



Increased bolus overrides and lower time in range: Insights into disordered eating revealed by insulin pump metrics and continuous glucose monitor data in Australian adolescents with type 1 diabetes

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ARTICLE INFO

Keywords:

Type 1 diabetes
Disordered eating behaviors
Eating disorders
Insulin pump
Continuous glucose monitor
Body mass index

ABSTRACT

Aims: To determine the prevalence of disordered eating behaviors (DEB) in a population of Australian adolescents with T1D and to investigate clinical parameters, insulin pump therapy (IPT) and continuous glucose monitor (CGM) data trends, and psychological attributes associated with DEB.

Methods: 50 participants (27 female, 23 male, average age 15.2 years, average duration of diabetes 6.2 years) were recruited. Diabetes Eating Problem Survey-Revised (DEPS-R) and Strengths and Difficulties Questionnaires were completed. Prevalence of disordered eating was reported, and associations with clinical parameters, insulin pump therapy (IPT) and continuous glucose monitor (CGM) metrics were assessed.

Results: Twenty-four participants (48 %) had an elevated DEPS-R score. Participants with elevated DEPS-R were more likely to be female (75 % vs 31.6 %, $p = 0.004$), have a higher HbA1c (8.2 %/67 mmol/mol vs. 6.9 %/51 mmol/mol, $p < 0.002$) and BMI Z-score (+1.28 SD vs +0.76 SD, $p = 0.040$). They had lower time in range, 3.9–10 mmol/L (50.3 % vs. 63.8 %, $p = 0.01$) and higher mean glucose (10.0 mmol/L vs. 8.3 mmol/L, $p = 0.005$). Of the 60 % using IPT, participants with elevated DEPS-R had increased meal bolus overrides (7.9 % vs 3.8 %, $p = 0.047$). Reported difficulties on SDQ were higher in the elevated DEPS-R group (18.3 vs 10.5, $p < 0.002$).

Conclusions: DEB are common in Australian adolescents with T1D and associated with increased dysglycemia. Diabetes technology cannot be solely relied upon for detection of DEB and there remains a need for routine screening.

1. Background

Disordered eating behaviors (DEB) are common in the population and predispose individuals to eating disorders (EDs).¹ Studies on the prevalence of DEB and ED in T1D have consistently shown increased prevalence in adolescents with T1D compared to age-matched controls across different countries and cultures.^{2–4} Eating disorders in type 1 diabetes are associated with significantly higher mortality than either condition occurring in isolation.⁵ DEB in T1D are associated with worse metabolic control,⁶ and higher risk of acute and chronic complications of T1D.⁷ DEB often emerge in adolescence, a time where individuals with T1D often experience worsening glycemia.⁸ Crucially, increased

dysglycemia in childhood and adolescence has been linked to higher rates of diabetes complications in adulthood, independent of subsequent control in adulthood.⁹

The prevalence of DEB in T1D varies based on the measure used and population studied. When diabetes-adapted screening measures are used, the rate of disordered eating in adolescents with T1D is 39.3 %, compared to 32.5 % in peers without T1D.² Data from the MILES study, the largest published cohort of Australian type 1 youth, described a self-reported rate of disordered eating of 38 % using a diabetes-adapted screening tool.¹⁰

The use of diabetes technologies - insulin pump therapy (IPT) and continuous glucose monitors (CGM) - have been demonstrated to

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improve glycemic outcomes^{11,12} and there has been widespread uptake in the last decade. As a result of diabetes technologies, the clinician has significantly more data available regarding patterns of insulin administration and glycemia throughout the day. Data on diabetes technology and DEB in adolescents remains limited. A systematic review published in 2021¹³ reported findings on associations of diabetes technology and DEB in T1D and suggested that greater flexibility of insulin administration in IPT may have clinical benefits in DEB. Importantly however, conclusions were based on scarce empirical evidence and the need for further research was highlighted. No studies to date have demonstrated patterns of IPT management behaviors that are associated with DEB.

The purpose of the current study is to address a knowledge gap in DEB and T1D by determining what IPT and CGM data are associated with DEB in T1D. Our primary aims were to a) determine the rate of DEB in a population of Australian youth with T1D, and b) determine the IPT management behaviors and CGM metrics associated with DEB. A secondary aim was to determine the psychological attributes associated with DEB in T1D.

2. Subjects, materials and methods

2.1. Participants and procedures

Adolescents aged 12.0–17.9 years with T1D diagnosed at least 1 year attending the John Hunter Children's Hospital (JHCH) diabetes clinic, Newcastle, Australia, were eligible for enrolment. A duration of diabetes of 1 year was selected to avoid the potential confounding variables of fluctuation in weight and change in eating habits associated with newly diagnosed diabetes. Participants were excluded if there was significant medical or psychological illness (e.g. psychosis, major depressive disorder interfering with ability to perform activities of daily living). Participants were approached for inclusion in the study at routine outpatient visits. All adolescents were eligible regardless of insulin regime or CGM use. Informed parental consent and adolescent assent were obtained for all participants. Ethics approval was granted by the Hunter New England Human Research Ethics Committee (Reference No. 2020/ETH02197).

2.2. Measures

Two questionnaires were administered to the adolescents: The Diabetes Eating Problems Survey - Revised (DEPS-R),¹⁴ and the Strengths and Difficulties Questionnaire - Youth (SDQ-Y).¹⁵ Primary caregivers completed the Strengths and Difficulties Questionnaire - Parent (SDQ-P).¹⁵

The Diabetes Eating Problem Survey - Revised (DEPS-R) is a 16-item screening tool for disordered eating behaviors in people with T1D. It has shown to be a reliable and valid tool for screening for DEB and ED in adolescents with T1D.¹⁶ The responses are scored on a 6-point Likert scale. A score of 20 or more is reflective of clinically significant disordered eating pathology.

The Strengths and Difficulties Questionnaire (SDQ) is a behavioral screening questionnaire that is a reliable and valid tool used to assess young people's behaviors, emotions and relationships.¹⁵ The questionnaire includes youth-reported and parent-reported scales in five domains: emotional problems, conduct problems, hyperactivity, peer problems, prosocial and an impact score that rates overall distress and impairment. It has cross-cultural validity and validated scoring that has been shown to accurately reflect the level of severity of psychopathology in young people.¹⁷

Demographic and clinical data were obtained from the medical record including: Age, sex, Aboriginal or Torres Strait Islander status, duration of diabetes, BMI, BMI Z-score, Change in BMI Z-score over the preceding 12 months, insulin therapy type (MDI or IPT), total daily insulin dose (Units/kg). Postcodes were used to derive socioeconomic status measured by the Socioeconomic Indexes for Areas (SEIFA) Index

of Disadvantage Score.¹⁸

Hospital presentation data were collected from the electronic medical record. Presentations to emergency departments in the local health district were screened and categorized into presentations for diabetic ketoacidosis, severe hypoglycemia and planned diabetes stabilization admissions. Utilization of health services outside the local health district were unable to be captured.

IPT data were collected from online data sources for the 14 days prior to questionnaire completion. IPT data included: use of hybrid closed loop system, total daily insulin dose, average basal insulin per day, average bolus insulin per day, average number of boluses per day, number of basal rate suspensions, and percentage of calculated bolus doses overridden by user. CGM downloads for the 14 days prior to survey completion were collected.

2.3. Sample size

The objective of the study was to estimate the rate of disordered eating in a population of adolescents with T1D attending a tertiary center to within a precision of $\pm 14\%$. Assuming a disordered eating rate of 35%, a sample size of 50 participants was selected to give a 95% confidence interval (using the Clopper-Pearson method) with the desired precision.

2.4. Outcomes and statistical analysis

The primary outcome is the prevalence of disordered eating as defined by DEPS-R score ≥ 20 . Secondary outcomes are the association between disordered eating and IPT and CGM metrics, and clinical data. Data were analyzed using STATA version 13.1 for Windows. Differences between the groups were determined using Student's *T*-Test for continuous variables and Chi-Squared Test for categorical variables. The relative risk, its standard error and 95% confidence interval were calculated according to the formula outlined by Altman.¹⁹

CGM data were analyzed using STATA software to derive time in ranges and episodes of hypoglycemia. An international consensus statement on reporting CGM data in clinical studies was used to determine CGM data eligibility and endpoints for the study.²⁰ Sensor wear time was reported for all participants who used CGM; hypoglycemia episodes and time in ranges were only reported if $>70\%$ of readings over 14 days were available. An episode of hypoglycemia was reported if a blood glucose level below 3.0 mmol/L (54 mg/dL) was recorded lasting 15 min or more. Time in ranges reported were: Time in range (3.9–10.0 mmol/L, 70–180 mg/dL), time below range (<3.9 mmol/L, <70 mg/dL), time in hypoglycemia, level 2 (<3.0 mmol/L, <54 mg/dL), time above range (>10 mmol/L, >180 mg/dL), and time in hyperglycemia, level 2 (>13.9 mmol/L, >250 mg/dL).

3. Results

A total of 166 patients were identified as eligible for the study. Of those, 54 families were approached for inclusion in the study between May 2022 and March 2023 and 50 participants were recruited. Four participants declined to be in the study. Baseline demographics of the study cohort compared to the clinic population are presented in Table 1. The study cohort was representative of the clinic population in regards to age, sex, BMI, duration of diabetes and method of insulin administration. The average age of the study cohort was 15.1 (range 12–17.5) years, and 54% were female (23 male, 27 female). The average duration of diabetes was 7.5 ± 3.3 years. The average HbA1c was $7.5\% \pm 1.6$ (58.6 mmol/mol ± 17.4). Of the 30 participants (60%) using IPT, 12 participants (24%) used IPT without sensor augmentation, 7 participants (14%) used a sensor augmented (low glucose suspend) system, and 11 participants (22%) used a hybrid closed loop system (Tandem t:slim Control IQ = 1, Medtronic 780G = 2, Medtronic 770G = 6, Medtronic 670G = 2). Seventy-two percent used CGM ($n = 36$). No

Table 1

Comparison of baseline characteristics between study cohort and clinic population aged 12-17 yrs.

Category	Study cohort (n = 50) Mean (SD) or n (%)	Clinic population (n = 166) Mean (SD) or n (%)
Age, years	15.2 (1.4)	16.1 (1.7)
Female	27 (54 %)	88 (53 %)
Diabetes duration, years	6.2 (3.4)	7.8 (3.7)
BMI, kg/m ²	25.5 (5.9)	23.8 (5.0)
HbA1c (mmol/mol)	58.6 (17.4)	57 (13)
CGM use	36 (72 %)	84 (51 %)
IPT use	30 (60 %)	91 (55 %)
Manual mode	12 (24 %)	48 (29 %)
Low glucose suspend	7 (14 %)	14 (8 %)
Hybrid closed loop	11 (22 %)	29 (17 %)

participants in the study had a previous diagnosis of an eating disorder.

Analysis of the study cohort by DEPS-R score is presented in **Table 2**. Twenty-four participants (48.0 %, 95 % CI 33.7–62.6 %) had an elevated DEPS-R score of 20 or greater. Participants with elevated DEPS-R score were more likely to be female (75 % in the elevated DEPS-R group vs. 31.6 % in the non-elevated DEPS-R group, relative risk 2.56, 95 % CI 1.22–5.34, *p* = 0.004). There was no difference in Aboriginal or Torres Strait Islander Status or socioeconomic status between the groups.

HbA1c was significantly higher in the elevated DEPS-R group (8.2 %/67 mmol/mol vs. 6.9 %/51 mmol/mol, *p* < 0.002). As shown in **Fig. 1**, DEPS-R score was strongly correlated with HbA1c (*R* = 0.643, *p* < 0.001). Average BMI Z-score was significantly higher in the elevated DEPS-R group (+1.28 SD vs +0.76 SD, *p* = 0.040). There was no significant difference in change in BMI Z-score over 12 months between the groups (+0.37 SD vs. +0.28, *p* = 0.066).

Table 2

Comparison of baseline characteristics between groups. DEPS-R = Disordered Eating Problem Survey-Revised, RR = relative risk, ATSI = Aboriginal or Torres Strait Islander, IPT = insulin pump therapy, CGM = continuous glucose monitor, BMI = body mass index, SD = standard deviation.

Category	DEPS-R < 20 (n = 26) Mean (SD) or n (%)	DEPS-R ≥ 20 (n = 24) Mean (SD) or n (%)	<i>P</i> Value	RR (95 % CI)	χ ²
Age, years	15.1 (1.4)	15.2 (1.6)	0.366		
Female	9 (34.6 %)	18 (75 %)	0.004	2.56 (1.22–5.34)	8.2
ATSI	2 (7.7 %)	4 (16.7 %)	0.3		1.0
Diabetes duration, years	5.6 (2.9)	6.9 (3.7)	0.087		
BMI Z-Score	0.76 (1.0)	1.28 (1.1)	0.040		
Change in BMI score over preceding 12 months	+0.28 (0.3)	+0.37 (0.5)	0.066		
IPT use	17 (65 %)	13 (54 %)	0.419		0.7
Manual mode	4 (15 %)	8 (33 %)			
Low glucose suspend	6 (23 %)	1 (4 %)			
Hybrid closed loop	7 (27 %)	4 (17 %)			
CGM use	21 (80.8 %)	15 (62.5 %)	0.151		2.1
Daily insulin per kg, units	0.89 (0.3)	0.88 (0.3)	0.466		
Basal insulin, % of daily insulin	38.6 %	38.7 %	0.490		
HbA1c, IFCC	6.86 (0.9)	8.24 (1.8)	0.001		
Hba1c, mmol/mol	51.3 (10.3)	66.6 (20.2)	0.001		
Hospital presentations	4	10			
Severe hypoglycemia	2	1			
DKA	0	2			
Diabetes stabilization	0	7			

Bold indicates statistically significant (*p* < 0.05).

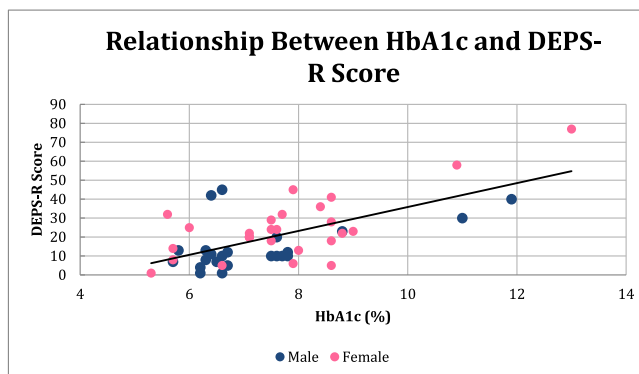


Fig. 1. Relationship between HbA1c (IFCC) and DEPS-R score.

The elevated DEPS-R group had more presentations to hospital than the non-elevated group (10 presentations vs 4). Two episodes of DKA occurred in the elevated DEPS-R group, while none occurred in the non-elevated group. Seven admissions for stabilization of diabetes occurred in the elevated DEPS-R group, while none occurred in the non-elevated group. Presentations for hypoglycemia were similar between the elevated and non-elevated DEPS-R groups (1 vs 2).

CGM and IPT data are presented in **Table 3**. CGM use was lower in the elevated DEPS-R group, however this did not reach statistical significance (62.5 % vs. 80.8 %, *p* = 0.151). For those that used CGM, percentage of sensor wear time was not different across the groups (74.5 % vs. 74.0 %, *p* = 0.477). Individuals in the elevated DEPS-R group had a significantly lower time in range (49.0 % vs. 68.1 %, *p* = 0.001) and higher average glucose (9.9 mmol/L vs. 8.3 mmol/L, *p* = 0.019). Glucose standard deviation was slightly higher in the elevated DEPS-R group, but this did not reach statistical significance (3.5 mmol/L vs. 2.9 mmol/L, *p* = 0.062). Individuals in the elevated DEPS-R group had significantly higher time above range (47 % vs 28 %, *p* = 0.001) and time in level 2 hyperglycemia (23 % vs 10 %, *p* = 0.001). Time below range and

Table 3

Comparison of IPT and CGM metrics between groups. IPT = insulin pump therapy, CGM = continuous glucose monitor, DEPS-R = Disordered Eating Problem Survey-Revised, SD = standard deviation.

Parameter	DEPS-R < 20 (CGM n = 17, IPT n = 17)	DEPS-R ≥ 20 (CGM n = 10, IPT n = 13)	<i>P</i> Value
IPT			
Number of times basal insulin is manually suspended	1.1 (2.2)	4.7 (8.1)	0.059
% Pump suggested boluses overridden by the user	3.8 % (4.8 %)	7.9 % (6.9 %)	0.047
Average number of boluses per day	5.8 (2.2)	5.0 (2.5)	0.203
Average carbohydrates entered per day, grams (SD)	227.5 (81.6)	206.6 (180.0)	0.345
Variability of carbohydrates entered per day, grams (SD)	98.1 (49.6)	97.3 (111.1)	0.491
CGM			
Time in range, 3.9–10.0 mmol/L (SD)	68.1 % (9.3 %)	49.0 % (18.3 %)	0.001
Time above range, > 10.0 mmol/L (SD)	28.0 % (10.8 %)	47.3 % (19.4 %)	0.001
Time above range, >13.9 mmol/L (SD)	9.5 % (7.3 %)	22.9 % (18.5 %)	0.001
% Time below range, < 3.9 mmol/L (SD)	3.9 % (2.8 %)	3.7 % (2.5 %)	0.446
% Time below range, < 3.0 mmol/L (SD)	0.7 % (0.6 %)	1.0 % (0.9 %)	0.171
Sensor wear time (SD)	74.0 % (27.2 %)	74.5 % (24.2 %)	0.477
Average glucose, mmol/L (SD)	8.3 (1.2)	9.9 (2.6)	0.005
Glycaemic variability (mmol/L)	2.9 (0.9)	3.5 (1.3)	0.062

Bold indicates statistically significant (*p* < 0.05).

episodes of hypoglycemia did not differ between the groups.

There was no difference in the percentage of participants using IPT between the elevated DEPS-R and non-elevated DEPS-R groups (65.4 % vs. 50.0 %, $p = 0.419$). There was also no difference between HCL use between the groups (23.1 % vs 25 %, $p = 0.843$). One-quarter of each group used a hybrid closed loop system. Participants in the elevated DEPS-R group had a higher percentage of meal bolus overrides (7.9 % vs 3.8 %, $p = 0.047$). There was no difference in grams of carbohydrates entered per day (206.6 g vs. 227.5 g, $p = 0.345$), standard deviation of carbohydrates (97.3 g vs. 98.1 g, $p = 0.491$) or the number of boluses administered per day (5.02 vs. 5.77, $p = 0.2$) between the two groups.

SDQ scores are presented in Table 4. Youth SDQ scores showed significantly higher youth perceived difficulties in the elevated DEPS-R group. The mean total difficulties score was higher in the elevated DEPS-R group (18.3 vs 10.5, $p < 0.002$). The greatest difference was seen in the emotional problems domain (average score 5.9 vs. 2.7, $p < 0.002$). Prosocial behavior scores were similar between the groups. Parental SDQ scores also showed significantly elevated total difficulties in the elevated DEPS-R group compared to the non-elevated group (average score 15.5 vs.10.1, $p = 0.003$). Parent scores showed higher perceived difficulties in emotional symptoms and peer problems.

4. Discussion

To our knowledge, this is the first study to report IPT metrics associated with DEB in a cohort of adolescents with T1D. A novel finding of our research is that pump recommended meal bolus doses were somewhat more likely to be overridden by those with disordered eating (7.9 % vs 3.8 %). Interestingly, the amount of carbohydrate entered into the pump, standard deviation of carbohydrate, number of boluses per day and number of manual pump suspends were similar between the groups. This suggests that carbohydrate restriction and skipping meals were not a common detectable sign of disordered eating using IPT metrics in this cohort. In a published case report,²¹ frequent boluses administered over a short period of time served as an indication for the presence of binge eating disorder that was subsequently diagnosed in an adolescent with T1D. This finding was not present to a detectable degree in our cohort, however subanalysis of eating disorder subtype and IPT metrics may reveal additional clinically relevant associations.

While concerns have been raised that IPT may increase the ability to manipulate insulin delivery in DEB,²² there is conflicting evidence on the rates of DEB among IPT and MDI users. In support of our findings,

many studies show no difference in rates of DEB between IPT and MDI users.^{23,24} A number of studies have demonstrated higher rates of DEB in MDI compared to IPT.^{6,25} In their synthesis of the existing literature, Priesterroth et al. concluded that there was no evidence that IPT facilitates insulin manipulation.¹³ We conclude that any method of insulin administration can be used to manipulate insulin for weight concerns. Further research is required to understand the benefits and drawbacks of IPT in DEB and ED.

DEB was associated with suboptimal glycemic control in our cohort, demonstrated by elevated average HbA1c and elevated average CGM glucose. Associations between CGM metrics and DEB have been reported in two studies of adults^{26,27} and one study of adolescents.²⁸ Similar to this study's findings, a study of 90 youth with T1D showed that higher DEPS-R scores were associated with higher mean sensor glucose although not standard deviation, time in hypoglycemia or mean amplitude of glycemic excursions.²⁸ Our study and these data lead us to conclude that DEB cannot be differentiated from other causes of suboptimal glycemic control based on CGM data alone but may serve as an indicator for further assessment. We suggest that disordered eating needs to be considered when addressing causes of dysglycemia in adolescents.

Presentations to hospital were also more common in the elevated DEPS-R group. The majority of the increased presentations were planned admissions for stabilization of diabetes. Neither presentations to hospital for severe hypoglycemia or hypoglycemia on CGM were more common in the elevated DEPS-R group. This is consistent with data presented by Ramachandran and colleagues,²⁷ where hypoglycemia on CGM was not more common in a population of adult women with DEB. The authors hypothesized that hypoglycemia may be more common with eating binges, where large quantities of food are consumed followed by subsequent attempts to correct hyperglycemia with large correction boluses of insulin. Further study of individuals with binge eating disorder may reveal specific patterns of glycemia on CGM associated with this pattern of eating and insulin administration.

While the use of HCL systems in adolescents is increasing, little is known about the associations between HCL systems and DEB.¹³ A recent study into DEB risk factors and HCL systems found that participants with DEB who used HCL had higher BMI z-score and lower HbA1c.²⁹ This may indicate that HCL algorithms can partially compensate for dysglycemia associated with disordered eating. Increased bolus overrides were seen in our cohort, but this metric is not reported with all HCL systems and bolus manipulation may differ based on the HCL system use. Further investigation is required to determine the clinically relevant behaviors unique to HCL system users with DEB.

This study reports a high prevalence of disordered eating of 48 % in an adolescent population in Australia with T1D. This is higher than previously reported in the one other Australian study and international cohorts which reported 38 % and 39.3 % respectively.^{2,10} One reason could be the higher average BMI z-score across the cohort, which has been associated with higher rates of disordered eating.^{25,30} In our cohort, there was no difference in BMI Z-scores over the 12 months preceding data collection. Previous research has demonstrated that participants who have ever reported being overweight were more likely to report disordered eating behaviors, regardless of recent change in BMI.³⁰ From this, our data suggest that a recent history of weight gain or weight loss is not necessarily a flag for the development of disordered eating in T1D.

In the present study, disordered eating was more common in females. While it is known that disordered eating is generally more common in females,³¹ it may be underreported in males. Previous studies have reported higher rates of disordered eating in males with type 1 diabetes compared to males without type 1 diabetes.³² Gender representation in this study was similar to the MILES study (50 % of females and 18 % of males in the MILES cohort, 66 % of females and 21 % of males in this study).¹⁰ In males, disordered eating or insulin manipulation may be associated with a desire for increased muscle mass and larger body shape

Table 4

Comparison of SDQ scores between the groups.

SDQ = Strengths and Difficulties Questionnaire, DEPS-R = Disordered Eating Problem Survey-Revised.

Parameter	DEPS-R < 20 (n = 26)	DEPS-R ≥ 20 (n = 24)	P Value
SDQ-Y			
Emotional	2.7	5.9	0.000
Conduct	1.5	2.5	0.023
Hyperactivity	4.5	6.0	0.015
Peer	1.9	3.8	0.002
Prosocial	8.0	7.9	0.443
Total Difficulties	10.5	18.3	0.000
Impact	1.4	2.0	0.225
SDQ-P			
Emotional	3.2	5.3	0.005
Conduct	1.2	2.0	0.039
Hyperactivity	3.7	4.4	0.156
Peer	2.0	3.0	0.057
Prosocial	8.5	8.2	0.304
Total Difficulties	10.1	15.5	0.003
Impact	1.7	3.0	0.058

Bold indicates statistically significant ($p < 0.05$).

rather than thinness, and this has been demonstrated to not correlate well with DEPS-R score.¹⁰ Therefore, it is possible that disordered eating was under-recognized in our male cohort due to limitations of the screening tool used.

The present study demonstrated significantly higher psychosocial difficulties in the disordered eating group based on youth and parent reported SDQ scores. Models for the development of disordered eating in T1D consider pre-existing depression prior to the diagnosis of T1D a significant risk factor.³³ Subsequent effects of the diagnosis, treatment regime and weight gain may exacerbate depression and body dissatisfaction.³⁴ In our cohort, the greatest difference in SDQ-Y was seen in the emotional problems domain, which has shown high accuracy in screening for anxiety and depression in youth.³⁵ It is unclear from the present data whether this distress preceded the development of disordered eating, or developed as a result of it.

This study has a number of strengths. Data collection occurred opportunistically in the clinical environment so that data collected reflects what is seen in real world practice. Correlation with CGM and IPT metrics are novel and provide insights into assessment of disordered eating in T1D. The association between disordered eating and psychological distress highlights the complexity of coexisting DE and T1D and the need for multidisciplinary management.

A limitation of this study is that screening tools are not as accurate at identifying DEB as the gold standard diagnostic interview.¹⁶ Additionally, the DEPS-R does not differentiate between restricted eating, binge-eating and purging behaviors. It is possible that different eating disorder subtypes may have clearer clinical associations. For example, case reports of individuals with binge-eating have demonstrated increased number of boluses following binge episodes and increased bolus to basal ratio,²¹ however this has not been replicated in larger cohort studies. The present research was an exploratory study performed at a single

time point in a tertiary center. We found increased overridden boluses in the elevated DEPS-R group, however more research is required into the nature of this bolusing behavior to determine the true effect of this metric and its relation to disordered eating. Finally, given the small sample size, further studies with a larger population are required to determine the generalizability of the associations found in this cohort.

5. Conclusions

Disordered eating behaviors are associated with suboptimal glyce-mic control and higher levels of psychological distress in adolescents with T1D. IPT users with DEB may override boluses more frequently. Elevated DEPS-R score was associated with a higher BMI Z-score. Insights from diabetes technology alone cannot be relied upon to detect DEB in adolescents with T1D, and screening for DEB and ED should be routinely performed. Specialist multidisciplinary clinics for young people with T1D and DEB may allow early intervention to prevent worsening glycemic control. With increasing HCL system use, further investigation is required to discern practices associated with DEB in this population.

CRedit authorship contribution statement

CL completed data collection, data analysis and prepared the manuscript for submission. CS, PL, and BK were involved with design of the study, supervision of data collection, editing of manuscript. AF was involved in design of the study and data collection.

Declaration of competing interest

None.

Appendix A. Differences in technology users (participants using either CGM or IPT) vs. non technology users in elevated and non-elevated DEPS-R groups.

	DEPS-R < 20			DEPS-R > 20		
	No technology (n = 3)	Technology (n = 23)	P-value	No technology (n = 5)	Technology (n = 19)	P-value
Female	1 (33.3 %)	8 (34.8 %)	0.96	3 (60 %)	15 (79 %)	0.384
ATSI	1 (33.3 %)	1 (4.3 %)	0.08	1 (20 %)	3 (15.8 %)	0.82
Age, years (SD)	15.2 (1.4)	15.1 (1.3)	0.461	16.3 (1.1)	15.0 (1.5)	0.045
Diabetes Duration, years (SD)	4.2 (3.2)	5.8 (2.8)	0.8	6.4 (3.8)	7.0 (3.9)	0.624
Diabetes related hospital presentations in preceding 12 months, Average (SD)	0.33 (0.57)	0.13 (0.34)	0.189	1 (1.22)	0.36 (0.68)	0.067
BMI Z-Score (SD)	24.7 (4.69)	23.5 (4.5)	0.326	31.2 (7.8)	26.5 (6.2)	0.085
Change in BMI Z-score over preceding 12 months (SD)	0.56 (0.46)	0.25 (0.28)	0.068	0.19 (0.22)	0.42 (0.49)	0.835
HbA1c, IFCC (SD)	7.3 (0.9)	6.8 (0.9)	0.18	10.2 (2.1)	7.7 (1.4)	0.002
HbA1c, mmol/mol (SD)	57 (10)	51 (10.3)		88 (24)	61 (15)	
SDQ-Y Total (SD)	16.3 (2.5)	9.7 (5.2)	0.023	18.8 (6.4)	18.1 (6.4)	0.416
SDQ-P Total (SD)	11.3 (5.5)	9.9 (7.0)	0.373	17.3 (9.2)	15.1 (5.4)	0.265

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