FEATURE ARTICLE

Continuous Glucose Monitoring in Young Adults With Type 1 Diabetes: Impact on Hypoglycemia Confidence and Fear

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BACKGROUND | Fear of hypoglycemia in people with type 1 diabetes has a detrimental effect on glycemic control and quality of life. The association between continuous glucose monitoring (CGM) and hypoglycemia confidence and fear has not previously been assessed in the young adult population.

METHODS | This was a prospective cohort study using questionnaires to assess the impact of CGM on hypoglycemia confidence (using the Hypoglycemia Confidence Scale [HCS]) and hypoglycemia fear (using the Hypoglycemia Fear Survey II [HFS]) in 40 young adults with a preexisting diagnosis of type 1 diabetes.

RESULTS | Scores on the HCS were greater at baseline for those with a longer duration of diabetes. Participants with higher general anxiety scores on the Generalized Anxiety Disorder 7-item scale had higher hypoglycemia fear at baseline (total score and worry component, but not behavior component of the HFS). Between baseline and follow-up, HCS scores increased on average by 0.2 (95% CI 0.1–0.4, $P = 0.01$) on a scale of 1–4. HFS scores decreased by 1.8 (95% CI −3.0 to −0.5, $P = 0.006$) on a scale of 0–24 for the worry component and by 2.5 (95% CI −4.4 to −0.6, $P = 0.01$) on a scale of 0–44 for total (worry + behavior components). At follow up, 83% of participants planned to continue using CGM all or most of the time. There was a very high self-reported effect of CGM on life with diabetes (median 8.0 [interquartile range 6.5–10.0], where 10 indicated a very big difference).

CONCLUSION | Hypoglycemia confidence and fear improve with CGM use in young adults.

Fear of hypoglycemia in people with type 1 diabetes has a detrimental effect on glycemic control and quality of life (1). In the pediatric setting, a significant reduction in hypoglycemia fear was evident for both parents and children using a single-question Likert-scale item before and after use of continuous glucose monitoring (CGM) (2). The association between CGM and hypoglycemia confidence and fear has not been assessed previously in the young adult population.

The aims of this study were to determine whether hypoglycemia confidence or fear at baseline were associated with participant characteristics; whether there were changes in hypoglycemia confidence or fear after implementation of CGM; if there were changes, whether they differed by participant characteristics; what proportion of participants planned to continue to use CGM at the conclusion of the study; what participants liked and disliked about CGM; and whether they thought CGM made a difference to their life with diabetes.

Research Design and Methods

Background

The study took place at a tertiary diabetes center accredited by the Australian National Association of Diabetes Centres.

In Australia, federally funded CGM was recently made available under the National Diabetes Subsidy Scheme (NDSS) for people <21 years of age with type 1 diabetes

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who had either frequent significant hypoglycemia, impaired awareness of hypoglycemia, or significant fear of hypoglycemia (3).

Recruitment and Inclusion Criteria

Young adults aged 16–20 years with type 1 diabetes attending our center between November 2017 and February 2019 were eligible for the study if they had not previously used CGM, met NDSS eligibility criteria for federally funded CGM (3), and elected to start CGM through our center.

All participants gave written informed consent. This study was approved by the Human Research Ethics Committee (HREC/18/MHS/2).

Intervention

Study participants attended two 2-hour group CGM education sessions with diabetes nurse educators. Participants were started on CGM and asked to return for routine monitoring. Regular input from a clinician was available to identify and troubleshoot problems.

Outcomes

The primary outcomes were hypoglycemia confidence and hypoglycemia fear as measured by the hypoglycemia confidence scale (HCS) (4) and the short form of the hypoglycemia fear survey II (HFS) (5), respectively. The HCS and HFS were completed at the first CGM training session and again ~6 months later.

The HCS was developed to evaluate a distinct element of a person's experience in insulin-using diabetes, independent of hypoglycemia fear. It was conceptualized as encompassing the belief that one can "stay safe" from serious problems from hypoglycemia and thus measures people's ability to do what they want to while managing their risk of hypoglycemia. Construct validity has been established, and the HCS has been found to be valid across a wide range of ages and has had consistent results independent of age (4).

The HFS was developed to assess the level of fear of hypoglycemia among people with diabetes. The 11-item HFS short form used in this study matches the structure of the HFS long form (a three-factor model comprised of worries related to hypoglycemia, behaviors related to avoiding hypoglycemia and its negative consequences, and behaviors related to maintaining high blood glucose to prevent hypoglycemia, including those in the 16- to 20-year age-group), while maintaining internal reliability. The two forms are highly correlated (5,6).

Secondary outcomes were results at follow-up of a short in-house survey of what participants liked and disliked about using CGM, the effect CGM had on their life with diabetes, and how often they planned to use CGM in the future (see Supplementary Material).

Participants additionally completed the Generalized Anxiety Disorder 7-item scale (GAD-7) because it was thought that hypoglycemia confidence and fear were likely to be associated with general anxiety levels (7).

Statistical Methods

Associations between the HCS, HFS total score (HFS-T), and HFS subscales for worry (HFS-W) and behavior (HFS-B) at baseline and participant characteristics, including sex, age, level of education (did not complete school vs. completed grade 12 vs. attending university), duration of diabetes, and level of anxiety (GAD-7 score) were estimated using univariable linear regression. Paired *t* tests were used to estimate change between baseline and follow-up for the HCS, HFS-T, HFS-W, and HFS-B scales. Associations between change in HCS and HFS from baseline to follow-up and participant characteristics were estimated using linear regression adjusted for baseline values.

All analyses were performed using Stata, v. 15.1, statistical software (Stata Corp., College Station, TX). $P < 0.05$ was considered statistically significant throughout all inferential analyses.

Results

During the 15-month study period, of 129 young adults aged 16–20 years with type 1 diabetes who attended our center, 47 met inclusion criteria, and 41 provided consent and were enrolled in the study. Follow-up data were unavailable for one person; hence, results are based on 40 participants. All participants used a Dexcom G5 CGM system. The technology at the time of this study did not allow for integration of the CGM with insulin pump therapy. Baseline demographic and clinical characteristics and time to follow-up are summarized in Table 1.

Hypoglycemia Confidence and Fear at Baseline: Associations With Participant Characteristics

The mean HCS score at baseline was 3.2 (SD 0.5, on a scale of 1–4) and the mean HFS-T scare was 14.0 (SD 7.6, on a scale of 0–44; Table 2). HCS and HFS scores at baseline were not associated with sex, age, or level of education (Supplementary Material).

TABLE 1 Baseline Demographic and Clinical Characteristics and Time to Follow-Up for 40 Young Adults With Type 1 Diabetes Attending the Center from 2017 to 2019

	Value	Range
Age, years	18.9 ± 0.9	16.9–20.9
Female	23 (57)	–
Education		
Did not complete school	2 (5)	–
Grade 12	17 (43)	–
University	21 (53)	–
Method of insulin administration		
Multiple daily injections	29 (73)	–
Insulin pump therapy	11 (27)	–
Duration of diabetes, years	8.0 ± 4.6	0.3–17
A1C, mmol/mol*	77.1 ± 17.0	49–120
GAD-7 score†	3.5 (0.5–8.0)	0–21
Time to follow-up, months	7.5 (5.9–11.9)	4.6–21.4

Data are *n* (%) except for age, duration of diabetes, and A1C, which are mean ± SD, and GAD-7 score and time to follow-up, which are median (IQR) *A1C, %: 9.2 ± 3.7; range 6.6–13.1. †Scores on the GAD-7 range from 0 to 21, with higher scores indicating more anxiety.

On average, participants with a longer duration of diabetes had a higher HCS score at baseline (increase of 0.2 units per additional 5 years of diabetes duration, 95% CI 0.1–0.4, $P = 0.007$). Duration of diabetes was not associated with HFS score.

Participants with higher GAD-7 scores had higher HFS scores at baseline (HFS-T and HFS-W, but not HFS-B). On average, the HFS-T score was 2.8 units higher (95% CI 1.0–4.6, $P = 0.003$) and the HFS-W score was 2.1 units higher (95% CI 0.8–3.3, $P = 0.002$) for a GAD-7 score that was 5 units higher. GAD-7 was not associated with HCS score at baseline.

Change in Hypoglycemia Confidence and Fear From Baseline to Follow-Up

On average, the HCS score was higher and the HFS score (HFS-T and HFS-W, but not HFS-B) was lower at follow-up than at baseline (Table 2). Average changes were small but statistically significant. Change in HCS and HFS scores did not differ by sex, age, education level, duration of diabetes, or GAD-7 scores when adjusted for baseline values (Supplementary Material).

Additional Results at Follow-Up

At follow-up, 22 study participants (55%) reported that they planned to use CGM all of the time, while 11 (28%) planned to use it most of the time, 3 (8%) some of the time, and 4 (10%) never. The most common things people liked about using CGM were having knowledge of their blood glucose levels, feeling safer sleeping, and convenience. The most common things they disliked were cost, skin reactions, and having a bulky monitor attached. The median self-reported effect of CGM on life with diabetes was 8.0 (IQR 6.5–10.0), where 0 indicated no difference and 10 indicated a very big difference.

Discussion

Modest improvements in self-reported hypoglycemia confidence and hypoglycemia fear (HFS-T and HFS-W, but not HFS-B) were seen after CGM training and use in our sample of young adults. This is one of few surveys to investigate the impact of CGM on hypoglycemia fear and confidence using validated survey measures and the first study focused on the young adult population.

Similar baseline scores have been seen in adult populations (5,8,9). In the GOLD 3 study (8), 161 adults (≥18 years of age) were randomized to CGM or blood glucose monitoring (BGM) with a glucose meter. Participants randomized to CGM had modestly higher hypoglycemia confidence scores than those using BGM (3.4 vs. 3.27, $P < 0.001$). The HypoCOMPaSS (Comparison of Optimized MDI Versus Pumps With or Without Sensors in Severe Hypoglycemia) trial (9) assessed fear of hypoglycemia in adults (≥18 years of age) with impaired hypoglycemia awareness after 24 weeks of CGM or BGM. No difference in HFS II or its subsets of behavior and worry was seen between the CGM and BGM groups. The average GAD-7 score in our study is in keeping

TABLE 2 HCS, HFS-T, HFS-W, and HFS-B Scores at Baseline and After 5–21 Months of CGM in 40 Young Adults With Type 1 Diabetes

Outcome (Possible Score Range)	Baseline, mean ± SD	Follow-Up, mean ± SD	Difference, mean (95% CI)	*P**
HCS (1–4)†	3.2 ± 0.5	3.4 ± 0.5	0.2 (0.1–0.4)	0.01
HFS-T (0–44)‡	14.0 ± 7.6	11.5 ± 7.2	−2.5 (−4.4 to −0.6)	0.01
HFS-W (0–24)	8.2 ± 5.3	6.5 ± 4.7	−1.8 (−3.0 to −0.5)	0.006
HFS-B (0–20)	5.8 ± 3.6	5.0 ± 3.2	−0.7 (−1.9 to 0.4)	0.21

*Paired *t* tests. †Higher scores indicate higher confidence. ‡Higher scores indicate higher levels of fear.

with published literature reported for this age-group (6.0) (10).

Participants with a longer duration of diabetes reported higher hypoglycemia confidence at baseline, perhaps reflecting a level of expertise in management of diabetes that improves with duration of diabetes.

Ten percent of participants elected to discontinue CGM use soon after commencement, and, at follow-up, only 55% indicated their intention to continue using CGM at all times. This rate of uptake is in keeping with rates reported in the literature (11). Those reporting that they did not intend to ever use CGM all had either skin reactions or a particular aversion to wearing a bulky device. Similar reasons for discontinuation of CGM have been published for pediatric cohorts (12). At the time of the study, ongoing CGM use for people >21 years of age required self-funding, which may have been an impediment to ongoing sustained use.

Limitations

The exploratory nature of this study, its lack of a control group, and its small sample size limit the ability to draw strong conclusions. All participants met NDSS criteria. Additionally, participants chose to use CGM and to take part in the study. The NDSS criteria and self-selection meant that study participants were not representative of all young adults with diabetes. Additionally, several outcomes, including frequency of intended ongoing use of CGM, were self-reported.

Future Research

We found decreases from baseline and follow-up in both the HFS-W and HFS-B subscales of the HFS. However, the decrease in behavior was smaller and not statistically significant. The lack of statistical significance could reflect the small sample size or a true lack of effect. It is well understood that anxiety drives avoidance behavior (13). In clinical practice, we have observed that changes in emotion and cognition often precede changes in behavior. This may well explain the finding that hypoglycemia fear decreased, whereas behavior did not change. It may well be that young adults begin to feel less afraid of hypoglycemia and to worry less about losing control, but that changes to their actual behavior take longer to occur. For example, it may be that CGM allows people to worry less in distracting social situations, but that the act of administering insulin to treat hyperglycemia when socializing takes longer to adopt.

Further research could consider combining CGM with "exposure therapy," wherein people are helped to confront situations they habitually avoid, such as exercise or going to sleep with blood glucose levels <10 mmol/L (180 mg/dL). Such therapy may be particularly helpful in the subgroup with high baseline HFS-B scores.

It is noteworthy that 17% of the total sample chose not to adopt CGM after the study. Our experience is that young adults with diabetes often resent their illness for a variety of reasons. The illness itself is an imposition, but, in addition, many young people feel that they have been forced into adopting technology such as an insulin pump without being fully ready and that much of their medical care has happened to them rather than with them (i.e., collaboratively). It may be that a lingering sense of resentment partly explains their rejection of CGM. Further study on this is warranted.

Future studies could also assess whether newer CGM devices with a slimmer profile and integration with other technologies such as insulin pumps result in greater uptake.

Summary

Baseline hypoglycemia confidence was higher for young adults with a longer duration of diabetes, and baseline hypoglycemia fear was higher for those with higher general anxiety levels. There were modest improvements in self-reported hypoglycemia confidence and hypoglycemia fear (HFS-T and HFS-W, but not HFS-B) scores) after 5–21 months of CGM. The median self-reported effect of CGM on life with diabetes was 8.0 (IQR 6.5–10.0), where 0 indicated no difference and 10 indicated a very big difference. At follow-up, 33 of 40 participants (83%) planned to use CGM all or most of the time.

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DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

S.L.T., M.V., and A.H. designed the study. S.L.T., C.C., and M.V. administered surveys. S.L.T. and A.G. analyzed the data and principally wrote the manuscript, with writing contributions from H.L.B., C.C., M.V., and A.H. All authors read and approved the final manuscript. S.L.T. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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