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Perspectives in Practice

A Comparison of Structured Education Programs for Pediatric Patients With Type 1 Diabetes: Multiple Daily Injection Therapy Delivered by Group Workshop vs. Self-Study Course

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Key Messages

- Self-study courses can be used in lieu of group workshops for effectively delivering the multiple daily injection (MDI) therapy curriculum to youth with type 1 diabetes without compromising glycemic control.
- A self-study course format provides youth with type 1 diabetes and their caregivers equitable access to structured education programs on MDI therapy, from which they may have previously been precluded due to geographic or financial barriers when only group workshops were offered.

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Introduction

The Diabetes Control and Complications Trial and Epidemiology of Diabetes Interventions and Complications Study demonstrated that intensive insulin therapy improves glycemic control, compared to conventional therapy, and reduces the risk for diabetes-related long-term microvascular complications (1–3). Diabetes Canada Clinical Practice Guidelines state that children with type 1 diabetes can adopt basal-bolus therapy, a form of intensive diabetes management, to meet glycemic targets (4). Basal-bolus insulin therapy, which can be delivered as multiple daily injections (MDIs), is a type of insulin regimen that uses a long-acting insulin analogue once or twice daily and a rapid-acting insulin analogue with meals and snacks. The MDI regimen requires carbohydrate counting to calculate the prandial rapid-acting insulin dose using insulin-to-carbohydrate ratios. Additional calculations address hyperglycemia and preempt activity-related hypoglycemia.

Structured type 1 diabetes education programs are based on the philosophy that education and support of self-management skills influence glycemic outcomes (5,6). According to the National Institute for Health and Care Excellence (Department of Health, United Kingdom), structured education programs should include a written curriculum, a patient-centered philosophy, trained educators, quality assurance and audits (7). Among adults with type 1 diabetes, training in flexible, intensive insulin management can improve quality of life, reduce hypoglycemia and diabetic ketoacidosis, improve glycemic control and reduce health-care costs (8–11). A handful of randomized controlled trials involving pediatric patients with type 1 diabetes have studied the effects of structured education courses, but the results have been more modest. The Kids in Control of Food (KICk-OFF) program was offered to youth with type 1 diabetes using MDI therapy and included a curriculum dealing with carbohydrate counting, insulin adjustment and management of hypoglycemia and ketosis. The KICk-OFF program was compared to usual care across 31 pediatric centres in the United Kingdom in a randomized trial. Those with the highest baseline glycated hemoglobin (A1C) levels showed improved levels at 2 years compared with the control group but, overall, no differences in A1C levels between the groups were shown at 2 years (12).

Developmentally appropriate education encourages problem solving and self-management skills in pediatric patients and caregivers to reduce the risk for severe hypoglycemia and ketosis (13,14). Structured education programs for flexible insulin therapies

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are typically delivered through group workshops (GWs) over 4 to 5 consecutive days, but families experience lost days from school and work and incur travel expenses (7–10,12,15). The Families, Adolescents and Children Teamwork Study was a randomized trial comparing a diabetes self-management education program consisting of 6 monthly 90-minute group sessions with conventional care (15). The authors reported that 30.4% of the intervention arm did not attend any sessions, and only 47.5% attended 4 or more sessions, precluding effective delivery of the curriculum.

The Stollery Children's Hospital Pediatric Diabetes Education Centre (PDEC), University of Alberta, Edmonton, Canada, initially provided MDI therapy to pediatric patients with type 1 diabetes and their families during in-person structured education GWs. However, waiting lists developed, and patients experienced barriers due to family, work and activity commitments. To surmount these barriers, certified diabetes educators (CDEs) developed a self-study course (SSC) based on the GW education material. There is limited information about the effectiveness of in-person vs. self-study learning tools to educate youth with type 1 diabetes and their families about MDI therapy. The aims of this article are 2-fold: to describe the design and implementation of an MDI curriculum by traditional GW compared to SSC; and to compare the effectiveness of the GW to SSC.

Methods

The PDEC follows approximately 1,000 pediatric patients with type 1 diabetes from central and northern Alberta, northeastern British Columbia and Northwest Territories. Youth and their caregivers who participated in MDI therapy structured education programs by GW or SSC between January 1, 2010, and December 31, 2015, were included in this study. All patients initially took a split-mixed insulin regimen injected 2 or 3 times per day using intermediate-acting and rapid-acting insulins. Youth and/or caregivers who could not read or comprehend English, had learning disabilities or had low motivation (i.e. precontemplative or contemplative) were not eligible for the GW or SSC and received 1-on-1 teaching with a CDE. The study was approved by the University of Alberta Human Research Ethics Board.

The GW was a hospital-based outpatient education program limited to 4 classes per year due to staffing and clinic space availability. Workshops were conducted between January 2010 and August 2011. Information was provided outlining the pros and cons of MDI therapy, and an assessment was completed of the youth's goals in changing to MDI therapy. CDEs (RN and RD) delivered 6 h of education over 2 days, using lectures, handouts and a quiz/food record, for a maximum of 8 youth and their caregivers. Comprehension was assessed by using worksheets, and the workshop was considered complete when the youth and caregivers attended both days of education.

In November 2011, CDEs developed a pediatric-focused curriculum based on the GW content. Information was divided into chapters and presented through PowerPoint slides and workbooks that were e-mailed to or printed for the youth and caregivers. Youth were expected to complete the SSC on their own time to allow individualized pacing. Caregivers were requested to complete the SSC to promote in-home educational support, but exceptions were made for adolescents transitioning to adult care. The workbooks focused on critical thinking, assessed literacy and numeracy skills and required participants to apply learning. These objectives were actualized by answering nearly 70 questions (true/false, short-answer, fill-in-the-blank). Participants commented that it was possible to complete the entire SSC in fewer than 3 h. Completed workbooks were returned in person or by e-mail or mail, and a CDE contacted families to clarify incorrect concepts. The SSC underwent 3 revisions based on feedback from families and staff (SSC 1 through 4). The educational curriculum was considered to be complete when the workbook was finished in full. Table 1 lists the topics in the GW and the content changes for SSC 1 through 4.

The study design was a retrospective chart review of PDEC patients who participated in a structured education program about MDI insulin therapy. Information regarding gender, age at diagnosis, duration of diabetes and A1C levels were collected at the initiation of MDI therapy. The curricular format was noted for each youth, including whether the youth, the caregiver or both

Table 1
Comparison of educational topics presented through either group workshop or self-study course

Group workshop	SSC-4 (final version)	Modifications made to older SSC versions
Taught from January 2010 to August 2011 Application package: goal for changing to MDI therapy, MDI basics: insulin action, injection technique review Nutrition review: carbohydrate counting knowledge assessment Recordkeeping: how to record blood glucose, carbohydrate amounts, insulin doses and activity	Used from August 2013 to December 2015 MDI basics: insulin action, injection technique review and patient goal for changing to MDI therapy Nutrition review: carbohydrate counting knowledge assessment Recordkeeping: how to record blood glucose, carbohydrate amounts, insulin doses and activity	SSC-1, used from November 2011 to May 2012 Additional content included • Sample recordkeeping sheet in the Appendices • Dot plot graph exercise in insulin adjustments section • Alcohol guidelines • Glucagon review • Worksheet on being prepared for the first clinic visit about MDI therapy: records to bring, review of trends in blood glucose control, areas of focus/questions/concerns
Insulin dose calculations: I:C ratios, hypo- and hyperglycemia management	Insulin dose calculations: I:C ratios, hypo- and hyperglycemia management	SSC-2, used from February 2012 to January 2013 Additional included content: • Same as SSC-1
Sick-day guidelines Activity management Insulin adjustments Alcohol guidelines	Sick-day guidelines: ketone management, insulin dosing/timing Activity management for planned and spontaneous activities Insulin adjustments Content removed: • Same as SSC-3	SSC-3, used from December 2012 to February 2014 Content changes*: • Recordkeeping sheet moved from Appendices into the body of the recordkeeping chapter • Dot plot graph exercise removed from insulin adjustment section • Alcohol guidelines removed • Glucagon review removed • Worksheet on being prepared for the next clinic visit removed

I:C, insulin-to-carb ratios; *MDI*, Multiple daily injection; *SSC*, self-study course.

* These items were removed because content was deemed redundant (dot plot graph, clinic visit prep sheet), no longer applied to the wider age range of patients starting MDI in SSC-3 and -4 (alcohol guidelines), or were determined to be better suited for in-person discussion with hands-on demonstrations (glucagon).

participated in the educational program. The effectiveness of the curricular formats was determined by analyzing 1) completion rates, 2) accessibility and 3) A1C levels. Completion rates were measured by determining the rates of attendance at the GWs and the rates, scores and times to completion for the SSCs. The postal code for the PDEC (T6G 1C9) and the residential postal codes for the patients at the time of initiation of MDI therapy were entered into the Canada Route Planner and Canada Mileage Calculator program (driving-distances.com/canada-route-planner-mileage.php) to determine driving distances.

All patients had baseline A1C levels tested within 3 months of starting MDI therapy; however, not all patients subsequently had timely A1C levels tested, reflecting the reality of clinical practice. Therefore, we looked at the A1C levels of the patients as a group for the 18 months subsequent to starting MDI therapy. We found natural breakpoints in the data, so we categorized the follow-up A1C levels according to the time frames in which they were performed: date 1 (1.5 to 4.5 months); date 2 (4.5 to 7.5 months); date 3 (7.5 to 10.5 months); date 4 (10.5 to 13.5 months); date 5 (13.5 to 16.5 months); and date 6 (16.5 to 19.5 months). Hospital laboratory A1C levels were measured by ion exchange chromatography on the BioRad Variant II (January 2010 through October 2010) or the BioRad Variant II Turbo 2.0 (November 2010 to end of 2015) (Bio-Rad Laboratories, Hercules, California, United States). Point-of-care capillary A1C measurements (Siemens DCS Vantage; Siemens, Munich, Germany) were performed as part of routine clinical care and were measured by the DCA Systems Hemoglobin A1C Reagent Kit (Siemens) following the standard operating procedure.

Categorical variables were analyzed and are presented as frequencies. Continuous variables are expressed as medians with ranges. All statistical analyses were performed using SPSS, v. 25 (IBM, Armonk, New York, United States).

Results

There were 170 patients who started MDI therapy through either GWs (n=25) or SSCs (n=145). There were no differences between those who participated in GWs and those who completed SSCs with respect to gender, age at diagnosis, age at MDI start, duration of diabetes at MDI start or baseline A1C levels (Table 2).

The completion rates for the GWs and SSCs were as follows: 24/25 (96%) GWs; 8/8 (100%) SSC-1; 19/22 (86%) SSC-2; 22/25 (88%) SSC-3; and 73/90 (81%) SSC-4. The median time for SSC completion was 1.25 months. Families had the option of completing the workbook together or individually; the average parent score was 92%; the average youth score was 89%. When families decided to complete the SSC individually, many times the parents did not; completion rates for children or adolescents was 91% vs. 74% for parents. The number of MDI starts increased from 1.3 patients per month with GW to 3.2 patients per month by SSC-4.

A major difference between the groups was the distance between their homes and the PDEC. The median distance for the GW group was 16 km compared to 38 km for the combined SSC groups and 81.5 km for the SSC-4 group. Only 16% of the participants in the GW group lived more than 100 km away compared to more than 40% in the SSC group.

Median A1C levels preceding initiation of MDI therapy were similar in both groups (8.9% compared to 8.5%, GW vs. SSC, respectively). In general, A1C levels appeared to improve within the first half year after changing to MDI therapy (Table 2). Subsequent to starting MDI, there were no major differences in A1C levels between those who had learned about MDI by participating in GW compared to those who had done the SSC.

Discussion

The results of this study demonstrate that an SSC can be used in lieu of GW to effectively deliver the MDI therapy curriculum to youth with type 1 diabetes and their caregivers. The completion rate for the SSC was 84% compared to 96% for GWs, with 91% of the youth completing the SSC independently (compared to 74% of parents), indicating that the SSC format engages youth. We also did not observe a major deterioration in glycemic control by changing

Table 2
Demographic and clinical characteristics of youth with type 1 diabetes participating in either the multiple daily injection therapy group workshop or the self-study course

	Group workshop	Self-study courses				
		All	SSC-1	SSC-2	SSC-3	SSC-4
Number (N=170)	25	145	8	22	25	90
Male gender, n (%)	14 (56.0)	78 (53.8)	5 (62.5)	16 (72.7)	13 (52.0)	44 (48.9)
Age at diagnosis (years)	10.3 (1.2–16.0)	10.3 (0.7–16.8)	11.5 (9.1–16.8)	12.3 (0.7–15.6)	12.0 (1.1–16.6)	9.2 (0.8–16.5)
Age at MDI start (years)	14.5 (8.2–17.5)	15 (2.7–17.9)	14.8 (12.0–17.9)	15.6 (12.5–17.3)	14.8 (3.9–17.1)	14.9 (2.7–17.7)
Duration of diabetes at MDI start (years)	2.8 (0–13.5)	3.5 (0–16.1)	2.9 (0.1–6.3)	3.0 (0–15.7)	3.2 (0–13.2)	4.3 (0–16.1)
Distance between home and PDEC (km)	16.0 (4–362)	38.0 (1–1037)	29.0 (9–995)	24.5 (1–676)	29.0 (4–516)	81.5 (7–1037)
Number (%) who lived >100 km away from PDEC	4 (16.0)	59 (40.7)	3 (37.5)	5 (22.7)	9 (36.0)	43 (47.3)
A1C at MDI start (%)	8.9 (7.4–11.4)	8.5 (5.0–14.0)	9.7 (9.1–11.2)	8.6 (6.3–11.3)	8.3 (6.3–14.0)	8.3 (5.0–13.1)
Date 1, 1.5 to 4.5 months	8.3 (6.4–12.2) n*=7	7.6 (5.9–14.0) n=70	8.6 (6.0–10.6) n=6	7.9 (6.8–10.4) n=10	7.4 (6.0–8.6) n=9	7.4 (5.9–14.0) n=45
Date 2, 4.5 to 7.5 months	8.2 (6.0–12.0) n=22	7.9 (5.2–14.0) n=107	8.5 (8.3–9.9) n=3	8.0 (7.2–10.2) n=18	7.0 (5.2–11.4) n=21	8.3 (5.5–14.0) n=65
Date 3, 7.5 to 10.5 months	7.8 (7.0–9.5) n=8	7.9 (6.0–13.0) n=68	8.8 (8.0–10.0) n=3	7.8 (6.5–13.2) n=12	7.0 (6.3–10.9) n=13	8.3 (6.0–11.2) n=40
Date 4, 10.5 to 13.5 months	8.2 (5.5–9.9) n=11	8.4 (5.7–13.1) n=75	9.4 (8.9–10.6) n=4	9.6 (6.6–13.1) n=9	7.6 (5.7–11.7) n=14	8.2 (6.5–12.7) n=48
Date 5, 13.5 to 16.5 months	8.4 (6.9–10.1) n=8	8.0 (6.7–14.0) n=27	9.7 (8.9–11.3) n=3	8.6 (7.7–10.5) n=4	8.0 (6.7–8.0) n=6	8.3 (6.7–14.0) n=14
Date 6, 16.5 to 19.5 months	8.3 (6.6–10.6) n=9	8.3 (6.2–14.0) n=32	11.3 (11.3–11.3) n=1	8.3 (7.0–11.5) n=5	8.0 (7.6–10.2) n=4	8.1 (6.2–14.0) n=22

A1C, glycated hemoglobin; *MDI*, multiple daily injection; *PDEC*, Pediatric Diabetes Education Centre; *SSC*, self-study course.
Note: Median and range shown unless otherwise indicated.
* Within each cell, the number (n) who had A1C results available during that time interval is shown.

from the GW to the SSC format. We were able to increase the uptake of MDI therapy at our centre (1.3 MDI starts per month before the SSC compared to 3.2 afterwards). Moreover, we were able to support MDI therapy initiation among youth with type 1 diabetes from more geographically distant areas by the fourth version of the SSC (16% compared to 47% living more than 100 km from the centre).

The MDI therapy SSC arose from limited clinical space and staffing availability, long waiting times between workshops and geographical barriers. A recent systematic review identified multiple reasons for poor uptake of structured diabetes education programs: timing of programs, limited time, family and work conflicts, limited finances (for parking, overnight stays) and negative feelings toward group-based programs (16). The SSC allowed for individualized pacing and could be rolled out throughout the year. In addition, it facilitated more personalized assessment of learning gaps and needs than did the GWs. Diabetes educators were able to focus their time on addressing specific questions or misconceptions rather than delivering general principles. Offering SSCs instead of GWs promotes equitable education for those in remote locations.

We recognize certain limitations of our study. The GWs and the SSCs were conducted in series and not offered simultaneously, which would have permitted more direct comparisons of the curricular methods. The lengths of time over which completion rates were calculated for the 2 curricular formats were also not the same. Although the SSCs permitted individual and flexible pacing, it also resulted in a longer time to completion of the curriculum compared to GWs. In addition, though we encouraged youth with type 1 diabetes to check their A1C levels every 3 months, in clinical practice, not all are adherent to this recommendation. Some of the A1C data subsequent to MDI initiation are missing or were not done at regular intervals. We cannot attribute causality to the curricular method and A1C levels because many variables that affect glycemic control (hypoglycemia, missed insulin boluses) were not tracked. Participants who learned about MDI therapy through the GWs or SSCs were a select group who were motivated to improve their glycemic control and complete the curriculum. Individuals who could not speak or read English, did not count carbohydrates, struggled with numeracy or literacy or lacked motivation were not offered the SSC.

In conclusion, the delivery of a curriculum teaching principles of MDI therapy can be accomplished through a structured SSC. This curricular format should be strongly considered to improve accessibility for pediatric patients with type 1 diabetes and their caregivers who live in more geographically distant or remote areas of Canada.

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Author Contributions

KJ and ER conceptualized the study; GW developed and modified all self-study programs and collected the data; KJ, GW and ER conducted the data analysis; KJ and ER drafted the manuscript; all authors reviewed and edited iterations of the manuscript and approved the final draft.

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