session/module, all families were trained in accuracy of urine-glucose testing using a feedback program developed by Epstein et al. (1981). Families were also instructed in motivational techniques, including the development of a point economy and the use of parental praise.

Insulin adjustment. This module was designed to train parents in determining appropriate insulin dosages for their children dependent on urine glucose or acetone values. This information was provided on increasing and decreasing dosages, and how to make changes due to illness or stress. In general, parents were instructed to make changes in insulin dose by increments or decrements of 10% instances, or 20% during illness or stress.

After parents were provided this module, they were asked to determine appropriate insulin changes at each subsequent contact. Parents and children were provided feedback on the accuracy of their adjustments by the consulting physician (D.D.) who had evaluated their urine glucose records. The physician feedback was faded 6 wk after the presentation of the insulin adjustment module.

Diet. This module was based on a modified "traffic-light" diet (Epstein, Masek, & Marshall, 1977), where foods are divided into three categories: Red (Stop!) foods which should be avoided; Yellow (Caution) foods which should be eaten cautiously; Green (Go) foods over which there are no restrictions. The major goal was to decrease intake of red foods. No restrictions were placed on intake of yellow or green foods. A listing of red foods is presented in Epstein et al. (in press). Children monitored their daily intake of red foods in a habit booklet provided for them. Control of red foods was designed to decrease intake of simple carbohydrates and saturated fats.

Exercise. This module focused on the importance of exercise as an adjunct to the treatment of diabetes, indicating appropriate ways for the diabetic to match eating and exercise, such as having an extra snack prior to or while exercis-

ing to prevent a hypoglycemic reaction. Upon the initiation of the exercise module, children and parents met with the experimenters at a local park where they began an exercise program consisting of education in safe and proper ways to exercise, modeling proper warm-up and cool-down procedures, and a walking/running program where staff, parents, and children ran/walked increasingly longer distances beginning at 1 mile until 3 miles was achieved, with increases occurring in weekly ½-mile increments. Families were encouraged to continue this exercise program at home exercising at least four times per week.

The exercise program was based on an aerobic exercise program developed for overweight children (Epstein, Wing, Koeske, Ossip, & Beck, Note 3). Children were instructed in monitoring their activity using a point system in which points were roughly related to caloric expenditure.

Shot administration. This module dealt with the self-administration of insulin injections that has been identified by diabetic families as problematic. Modeling of shot administration was performed and instructions regarding rotation of the injection site were given.

Stress. This module focused on the difficulties of living with diabetes and the psychological stress that often accompanies chronic illnesses. Children and parent separately discussed areas of stress which were most problematic. Parents received instructions on parent management, and the diabetic children role played various diabetes related stressful situations with multiple appropriate responses being modeled. The effects of stress on diabetic control and the implications for insulin dose adjustments were also discussed.

Hypoglycemia. This module focused on the identification and discrimination of insulin reactions commonly occurring in diabetes, as well as the appropriate course of action. Special attention was given to attempts to discriminate between hypoglycemia and anxiety.

Parental/Child Contracts

At the beginning of the program, parents deposited $35, $5 of which was returned contingent on attendance at treatment meetings. Contracts have been demonstrated to be useful in promoting adherence for health care behaviors (Epstein & Wing, 1979).

Child contracts were negotiated to improve control and were implemented using a point economy. During baseline, children could earn points for correct measurement of urine glucose, for finding the correct number of marked items, and by matching the glucose values determined by their parents during the parental reliability checks. After treatment began, the children could also earn points for diabetes control.

Control was initially defined as two or more urine glucose tests/day which read less than 1%. After 2 wk on this contingency, control was defined as three tests a day of 1% or less. The 1% or less criterion is based on suggestions by Drash (1976) that good control is represented by the majority of urine glucose recordings of less than 1%. Thus, while the major dependent measure was percentage of negative tests, the parents and children were not aware of this. This was done to decrease the possibility of experimenter demands influencing the dependent measure. During treatment children could earn points for validity (finding the correct number of clinkers), points for reliability (agreement with parental checks), and points for control (number of urine tests under 1%).

During treatment, parents and children were seen separately. Children's sessions began by a review of the week's daily record sheets. Children were praised for completion of forms and for improvement in urine glucose concentrations. Children who met a prespecified (and increasing) criterion of points on their weekly diaries had smiley face stickers posted on a weekly chart. Phone contact was made with parents and children each week to reinforce habit change and problem solving.

RESULTS

Daily Urine Tests

The mean proportion of negative urines for children in each group is presented in Figure 1, with the standard error of the mean for all observations in each phase shaded in. Weekly means per group are presented during treatment, and the follow-up data represent the mean for the last 2 wk of follow-up. These results

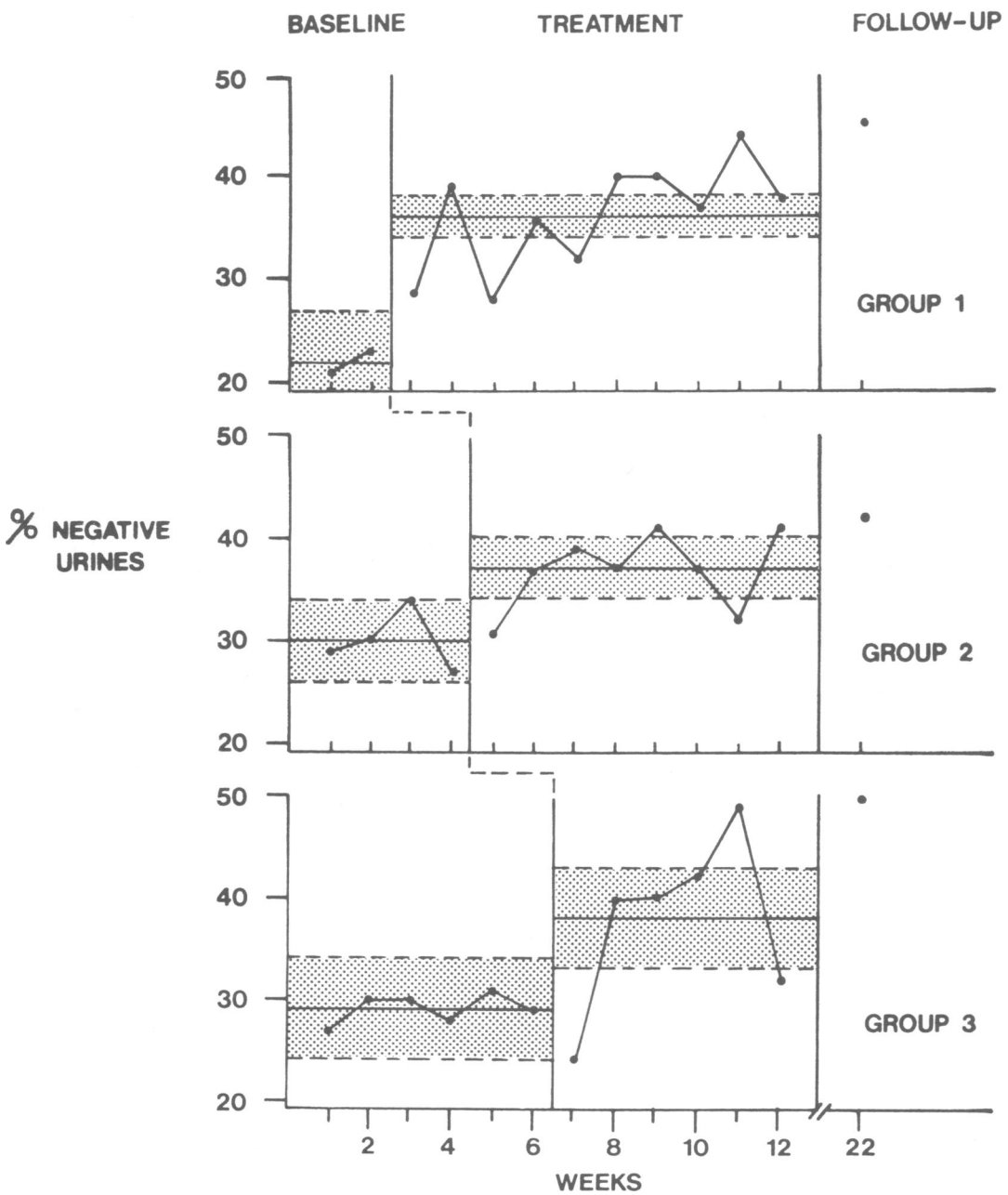

Fig. 1. Percentage of 0% urine concentration tests weekly for children in each group. The mean and standard error of the mean for all the observations in each phase by group are represented by a solid and dotted line, respectively.

Table 2
Parameters of Metabolic Control (X ± SEM)

	Pre-	*Post-*	*Follow-up*	*P*
Negative Urines (%)	27 ± 5.4	39 ± 4.5	45 ± 5.6	< .01 post, FU > pre
GHb (%)	10.0 ± .37	10.8 ± .34	10.7 ±.34	< .01 post, FU > pre
Plasma Glucose (mg/dl)	227 ± 17.4	233 ± 25.8	225 ± 21.5	n.s.
Insulin Dose (units/kg)	.98 ± .055	1.01 ± .060	.98 ± .053	n.s.
Triglycerides (mg/dl)	70.9 ± 4.95	58.7 ± 4.52	61.4 ± 4.40	< .05 pre > post
Cholesterol (mg/dl)	145.7 ± 7.91	148.8 ± 6.28	158.1 ± 6.49	< .01 FU > pre, post
HDL-Cholesterol (mg/dl)	51.0 ± 3.39	49.2 ± 2.73	50.1 ± 2.22	n.s.

show that the proportion of negative urines was stable during baseline for each of the groups. The sequential introduction of treatment was associated with reliable improvements in the proportion of negative urines across each group, suggesting that treatment was responsible for the increased number of negative urine tests. The improved control was maintained during follow-up.

Parameters of Metabolic Control

The pre-, post, and follow-up values for percentage of negative urines, percent GHb, plasma glucose and lipids, and units of insulin/kg are presented in Table 2. Separate one-way analyses were performed on pre-post values for each measure, with Newman-Keuls Multiple Range Test used to compare means. The results of these analyses show significant increases in the percentage of negative urines, $F(2, 37) = 6.24$; $p < .01$, from 27% to 39% ($p < .05$) maintained ($p < .01$) at follow-up (45%), and increases in percent GHb values, $F(2, 36) = 7.62$; $p < .01$, from pre- (10.0) to post- (10.8), which then remained unchanged at follow-up (10.7). No significant changes were observed in plasma glucose or units of insulin/kg body weight.

The parameters of metabolic control were intercorrelated separately for pre-, post-, and follow-up assessments. The percentage of negative urines used to correlate with the pre-, post-, and follow-up values were the mean proportions for the weeks 1 and 2, 11 and 12, and 21 and 22, respectively. The results of these analyses are presented in Table 3.

These results show that both glucose and per-

Table 3
Intercorrelation of Measures of Control

	Glucose (mg/dl)			*Percentage (0% Urines)*			*Insulin (units/kg)*		
	Pre-	*Post-*	*Follow-up*	*Pre-*	*Post-*	*Follow-up*	*Pre-*	*Post-*	*Follow-up*
% GHb	.46*	.50*	−.34	−.58*	−.83*	−.14	.06	.10	−.24
Glucose	- - - - - - -			−.25	−.39	.25	−.27	−.55*	−.14*
Urine				- - - - - - -			.30	−.24	−.30

*Denotes $p < .05$.

centage of negative urines are correlated with percent GHb at pre-, and post-assessment, with percentage of negative urines being a better predictor of percent GHb than serum glucose at each measurement occasion. In fact, the correlation between the proportion of negative urines and percent GHb at posttest is very high, $r = -.83$ (17); $p < .001$. Significant relationships between the serum glucose and negative urines with GHb are not observed at follow-up. The insulin dose (units/kg) correlated with serum glucose at the end of treatment and follow-up.

Changes in serum lipids are also presented in Table 2. Analysis of these data show that triglycerides, $F(2, 37) = 3.26$; $p < .05$, were significantly ($p < .05$) reduced from 70.9 to 58.7 mg/dl at posttest; however, the values were slightly increased at follow-up (61.3 mg/dl). The cholesterol values, $F(2, 37) = 5.63$; $p < .01$, show no changes during treatment, but a small but significant ($p < .01$) increase during follow-up. No changes were observed in HDL cholesterol. All lipid values were within the normal range for age.

Consumer satisfaction ratings obtained at the end of treatment show a mean satisfaction rating of 8.5 out of 9, suggesting participants were quite pleased with the treatment program. In addition, at the end of treatment all of the children were self-administering insulin, an increase from 10 out of 20 pretreatment.

DISCUSSION

The goal of this study was to utilize common procedures in diabetes management (urine testing, diet, exercise) to increase the proportion of urine tests that contained no glucose. The proportion of negative urine results did show significant and consistent increases subsequent to the introduction of treatment. No increases were observed during baseline, when children were given points and praise for accurate recording. Increases were reliably observed after the introduction of treatment, which began with insulin adjustment and the opportunity for children to earn points for improved control. In addition, the positive changes were maintained over a 2-mo follow-up.

A new measure of adherence to the urine testing regimen was developed, based on the marked item technique of medicine compliance (Epstein & Masek, 1978). In addition, the traditional diabetic diet was stressed, based on instructional, monitoring, and reinforcement procedures which have changed eating behaviors in young children (Epstein, Masek, & Marshall, 1978). Finally, an exercise program which can significantly improve fitness in overweight children (Epstein et al., Note 3), was adapted for diabetic children.

The behavioral goals recommended in the present study were based on traditional diabetes management with insulin adjustment based on glucose in the urine, supplemented by careful attention to diet and exercise. The level of control obtained is tighter than advocated previously by Drash (1976), who recommended only that the majority of tests be less than 1%. The statistically reliable changes observed in this study from a mean of 27% at baseline to 39% at the end of treatment to 45% at the end of follow-up compare favorably with results presented by Dunn et al. (1979), who showed a range of negative urines from 21 to 40% in a summer camp for diabetic children.

The significant changes in percentage of negative urine tests were not associated with general improvements in metabolic control. During treatment, serum glucose and percentage of negative urines correlated with glycosylated hemoglobin, consistent with other reports (i.e., Dunn et al., 1979). However, at follow-up, the correlation disappeared. The absence of a relationship in repeated measures over time has also been reported by Koenig, Peterson, Jones, Saudek, Lehrman, and Cerami (1976), who showed glycosylated hemoglobin changes may lag for several weeks after changes in other measures of control. The pattern of the relationship between serum glucose or negative urines with glycosylated hemoglobin suggests dynamic changes in

the short-term measures of control (urine or serum glucose) which are not immediately reflected in the longer term measures of control (i.e., GHb).

Although the degree of control was better than typically recommended (Drash, 1976), or observed (Dunn et al., 1979), it is possible that the proportion of negative urines would have to increase beyond 50% of all urines tested to alter other metabolic measures of control. However, pursuing this degree of control is inconsistent with the traditional training many diabetics have received (Travis, 1978), which is to avoid both negative urines and 5% urines. As the goal of decreased serum and urine glucose is pursued, an increased incidence of hypoglycemic episodes is possible, which makes parents hesitant to increase insulin doses. In the present study, no parent was ever observed to increase insulin dose voluntarily, except during ilnesses, while decreases in dosage were common.

The central issue in attempting to control serum glucose and GHb by targeting urine glucose may be the general unreliability of urine glucose measures (Service et al., 1972). If urine glucose is used as the source of feedback for adjustment of components of diabetes adherence, and urine glucose measures are inaccurate, the proper adjustment of eating, exercise, and insulin will be difficult, if not impossible. One obvious problem with the method is that quantitative information is only provided when serum glucose is significantly elevated, so that children may learn to discriminate levels of hyperglycemia, but never learn to discriminate among levels of normal serum glucose. In addition there is considerable variability in renal threshold for glucose, so that negative urine tests may be associated with a wide variety of serum glucose values across subjects (Walford, Page, & Allison, 1980). More precise measures provided by home glucose monitoring (Sönksen, Judd, & Lowy, 1978) may be necessary to adjust insulin to physiological requirements better.

Targeting adherence is a reasonable first step to improve control because all juvenile diabetics require insulin, and need to regulate eating and exercise behaviors. However, there are other areas of behavioral procedures that might be important for diabetic control which relate to reducing stress. Based on the available literature, there are two methods that might be useful in reducing stress. The first method to reduce stress would be by altering the conditions that cause stress. This approach is used by Minuchin and his colleagues (1975), who have developed a model to describe how a family interaction patterns may produce stress and poor metabolic control. In a series of uncontrolled case studies, Minuchin et al. (1975) have demonstrated improvements in control after psychosocial treatment. The second method is to modify directly and physiological changes that occur during stress by relaxation training. Fowler, Budzynski, and Vandenbergh (1976) presented data showing a decrease in the amount of insulin required after EMG assisted relaxation training. However, Seeburg and DeBoer (1980) reported no improvement in diabetes control after EMG biofeedback, due in part to reported hypoglycemia because of lowered insulin requirements.

For some time the most common treatment for diabetic children will continue to be traditional management using insulin adjustment, urine glucose monitoring, and diet and exercise regulation. Although improvement was not obtained for all measures of control in the present study, the results suggest that behavioral techniques may be useful to improve behavioral regulation of treatment, particularly focusing on improving adherence to components of the diabetes regimen.

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