

A Pilot Study to Stabilize Normoglycemia During an Educational Camp for Children and Adolescents With Type 1 Diabetes Mellitus

Stan De Loach, PhD, CDE

Certified Diabetes Educator and Clinical Psychologist, Mexico City, Mexico

ABSTRACT

Background: Children and adolescents with type 1 diabetes mellitus (DM) who participate in diabetes camps do not often achieve stable, normoglycemic control, largely because changes in the campers' activity levels and food options necessitate adjustments to their insulin use and nutritional therapies. It would seem logical, with the abundance of diabetes education and professional consultation freely available at these camps, that the glycemic levels of these young campers could approach normal values.

Objective: This informal study was designed to explore the feasibility of safely achieving stable, short-term normoglycemic control in children and adolescents with recent-onset type 1 DM attending a diabetes camp.

Methods: A multidisciplinary team worked with children and adolescents 6 to 18 years of age during a residential 3-day/2-night diabetes camp. Demographic data were compiled from the application forms completed by the campers and signed by the campers and their parents. The staff functioned in 2 distinct roles: as managers (securing time, task, technique, and territory boundaries) and as consultants (addressing participants' educational, social, and emotional needs). The staff supported the campers in their attempts to quickly and safely achieve tight normoglycemic control (ie, 71–99 mg/dL) and stability (ie, an estimated mean amplitude of glycemic excursion [eMAGE] score ≤ 95) through their firsthand experience with self-directed learning methods, basal-bolus insulin analogue therapy, and a diet low in concentrated carbohydrates (CHOs). Campers chose foods from meal buffets, calculated preprandial and complementary doses of ultra-rapid insulin, and participated in physical exercise and self-monitoring of blood glucose (SMBG) at will. SMBG values retained in each camper's combined glucose/ketone monitor furnished statistical data. Initial and final glycosylated hemoglobin values were not measured because 3 days of glycemic control—at any BG level—would not be expected and have not been reported to produce significant changes. No follow-up of the campers was planned or possible.

Results: Six boys and 3 girls (aged 8–17 years; mean [SD] age, 11.8 [2.6] years; mean duration of diabetes, 1.62 [0.88] years) agreed to participate in the study. All but 1 of the campers were preadolescents. Mean BG levels on arrival and departure were 209 (101.5) and 81 (12.8) mg/dL, respectively ($P < 0.003$). The mean 3-day BG level was 95 (21.2) mg/dL. The 3-day mean eMAGE score (66.5 [28.1]) indicated stable glycemic control. Seven of the 9 campers (78%) returned to the camp the following year (2007).

Conclusions: Combining self-directed educational methods for learning diabetes self-management with insulin analogues in a basal-bolus therapy regimen, ad libitum physical activity and SMBG, and a diet low in concentrated CHOs, campers rapidly established routinely normal daily mean BG levels and glycemic stability. (*Insulin*. 2009;4:158–168)
© 2009 Excerpta Medica Inc.

Key words: type 1 diabetes mellitus, diabetes camp, low-carbohydrate food choices, insulin analogues, normoglycemia, multiple daily injections.

INTRODUCTION

Children and adolescents with type 1 diabetes mellitus (DM) who have attended diabetes camps have experienced erratic glycemic control compared with the glycemic stability that is common among peers without DM.¹ Studies have attempted to improve glycemic control in children and adolescents with type 1 DM.² However, there is "limited understanding of how [diabetes] camps positively influence [children and] adolescents with diabetes and the specific mechanisms

within camps that may foster outcomes for increased diabetes self-management."³ Although studies have examined the role of independence, autonomy,⁴ intentional support, psychological interventions,⁵ quality of life for adolescents with type 1 DM,⁶ and intensive insulin therapy,⁷ the measure of a successful outcome has not been the attainment of normal or near-normal glycemic control and stability.⁸ In the current study, normoglycemia (71–99 mg/dL) and normoglycemic stability were used as cardinal indicators of the campers'

competence in self-management of type 1 DM. No research has previously reported on efforts, successes, or failures to rapidly achieve stable normoglycemia for children and adolescents attending diabetes camps.

Each year, Campamento Diabetes Safari (held near Mexico City) offers diabetes education to children and adolescents 6 to 18 years of age with type 1 DM during a 3-day/2-night residential camp, which aims to foster self-awareness, comprehension, autonomy, and creativity in the self-management of type 1 DM. Staff members intentionally endeavor to help campers discover through personal experience and implement proactive, individualized solutions to glycemic disequilibrium to effectively maintain safe, stable normoglycemic control.

The long-range objective of the camp is to lay the foundation for competent self-management of type 1 DM that will prevent major long-term diabetic complications (ie, retinopathy, nephropathy, neuropathy, cardiopathy).^{9,10} All the components of the camp experience contribute to the therapeutic power of intensive insulin therapy, which has been found to significantly reduce the incidence and progression of microvascular complications in patients with type 1 DM.¹⁰

The camp's educational objective is to provide opportunities for young persons with type 1 DM to explore self-directed learning about diabetes self-management in a low-stress context with freely available professional consultation and material resources (ie, high-quality blood glucose [BG] monitors, reagent strips, insulin analogues, syringes, appropriate low-carbohydrate [CHO] foods). The staff embodies the primary educational task of offering opportunities to learn from personal experience about functional self-management of type 1 DM, including pertinent emotional and psychological facets.

The prime clinical objective is to minimize hypoglycemia and hyperglycemia by maintaining daily mean BG values within the target range (71–99 mg/dL), by limiting the 3-day estimated mean amplitude of glycemic excursion (eMAGE) value to ≤ 95 mg/dL, by advocating ad libitum self-monitoring of BG (SMBG) and physical activity, and by facilitating informed food selection and intake.

This study explored whether children and adolescents with recent-onset type 1 DM attending a diabetes camp could achieve tight normoglycemic control and short-term stability through a combination of self-directed diabetes education, a diet low in concentrated CHOs, use of insulin analogues in a subcutaneous basal-bolus regimen, and ad libitum SMBG and physical activity.

METHODS

Campers themselves elected to attend the diabetes camp after reviewing the detailed information about the camp that is available on the Internet.¹¹ This information covers all aspects of the camp (eg, objectives, staff's philosophical and practical approaches to self-management of type 1 DM, staff members' professional qualifications and type 1 DM status, insulin regimens supported, daily schedules and activities,

housing, menus). Campers discussed their participation with their parents, who ultimately delivered the signed application forms and registration fees. Other than the requirement that the campers be 6 to 18 years of age, have type 1 DM, and be using insulins for glycemic control, no further criteria for inclusion or exclusion were applied.

At registration, each camper signed a statement of affirmation to indicate his or her own voluntary presence at the camp and the absence of pressure from parents, physicians, certified diabetes educators, or others to attend the camp, as well as a statement of informed assent to participate in the planned noninvasive study of BG values during the 57 hours spent at camp.

The campers' informed but largely self-determined BG management was guided by a fundamental hypothesis, shared by campers and staff. This hypothesis was that children and adolescents with type 1 DM can decide to apply their diabetes education and personal experience to rapidly achieve stability in their daily glycemic values. While maintaining a conservative normal glycemic range (71–99 mg/dL), the campers continued to engage in plentiful physical activities and to eat a wide variety of appealing, low-CHO foods. They also used low doses of insulin analogues in a basal-bolus treatment regimen designed to support normoglycemia and to avoid excessive hyperglycemia and hypoglycemia.

The Laws of Small Numbers¹² provided the functional technology underlying this implicit hypothesis. These laws or descriptions of system functioning basically state that large inputs result in large mistakes, whereas small inputs result in small mistakes. They are based on the fact that many "biological and mechanical systems respond in a predictable way to small inputs but in a chaotic and considerably less predictable way to large inputs."¹² Applied to insulin doses and CHO intake, these laws are particularly instrumental in facilitating successful and stable BG self-management within an acceptable range of values.

This study did not explore whether previously existing glycemic control and stability subsequently improved as a result of attending the camp, but whether normoglycemic control and stability improved during attendance at the camp. No attempt was made to oblige, produce, or follow up on longer-term transformations of behavior incident to glycemic control and stability. Such behaviors are regarded as the responsibility and decision of the informed and educated individual with type 1 DM.

The investigation of psychological or psychosocial parameters that may have been impacted by attendance at the camp was likewise beyond the range of this glycemia-focused study. Native intelligence and cognitive ability were not evaluated.

Self-Directed Diabetes Education

Self-directed education invites the expression and exercise of choice in the pursuit of personally meaningful learning. It encourages campers to articulate elements of the diabetes curriculum of immediate need or interest to them.

To avoid entanglement in the politics of domination and submission, staff members do not impose unnecessary regimentation on the working relationship with campers, but instead adapt to the latter's preferences, accompanying them in the process of learning from daily experience, and modeling inquiry and flexibility as ways of relating appropriately to such complex relevant data as variability of glycemic values, treatment options, food choices, and insulin activity patterns.

Self-directed education encourages campers to articulate, learn, and apply elements of the diabetes curriculum of immediate need or interest to them.

In a similar vein, self-determination theory¹³ "postulates that individuals whose behaviors originate from volition or choice as compared [with] control or pressure are more prone to long-term adherence to particular goal-oriented behaviors."³ The self-directed learning model avoids excessive restrictions in the course of shared, verbal analysis of experience, leaving learning to occur through the exercise of personal authority and responsibility in the review of the errors and successes inherent in acquiring practical knowledge of diabetes self-management. The staff periodically indicates how campers may incorporate their experiential knowledge in the competent practice of type 1 DM care. Their consultation strives to foster "the internalization of diabetes management."⁴ Through such consultation, campers become actively and legitimately involved in constructing the architecture of their own health care and lifestyle.

Staff members, as a team, exercise 2 concurrent roles: (1) the manager role, to maintain the time, task, territory, and technical boundaries that allow the management of anxiety, which is, itself, necessary for learning to take place; and (2) the consultant role, to permit articulation, discussion, and shared analysis of the numerous learning opportunities presented each day during camp (ie, addressing participants' educational, social, and emotional needs).

As managers, staff members coordinate the published schedule and engineer safe use of territories for programmed or improvised activities. As consultants or advisors, they work in the "here and now," to encourage productive interaction around solicited or evident but unstated topics, concerns, difficulties, and interests. At the outset, campers and staff are explicitly authorized to initiate consultation at any time, for any reason. This authorization curtails unnecessary dependence and passivity, and increases consciousness of the indispensable exercise of personal freedom and responsibility in the prevention of the complications of DM that occur through mismanagement. Campers are free at all times to learn and are responsible for what they learn.

Because no plenary or total-group academic classes or presentations are used in the self-directed educational

method, the campers learn through self-discovery rather than direct instruction. Assorted themes arise to give content to staff's consultations. Is celery converted to sugar? Do proteins have calories? Why does everyone say that chicken skin is bad for you? What can I do when I want something sweet? Why rotate the finger-stick site when checking my BG? Why are symptoms absent when my BG is 313 mg/dL? Does an aspirin a day lead to bruises from injections? How do insulin pumps work? How would a girl feel if her boyfriend had DM? Do musicians have DM? Will my brother also develop DM? Can I have a baby? Will I die from DM? What does "depression" mean?

Self-directed inquiry frequently leads to emotional considerations. From verbally competent children, adolescents, and adults, type 1 DM demands chronic self-management as the principal avenue for treatment. The quality of self-management may parallel the psychological health of the "self." Emotional factors impact both the understanding and the application of information transmitted in the educational process; their dynamics are addressed during the camp in small and plenary group settings. Manifest group dynamics and participants' voluntary discussion of nightly dreams figure prominently in staff's evaluation and response to emotional conflicts and needs for support.

The staff engages campers as persons with type 1 DM and partners in their health care, not as unknowledgeable subordinates, passive novices, or persons of otherwise inferior status. Through prior and current education and experience, most campers have come to know their own body's metabolic responses to physical activity, insulin, and glucose excess or deficit better than any other person. However, personal knowledge may not have been previously solicited or articulated, impeding its contribution to effective diabetes self-care. At camp, participants grow to recognize and verbalize factors shaping their distinctive personal expression of type 1 DM.

The staff thus avoids comparing or coercing campers or exerting psychological pressure, guilt, or shame in exploring and defining the quality of their glycemic control. Sixty percent of the staff has type 1 DM; data from their own self-care activities are public and observable examples of adroit diabetes self-management. Staff members with type 1 or type 2 DM are required to have a glycosylated hemoglobin (A1C) value of $\leq 5.2\%$ to be considered for a staff position. Their firsthand knowledge (often conveyed in "teachable moments") guides consultations, although treatment decisions almost always rest with the individual camper.

Neither the quantity nor the quality of the DM education carried and/or acquired by the campers was standardized. In large measure, those depend on age, time from diagnosis, inherent mental abilities, cognitive developmental level,¹⁴ and the frequency and intensity of earlier DM educational efforts by a variety of health care professionals, as well as by nonqualified sources of additional, frequently inaccurate information, myths, and beliefs about type 1 DM. In this study, the individual learning provided by the data from measurable, "here-and-now" personal experience (How much

did 1/2 unit of ultra-rapid-acting insulin analogue lower my BG? Which CHO sources are shown in my BG measurements to affect glycemic control more drastically and negatively than others?) was assumed to be pertinent and valid.

DM education, whether through information exchange in dyads or through review of and guidance in the technical aspects of type 1 DM care in group settings, was individualized in response to campers' implicit or explicit requests and needs. Mexican cultural standards allow and encourage participation by peers in most of the individual's educational, recreational, or leisure-time activities.

As a result, although DM education was personalized and individualized for a given camper, others, whether staff members or other campers, were implicitly and explicitly authorized to attend to the points offered for learning and to participate in the exchange by listening or by posing comments or questions of their own.

DM education, whether through information exchange in dyads or through review of and guidance in the technical aspects of type 1 DM care in group settings, was individualized in response to campers' implicit or explicit requests and needs.

Therapy With Insulin Analogues

Glargine and lispro were used for all insulin therapy at the camp. Through time-predictable action profiles, these insulin analogues deliver stable glycemic regulation, while facilitating rapid regimen modification as needed. Lispro was also used for complementary insulin doses, in response to extemporaneous hyperglycemia.

All mealtime insulin was preprandial. Campers calculate and adjust doses of lispro before each injection, prandial or complementary. The staff participates in this process. Data obtained from SMBG 1 to 2 hours after injections verify dose precision, highlight factors influencing individuals' BG levels, quantify current insulin replacement requirements, and refine subsequent dose calculations.

Food Plan With Reduced Levels of CHO Content

Camp food¹¹ is considered tasty and nutritionally adequate, but contains little concentrated CHO (eg, tortilla, pasta, rice, fruit, milk). Water and flavored noncarbonated diet drinks are freely available. Less concentrated forms of CHOs, present in foods such as nuts, cooked and raw vegetables, soups, and salads, are used to supplement the diet. Campers select foods and drinks from meal buffets (Table I).

Physical Activity

Physical activity is joined with the use of insulin analogues and appropriate food choices to facilitate optimal short-term glycemic regulation. Available recreational activities¹¹ contribute opportunities for development and application of practical diabetes self-management skills in real-life contexts. For most participants, the amount and intensity of physical activity are greater than their at-home routines supply. Distances of 1/8 to 1/4 mile between venues for programmed events (eg, dining room, swimming pool, hotel) require unavoidable frequent walking, but the schedule also provides for optional individual and group physical activities, such as swimming.

The nature of recreational physical activities available relies on the self-directed learning philosophy and takes into account reports that "traditional competitive activities may thwart opportunities for autonomy support, and leader-centered instruction [at] camp may not be the most effective approach to working with [children and] adolescents with diabetes."³

Target BG Range

BG levels of 71 to 99 mg/dL constitute the campers' target glycemic range, during both absorptive and postabsorptive states. Serum glucose concentrations in children and adolescents who do not have DM are known to be tightly restricted to these levels.^{15,16} Their range, previously disclosed to participants and their parents as an informational and educational strategy, is used at the camp to benchmark overall diabetes self-management efforts and understanding.

Normoglycemia, defined as a BG level of 71 to 99 mg/dL, is a target range that denotes glycemia typical of persons who do not have any form of DM or impaired glucose metabolism antecedent to the development of DM.¹⁷ Although ranges of 80 to 180 mg/dL or 80 to 200 mg/dL are

Table I. Typical meal buffet at Campamento Diabetes Safari.

Breakfast	Eggs, bacon, sautéed cactus leaves, green salsa, jalapeño peppers, 120 mL of "light" drinkable yogurt (Danone de México, Mexico City, Mexico)
Lunch	Vegetable soup, smoked pork chop with melted cheese, salmon salad, lettuce/tomato/cucumber slices, sugar-free gelatin with unsweetened coconut and whipped cream sweetened with aspartame
Dinner	Lentil soup, unbreaded chicken nuggets, grilled asparagus spears, green salad, full-fat salad dressings, green salsa, mixed nuts

sometimes recommended and used for children and adolescents who have type 1 DM, the upper limits of these ranges are not optimal in terms of the prevention of long-term diabetic complications. Neither are they “normal” with respect to individuals who do not have dysfunctional glucose metabolism. Chronic or frequent hyperglycemia at or near the upper limits of those ranges may not adequately protect or ensure children’s normal physiologic growth and performance.

BG levels lower than the inferior limit of normoglycemia (71 mg/dL) may be legitimately considered hypoglycemic. Criteria used to classify a specific BG value as hypoglycemic are either: (1) biochemical (≤ 55 mg/dL; a documented SMBG of ≤ 50 mg/dL reflects pathologic biochemical hypoglycemia)¹⁸; (2) clinical (defined by the presence of symptoms of hypoglycemia, regardless of concurrent BG value); or (3) therapeutic (applied mainly in a setting of type 1 DM to signal the need for immediate measures [ie, glucose], both to raise BG to ~ 99 mg/dL and to prevent further BG decline should previously injected rapid-acting or ultra-rapid-acting insulin remain active). At the camp, therapeutic hypoglycemia often points to the advisability of reviewing insulin dosages, as well as the quantity and quality of foods eaten and the amount of physical activity undertaken, to limit or prevent future hypoglycemic episodes. BG levels of ≤ 70 mg/dL defined therapeutic hypoglycemia in this study.

The BG of 71 mg/dL used at camp as the lowest normal value is slightly greater than the most benign therapeutic definition (≤ 69 mg/dL) of hypoglycemia.¹⁹ A recent study of 303 nonobese Mexican children (< 6 years of age) without DM revealed a mean fasting BG level of 74.08 mg/dL; $> 67\%$ of these children had fasting BG values < 80 mg/dL.¹⁶

Compared with regular and intermediate insulins, lispro (the ultra-rapid-acting insulin analogue used at the camp) greatly abbreviates the time period of acute hypoglycemic risk. Likewise, compared with human neutral protamine Hagedorn (NPH) insulin, once-daily injections of insulin glargine (the basal insulin analogue used in this study) further reduce the risk of hypoglycemia and cause significantly fewer hypoglycemic episodes, particularly during the night.²⁰ To reverse any hypoglycemia without overcorrection and subsequent rebound hyperglycemia, campers learn to distinguish between treating documented or suspected hypoglycemia and treating its lingering symptoms.

For this study, the upper limit of fasting normoglycemia was 99 mg/dL, inasmuch as a fasting BG level of 100 to 125 mg/dL on 2 separate occasions triggers the diagnosis of dysfunctional glucose metabolism classified officially as prediabetes or impaired fasting glucose tolerance, which is not “normal.”²¹

Compared with regular and intermediate insulins, lispro (the ultra-rapid-acting insulin analogue used at the camp) greatly abbreviates the time period of acute hypoglycemic risk.

An arbitrary value of 130 mg/dL defined the lower threshold of hyperglycemia.²² The American Diabetes Association defines *peak postprandial hyperglycemia* as < 180 mg/dL,²¹ and the International Diabetes Federation designates the cutoff point as 140 mg/dL.^{23,24} Recent studies have shown these to be BG levels that a “normal” healthy person, child or adult, never attains.^{25,26}

The frequency of campers’ SMBG corresponded with their self-determined efforts to initiate timely and sufficient prevention and treatment of both hypoglycemia and hyperglycemia. If young people with type 1 DM choose to learn and apply the principles useful in maintaining BG levels defined as normal or near-normal during camp, fewer and less intense long-range diabetic complications of chronic hyperglycemia may be forthcoming.⁹

Initial and final A1C values were not measured at the camp because 3 days of glycemic control—at any BG level—is not expected, nor have been reported, to produce significant changes. In general, improved A1C levels “have not been consistently demonstrated” after attendance at diabetes camps.⁸

Glycemic Variability

Interday glycemic instability was assessed by comparison of mean daily BG levels. Intraday glycemic variability was appraised by eMAGE scores and SDs. Continuous glucose monitoring systems (CGMSs) provide data more suited to the calculation of true eMAGE scores than those supplied by periodic finger-stick measurements. Because CGMSs were not available for precise and repeated BG monitoring, the finger-stick values were used to compute the eMAGE.

Although glycemic instability produces considerable oxidative stress,²⁷ tied to risk for diabetic complications, data from the Diabetes Control and Complications Trial reveal that intraday BG variability, which is lower in persons without diabetes than in persons with diabetes,²⁸ has an insignificant influence on the development or progression of diabetic retinopathy and nephropathy.²⁹ McCarter et al³⁰ noted that the SD of BG values is a similarly minor contributor to or predictor of A1C levels.

However, measures of glycemic variability remain sensitive indicators of the potential for hypoglycemia. When mean BG is lowered without reducing glycemic instability, the incidence of hypoglycemia increases. Lowering both daily mean BG and glycemic variability together reduces the probability of biochemical hypoglycemia,³¹ which is a risk factor for hypoglycemic unawareness and severe hypoglycemia in children and adolescents.³²

Higher eMAGE scores reflect higher glycemic instability³³ and greater risk of hyperglycemia. These scores³⁴ are independent of mean glycemia and quantify intraday BG instability by measuring the amplitude of the day’s largest known BG excursions. In the present study, eMAGE scores of 0 to 95 substantiated stable glycemic control of type 1 DM. Scores > 95 were taken as indicative of excessive intraday glycemic variability.

Measures of glycemic variability remain sensitive indicators of potential hypoglycemia.

Data Collection

The data for this study came from documented SMBG values manually downloaded from the individual camper's BG meter (Optium XCEED blood glucose/ketone monitor; Abbott Laboratories, Abbott Park, Illinois) supplied without charge to each camper, for their use during and after attendance at the camp. After supervised hands-on instruction in the use of the meters, campers drew all their own blood samples.

Statistical Analysis

No statistical package was used for analysis. A scientific calculator was used to determine means and SDs, and to perform the unpaired *t* test analyses of the significance of differences between means.

RESULTS

Six boys and 3 girls (aged 8–17 years; mean [SD] age, 11.8 [2.6] years; mean duration of diabetes, 1.62 [0.88] years) registered for camp and agreed to participate in the study. Demographic characteristics of the campers and glycemic parameters are provided in **Table II**. All but 1 of the campers were preadolescents. Mean BG levels on arrival and departure were 209 (101.5) and 81 (12.8) mg/dL, respectively ($P < 0.003$).

Of the 9 campers, 5 had attended their first diabetes camp (at Campamento Diabetes Safari 2005) 1 year earlier and 4 had never attended any diabetes camp. Socioeconomic status, parental education levels, and previous severe adverse events (diabetic ketoacidosis and severe hypoglycemia) were not evaluated. No camper nor any staff member with type 1 DM used an insulin pump, although its use was not grounds for exclusion from the camp.

No camper had been diagnosed with a learning disability, mental retardation, cystic fibrosis, or HIV infection. Pubertal status was not charted or evaluated, and body mass index was not measured, although no camper was observed to be obese.

Although the quality and quantity of education sought from staff members differed among the campers, there was no effort to standardize or measure these factors. Neither was the time each staff person spent with individual campers structured or limited. Campers' perception of a scarcity of individual attention and system resources was unlikely, given that during waking hours they spent all their time together and that the staff-to-camper ratio was 1:1.5.

No BG data were missing or lost; each camper's BG meter contained the results of all of his or her glucose measurements, which were generally corroborated with the BG values recorded on paper by staff members present at the time of measurement. In precamp testing and calibration of

the meters, no instrument failed or produced results inconsistent with the parameters published by the manufacturer for the low, medium, and high control solutions used for calibration. Laboratory analyses of blood specimens were not available.

Results of this 3-day study suggested that a brief combination of the 4 pillars of type 1 DM treatment (insulin analogues, diet, physical activity, and diabetologic education) contributed to reductions in mean glycemic values and variability of glucose levels in this small sample of children and adolescents with brief previous exposure (0.58–2.58 years) to diabetes self-management principles. No significant differences were observed between the sexes in mean BG levels on arrival at the camp (boys, 214 mg/dL; girls, 198 mg/dL), 3-day mean glycemic values (boys, 88 mg/dL; girls, 108 mg/dL), or mean insulin requirements (basal: 15.83 and 18.67 units for boys and girls, respectively; bolus: 4.33 and 4.33 units, respectively).

All participants were using lispro for prandial or bolus insulin therapy at the start of camp; 7 of the 9 campers arrived using a glargine-lispro basal-bolus insulin regimen. The 2 remaining campers (11-year-old males) (**Table II**, campers E and F) switched from twice-a-day human NPH insulin to once-a-day glargine as the basal component of their insulin regimen, with written informed consent by their parents. The initial dose of glargine was estimated, according to the manufacturer's recommendation, as the total of ≥ 2 daily doses of NPH minus 20%. Daily titration of the initial glargine dose was not done, in part because both boys' daily mean (68–108 mg/dL) and 3-day mean (73–99 mg/dL) BG values stayed largely within the target range.

For all campers, the effective average total daily dose of glargine and lispro insulin analogues was 20.61 units, of which basal insulin doses represented 81% (16.78 units) and preprandial or bolus insulin doses represented 19% (3.83 units). Accepted standard basal-bolus insulin proportions ranged from 60/40 to 50/50 to 30/70, although the suitable ratio was adapted individually and varied with age, body weight, physical activity, insulin sensitivity, SMBG values, and food choices.³⁴ Basal-bolus ratios may require modification, especially when food choices and plans contain reduced quantities of concentrated CHOs (eg, <50–100 g of CHOs per day).

Preprandial doses of lispro sufficient to maintain postprandial euglycemia ranged from 0 to 3 units, with a mean preprandial dose of 1.41 units. In comparison with their reported habitual doses, all participants required less prandial insulin at the camp than at home.

Daily and 3-day BG profiles were analyzed for glycemic variability by using mean (SD) daily BG levels and eMAGE scores. The single BG measurement taken on arrival was excluded from statistical calculation of the subsequent 3-day values. This single arrival value represented a random sampling of immediate glycemic status, reported without classification as pre- or postprandial. The initial value may or may not be indicative of campers' typical medium- or long-term BG control. The measurement served chiefly as a prag-

Table II. Campers' demographic characteristics and glycemic parameters.

Camper	A	B	C	D	E	F	G	H	I	Mean (SD)	
Age, sex	8, M	9, M	9, F	10, M	11, M	11, M	12, M	12, F	17, F	11.8 (2.6)	
Arrival BG*	230	296	176	330	66	267	97	315	104	209.0 (101.5)	
Day 1 BG values*†	(n = 9) 103 46 82 72 60 96 133 66	(n = 10) 175 47 103 82 89 66 92 85 64	(n = 10) 111 54 101 84 63 61 109 82 93	(n = 14) 105 51 91 78 52 76 92 70 69 89 56 59 75	(n = 10) 55 61 69 59 81 66 67 81 73	(n = 10) 74 62 65 75 66 94 141 74 65	(n = 9) 86 85 83 58 85 82 72 80	(n = 6) 249 113 63 86 191	(n = 16) 118 232 263 179 167 179 217 165 121 118 170 186 166 58 61 66	(n = 11) 106 152 137 113 95 44 95 84 85 79 92	
Day 2 BG values*	(n = 14) 195 42 143 46 87 96 112 175 69 146 136 99 136 79	(n = 17) 58 99 108 162 182 121 40 84 54 52 80 93 92 58 133 57 97	(n = 13) 103 98 117 256 150 67 87 80 68 44 47 62 58	(n = 18) 67 48 173 82 50 78 68 90 125 93 76 36 84 83 71 52 67 70	(n = 16) 78 82 77 68 78 79 74 83 68 75 46 84 60 65 77 71	(n = 18) 131 172 215 47 92 94 45 71 111 151 162 145 95 81 89 88 61 95	(n = 12) 72 58 164 64 73 78 82 74 95 72 76 88	(n = 16) 118 232 263 179 167 179 217 165 121 118 170 186 166 58 61 66	(n = 11) 106 152 137 113 95 44 95 84 85 79 92		

(continued)

Table II (continued).

Camper	A	B	C	D	E	F	G	H	I	Mean (SD)
Day 3 BG values*	(n = 12)	(n = 6)	(n = 6)	(n = 9)	(n = 8)	(n = 9)	(n = 7)	(n = 10)	(n = 8)	
	33	63	86	84	64	58	148	124	70	
	29	110	46	57	64	113	48	105	90	
	46	123	90	72	86	67	112	164	94	
	217	116	90	59	90	63	88	169	95	
	194	236	113	178	92	110	99	148	90	
	92	96	70	53	86	221	78	143	100	
	100			85	76	125	88	156	79	
	91			50	89	45		162	70	
	64			64		98		117		
	60							69		
	50									
	84									
Departure (preprandial) BG*	84	96	70	64	89	98	88	69	70	81.0 (12.8)
Total SMBG readings	35	33	29	41	34	37	28	32	28	33.0 (4.4)
SMBG ≤50 mg/dL†	7	2	3	4	1	3	1	0	2	2.6 (2.1)
SMBG ≥130 mg/dL†	9	5	2	2	0	9	2	18	2	5.4 (5.7)
Daily mean BG values*†	82 (27.7)	89 (36.4)	84 (21.2)	74 (16.9)	68 (9.1)	80 (25.0)	79 (9.5)	140 (77.6)	78 (24.9)	94.0 (21.8)
	112 (45.9)	92 (39.8)	95 (56.8)	79 (30.9)	73 (9.8)	108 (45.9)	83 (27.3)	154 (60.1)	98 (29.0)	
	88 (59.6)	124 (58.8)	83 (22.6)	78 (39.6)	81 (11.5)	100 (53.4)	94 (30.8)	136.0 (31.8)	86 (11.6)	
3-Day mean BG value*†	96.0 (48.4)	97.0 (43.4)	89.0 (41.2)	77.0 (28.8)	73.0 (10.8)	99.0 (44.2)	85.0 (24.4)	146.0 (54.7)	89.0 (24.5)	95.0 (21.2)
Daily eMAGE scores*	46.6 (14.5)	92.0 (50.9)	44.8 (12.7)	31.3 (12.2)	15.3 (5.0)	47.3 (19.5)	20.7 (9.3)	120.5 (21.9)	0	66.0 (40.0)
	93.4 (32.4)	59.0 (16.8)	109.3 (28.1)	57.6 (36.2)	21.3 (10.9)	89.0 (68.4)	103.0 (4.2)	102.0 (15.9)	49.3 (2.9)	
	136.5 (48.8)	130.0 (14.1)	37.5 (9.8)	122.0 (4.2)	17.5 (6.4)	85.5 (24.0)	82.0 (25.5)	50.7 (7.4)	20.5 (0.7)	
3-Day eMAGE score*	92.2 (45.0)	93.7 (35.5)	63.9 (39.5)	70.3 (46.7)	18.0 (3.0)	73.9 (23.1)	68.6 (42.8)	91.1 (36.2)	23.3 (24.8)	66.5 (28.1)

BG = blood glucose; SMBG = self-monitored blood glucose; eMAGE = estimated mean amplitude of glycemic excursion.

*BG values in mg/dL.

†Not including arrival BG value.

matic point of entry for supervised real-life, self-directed manipulation of random glycemic levels. The resulting diabetes education, centered on understanding options for modification of random abnormal BG values,³⁵ was both individual and collective.

The mean (SD) arrival BG for the 9 campers was 209 (101.5) mg/dL; at the end of the 3-day study, their mean departure BG was 81 (12.8) mg/dL ($t = 4.23$; $P < 0.003$). The participants' mean daily BG values ranged from 68 (9.1) to 154 (60.1) mg/dL. The SDs of the mean daily BG levels ranged from 9.1 to 77.6 mg/dL; the SDs of the mean 3-day BG ranged from 10.8 to 54.7 mg/dL.

For the individual campers, daily eMAGE scores ranged from 0.0 to 136.5; the global daily mean (SD) eMAGE score was 66 (40.0). The 3-day mean eMAGE score for all campers was 66.5 (28.1), with a range of 18.0 to 93.7. All mean 3-day eMAGE values thus met the study's criterion (≤ 95) for rapidly achieved stable glycemic control of type 1 DM.

Campers experienced both hyperglycemia and hypoglycemia during the 3-day study. Of the 288 SMBG values obtained during the study (not including the 9 arrival values), 49 (17%) were hyperglycemic and 23 (8%) were hypoglycemic. None of the campers developed ketoacidosis. No episodes of severe hypoglycemia involving seizure or coma occurred. Applying the criterion of ≤ 50 mg/dL for pathologic biochemical hypoglycemia, the mean (SD) incidence of individual hypoglycemic values (44 [5.3] mg/dL) was 7.5%. No association was observed between frequency or intensity of physical activity and severe hypoglycemia, with or without seizure or loss of consciousness.

No association was observed between frequency or intensity of physical activity and severe hypoglycemia.

The opportune use of partial, single, or several 4-g glucose tablets, with the subsequent addition of combined CHOs/protein/fat (250 mL "light" yogurt or 1–3 tablespoons of peanut butter), quickly returned mild and moderate hypoglycemic BG values to the target range, generally without evidence of overcorrection. Each gram of oral glucose raised BG by ~ 5 mg/dL. Two instances (Table II, campers A and D) of severe, other-treated hypoglycemia (≤ 36 mg/dL) occurred without convulsions or loss of consciousness but required larger CHO intake to revert than did episodes of hypoglycemia in the 70- to 40-mg/dL range.

To encourage ad libitum SMBG, campers received an unquestioned, unlimited number of reactive test strips for the measurement of BG and blood ketones. Daily (6–18 times; mean [SD], 11 [4.4]) and 3-day total (28–41 times; mean, 33 [4.4]) ad libitum SMBG ranged widely in self-determined frequency. The individual frequencies of SMBG

are reported in Table II. Precamp SMBG frequencies are not known. The staff did not express, encourage, or stipulate any minimum or optimal number of times for daytime SMBG. Self-monitoring decisions were made by the campers themselves. However, twice each night (1:30 AM and 4:30 AM), the staff did monitor each camper's BG, with the camper's prior verbal permission and assent.

The variation in SMBG frequency during camp reflected individual judgment and behavioral choice, and may confirm the report³⁶ that furnishing BG reagent strips ad libitum, even without other clinical interventions, increases SMBG frequency and improves glycemic control, and that these effects show no attenuation over a 12-month period. For all campers, the self-determined frequency of SMBG detected and allowed prevention of further glycemic decline in a total of ~ 56 potential episodes of biochemical hypoglycemia.

The foods offered in the meal buffets, as well as for any necessary between-meal snacks, were sources of little or no concentrated CHOs. CHO consumption at or between meals was not measured with precision; estimated intake was 15 to 35 g per meal or < 100 g per day.

Before meals, campers surveyed the items in the buffet, chose the foods and quantities that they would consume, and decided whether they foresaw the desire for "seconds." The staff then asked individually for each camper's best calculation, based on personal experience and judgment, of the ultra-rapid-acting insulin dose suitable for the consumption anticipated. Prandial insulin doses were thus calculated before each meal; there were no set or standing prandial ultra-rapid insulin doses. Campers' thoughtful, independent preprandial dose decisions were rarely miscalculated to the point of requiring alteration by the staff.

Blood ketones were monitored for all 3 occurrences of BG > 240 mg/dL (Table II, campers C and H); the results were negative. No camper showed evidence of ketosis originating in insulin insufficiency or in glucose excess or deprivation.

On the final day of camp, 89% of parents attended an optional 1 1/2-hour dialogue with the managing director, who fielded the parents' questions, debriefed them, and reviewed their role as adult supervisors and health-care team partners responsible for assuring the age-appropriate transfer of diabetes self-care responsibilities to their sons and daughters.³⁷

DISCUSSION

Within a brief period, children and adolescents with type 1 DM are able to use the self-directed learning paradigm, their own wits and experience, and peer and professional education and consultation to successfully achieve and maintain BG values within a normal range of 71 to 99 mg/dL. The availability of a relatively nondemanding social context, psychological support, and diabetes expertise provides learning and tools useful in the pursuit of euglycemia and normoglycemic stability.

In this study, the beneficial context for glycemic normalization and stability encompassed self-directed diabetes learning opportunities, for which the campers contributed the curriculum, professional consultation addressing acute needs and currently operative interests, utilization of basal-bolus insulin analogue therapy, availability of foods with little or no CHO content, ad libitum physical activity and SMBG, and free access to all BG testing supplies in unrestricted quantities.

The unique context of this international DM camp allowed departure from standard professional- and parent-centered teachings about diabetes management. With respect to insulin regimen, a diet low in concentrated CHOs, and ad libitum SMBG, the camp experience is broadly adaptable for daily self-care of type 1 DM at home and school. By following self-directed learning methods and with professional consultation, elements of the camp protocol may be safely tailored to individual or family use. As is evident from the data in **Table II**, even with mean euglycemia and reduced instability of glycemic values, the risk of hypoglycemia is not totally eliminated. Of the 288 BG measurements obtained during the 3-day study, 23 (8%) were in the hypoglycemic range.

The study's limitations included: (1) the small number of subjects (the 1:1.5 ratio of staff to campers ensured sufficient time and personalized attention to consolidate application of lessons learned; the staff could not work effectively and individually with a larger number of campers); (2) the short duration of the study (the duration was coordinated with the official school calendar, which permitted absence from classes on official holidays); and (3) the absence of postcamp follow-up (a prohibitively expensive and unreliable undertaking, given the distribution of campers' residences over 6 geographically distant parts of the Mexican Republic).

In this camp setting, access to insulin syringes with 1/2-unit markings is indispensable. Syringes with 1-unit markings were used, but a 1/2-unit or 1/4-unit dose was often warranted. A large percentage of the hypoglycemic episodes reported were due to participants' technical inabil-

ity to deliver, with precision, minute doses of prandial or complementary U100 lispro insulin. Dilution of lispro with "Sterile Diluent for Humalog, Humulin N, Humulin 50/50, Humulin 70/30, or NPH Iletin" (Eli Lilly and Company, Indianapolis, Indiana) can reduce the concentration to U50 (1:2) or U10 (1:10), thereby permitting exact dosing when only standard insulin syringes marked in 1-unit increments are available. In subsequent years at the camp,³⁸ insulin syringes with 1/2-unit markings were made available by the manufacturer (Becton Dickinson de México, Mexico City, Mexico) to improve dosing precision.

Seven of the 9 campers (78%) returned to the camp the following year (2007).

CONCLUSIONS

Combining self-directed educational methods for learning diabetes self-management with insulin analogues as basal-bolus therapy, ad libitum physical activity and SMBG, and a diet low in concentrated CHOs, campers rapidly established routinely normal mean daily BG levels and glycemic stability.

ACKNOWLEDGMENTS

The author thanks Abbott Laboratories (Mexico City, Mexico), sanofi-aventis (Mexico City, Mexico), Eli Lilly and Company (Mexico City, Mexico), Danone de México (Mexico City, Mexico), Becton Dickinson de México (Mexico City, Mexico), and Soñar Despierto Foundation (Garza García, Mexico) for their generous material and technical support for Campamento Diabetes Safari. The author is grateful to Kathy Garrett, Barbara and Brian Splan, Nancy and Kenneth Marks, Estela García, and other individual donors for their financing for the camp and this study, and to Dr. Janet McGill for editorial guidance.

The author holds stock from Eli Lilly and Company and sanofi-aventis U.S. LLC. No institution provided financial support for this study or for preparation of the manuscript.

REFERENCES

1. Gunasekera H, Ambler G. Safety and efficacy of blood glucose management practices at a diabetes camp. *J Paediatr Child Health*. 2006;42:643-648.
2. Couch R, Jetha M, Dryden DM, et al. Diabetes education for children with type 1 diabetes mellitus and their families. www.ahrq.gov/downloads/pub/evidence/pdf/diabetesed/diabetesed.pdf. Accessed June 15, 2009.
3. Ramsing R, Hill E. How camps can help adolescents self-manage diabetes: Research. *Camping Magazine*. January 1, 2007. www.accessmylibrary.com/coms2/summary_0286-31797020_ITM. Accessed June 15, 2009.
4. Hill E, Sibthorp J. Autonomy support at diabetes camp: A self determination theory approach to therapeutic recreation. *National Recreation and Park Association*. www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=20063223277. Accessed June 15, 2009.
5. Winkley K, Ismail K, Landau S, Eisler I. Psychological interventions to improve glycaemic control in patients with type 1 diabetes: Systematic review and meta-analysis of randomised controlled trials. *BMJ*. 2006;333:65.
6. Cheung R, Young Cureton V, Canham DL. Quality of life in adolescents with type 1 diabetes who participate in diabetes camp. *J Sch Nurs*. 2006;22:53-58.
7. Karagüzel G, Bircan İ, Erişir S, Bundak R. Metabolic control and educational status in children with type 1 diabetes: Effects of a summer camp and intensive insulin treatment. *Acta Diabetol*. 2005;42:156-161.
8. Wang YC, Stewart S, Tuli E, White P. Improved glycemic control in adolescents with type 1 diabetes mellitus who attend diabetes camp. *Pediatr Diabetes*. 2008;9:29-34.
9. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in

- insulin-dependent diabetes mellitus. *N Engl J Med*. 1993; 329:977–986.
10. Saleh M, Grunberger G. Hypoglycemia: An excuse for poor glycemic control? *Clin Diabetes*. 2001;19:161–167.
 11. Campamento Diabetes Safari: Program 2006. www.continents.com/diabetes-safariinformation06.htm. Accessed June 15, 2009.
 12. Bernstein RK. *Dr. Bernstein's Diabetes Solution: The Complete Guide to Achieving Normal Blood Sugars*. New York, NY: Little, Brown and Co; 2007:102.
 13. Deci EL, Ryan RM. Self-determination theory: An approach to human motivation and personality. 2004. www.psych.rochester.edu/SDT/theory.php. Accessed June 15, 2009.
 14. Harkavy J, Johnson SB, Silverstein J, et al. Who learns what at diabetes summer camp. *J Pediatr Psychol*. 1983;8:143–153.
 15. Mauras N, Beck R, Ruedy K, et al, for the Diabetes Research in Children Network (DirecNet) Study Group. The physiological variations of plasma glucose concentrations in healthy, non-diabetic children: Use of continuous glucose sensors. 2003. <http://public.direc.net/slides/MaurasNonDiabeticSPR2003Presented5-5-03.ppt>. Accessed June 15, 2009.
 16. De Loach S. What are typical or "normal" fasting blood glucose (BG) levels among non-obese Mexican children from 1-5 years of age, who do not have diabetes mellitus (DM)? 2009. www.diabeteshealth.com/media/images/article_images/DeLoach_Study.pdf. Accessed June 15, 2009.
 17. Horton ES. What is the normal range for blood sugar levels, and what blood sugar level constitutes a true emergency? *ABC News*. January 1, 2008. http://abcnews.go.com/health/diabetes_screening/story?id=3812946. Accessed June 15, 2009.
 18. Rizza, RA, Service, FJ. Hypoglycemia/pancreatic islet cell disorders. In: Goldman L, Bennett JC, eds. *Cecil Textbook of Medicine*. 21st ed. Philadelphia, Pa: Saunders; 2000:1285–1292.
 19. Pérez Pastén E. Guía para el educador en diabetes [Guide for the diabetes educator]. México, D.F.: Soluciones Gráficas; 1997.
 20. Rosenstock J, Dailey G, Massi-Benedetti M, et al. Reduced hypoglycemia risk with insulin glargine: A meta-analysis comparing insulin glargine with human NPH insulin in type 2 diabetes. *Diabetes Care*. 2005;28:950–955.
 21. American Diabetes Association. Standards of medical care in diabetes—2009. *Diabetes Care*. 2009;32(Suppl 1):S13–S61.
 22. Ito C, Maeda R, Ishida S, et al. Importance of OGTT for diagnosing diabetes mellitus based on prevalence and incidence of retinopathy. *Diabetes Res Clin Pract*. 2000;49:181–186.
 23. Ceriello A, Colagiuri S, Gerich J, Tuomilehto J, for the Guideline Development Group. Guideline for management of postmeal glucose. *Nutr Metab Cardiovasc Dis*. 2008;18:S17–S33.
 24. Ceriello A, Colagiuri S. International Diabetes Federation guideline for management of postmeal glucose: A review of recommendations. *Diabet Med*. 2008;25:1151–1156.
 25. Mazze RS, Strock E, Wesley D, et al. Characterizing glucose exposure for individuals with normal glucose tolerance using continuous glucose monitoring and ambulatory glucose profile analysis. *Diabetes Technol Ther*. 2008;10:149–159.
 26. Ceriello A. Postprandial hyperglycemia and cardiovascular disease: Is the HEART2D study the answer? *Diabetes Care*. 2009; 32:521–522.
 27. Monnier L, Mas E, Ginet C, et al. Activation of oxidative stress by acute glucose fluctuations compared with sustained chronic hyperglycemia in patients with type 2 diabetes. *JAMA*. 2006; 295:1681–1687.
 28. Kessler L, Passemard R, Oberholzer J, et al, for the GRAGIL Group. Reduction of blood glucose variability in type 1 diabetic patients treated by pancreatic islet transplantation: Interest of continuous glucose monitoring. *Diabetes Care*. 2002;25:2256–2262.
 29. Kilpatrick ES, Rigby AS, Atkin SL. The effect of glucose variability on the risk of microvascular complications in type 1 diabetes. *Diabetes Care*. 2006;29:1486–1490.
 30. McCarter RJ, Hempe JM, Chalew SA. Mean blood glucose and biological variation have greater influence on HbA1c levels than glucose instability: An analysis of data from the Diabetes Control and Complications Trial. *Diabetes Care*. 2006;29:352–355.
 31. Saudek CD. Pumps: Hopes and expectations. In: FDA/NIH Joint Symposium on Diabetes: Targeting safe and effective prevention and treatment. Bethesda, Md: National Institutes of Health; 2004: 20–21.
 32. Bolli GB. Glucose variability and complications. *Diabetes Care*. 2006;29:1707–1709.
 33. Service FJ, O'Brien PC, Rizza RA. Measurements of glucose control. *Diabetes Care*. 1987;10:225–237.
 34. Service FJ, Molnar GD, Rosevear JW, et al. Mean amplitude of glycaemic excursions, a measure of diabetic instability. *Diabetes*. 1970;19:644–655.
 35. King AB, Armstrong DU. Basal bolus dosing: A clinical experience. *Curr Diabetes Rev*. 2005;1:215–220.
 36. Nyomba BL, Berard L, Murphy LJ. Facilitating access to glucometer reagents increases blood glucose self-monitoring frequency and improves glycaemic control: A prospective study in insulin-treated diabetic patients. *Diabet Med*. 2004;21:129–135.
 37. De Loach S. You can't push the river—self-directed education at diabetes camp in Mexico. 2008. www.diabeteshealth.com/read/2008/10/06/5934/you-cant-push-the-river-self-directed-education-at-diabetes-camp-in-mexico. Accessed June 15, 2009.
 38. Campamento Diabetes Safari program. 2009. www.diabetes-safari.com. Accessed June 15, 2009.

Address correspondence to: Dr. Stan De Loach, Apartado Postal 20 Bis, Colonia Centro, 06002 México 1, Distrito Federal, México. E-mail: saludo@usa.net