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Overeating, binge eating, quality of life, emotional difficulties, and HbA_{1c} in adolescents with type 1 diabetes: A Danish national survey

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ABSTRACT

Aims: To determine 1) the prevalence of symptoms of overeating (OE), subclinical binge eating (SBE) and clinical binge eating (CBE), in adolescents with type 1 diabetes (T1D), and 2) their associations with quality of life (QoL), anxiety, depression, HbA_{1c}, and body mass index standard deviation score (BMISDS).

Methods: In total 506 adolescents (age 12–17 years; mean 14.7 years; girls 49%) from the Danish Registry for Diabetes in Childhood and Adolescence (DanDiabKids) were included. Participants completed questionnaires on disordered eating, QoL, and emotional difficulties. A blood sample was sent for HbA_{1c} determination. BMISDS was determined from the DanDiabKids data.

Results: Prevalence rates of OE, SBE, and CBE were 8.4%, 18% and 7.9% respectively. Youth with CBE symptoms scored lowest on generic and diabetes specific QoL, highest on anxiety and depression symptoms, and had a higher HbA_{1c}. Youth with CBE had borderline increased BMISDS.

Conclusions: In a Danish national survey of adolescents with T1D, approximately one-third of participants had overeating or binge eating symptoms, comparable with the numbers in a U.S T2D population. Increased binge eating symptoms associated with lower QoL, higher depression scores, higher anxiety scores, and poorer clinical outcomes. Binge eating symptoms were markers for poor mental and somatic health.

Abbreviations: BAI-Y, Beck Anxiety Inventory for Youth; BDI-Y, Beck Depression Inventory for Youth; BMISDS, Body mass index standard deviation score; CBE, Clinical binge eating; ED, Eating disorder; NOE, No symptoms of overeating; OE, Overeating; PedsQL, Pediatric Quality of Life Inventory; QoL, Quality of life; SBE, Subclinical binge eating

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1. Introduction

The lifetime prevalence for having an eating disorder (ED) diagnosis was reported to be 8.4% in females and 2.2% in males, with the lifetime prevalence of the specific ED - binge eating disorder - being 2.8% in females and 1.0% in males [1]. The point prevalence of EDs was 5.7% in females and 2.2% in males but, for binge eating disorder, it was 2.3% in females and 0.3% in males [1]. Having type 1 diabetes (T1D) may increase the risk of having an ED. A large Canadian multicenter study with more than 300 adolescent females with T1D and thrice the number of non-diabetic control females reported twice the prevalence of EDs in the population with T1D [2], while a systematic review found that eating problems were more common in adolescents with T1D compared with non-diabetic peers [3]. Recently, a Danish case control registry study from the National Patient Registry including all Danish patients with T1D onset before the age of 18 and a mean follow-up time of 7.8 years, found higher probability of having an ED diagnosis in the group with T1D compared with the control group [4].

EDs may persist and evolve over time in adolescents with T1D, particularly in females [5]. EDs and/or disordered eating behaviors in adolescents with T1D have been associated with higher HbA_{1c} levels [6–8]. Furthermore, an Australian study of adolescents with T1D and a US study of youths with T1D and T2D reported a positive association between disordered eating and emotional difficulties [9,10].

EDs comprise a large spectrum of different conditions from anorexia nervosa to binge eating with or without increased body weight [11]. Binge eating is characterized by recurring episodes of eating an amount of food that is much more than what most other people would eat under similar circumstances, and a subjective experience of loss of control of eating, within a discrete period of time [12,13]. Binge eating is a common condition among patients with T2D where it is associated with obesity, poor quality of life, and symptoms of depression [13]. As with patients with T2D, patients with T1D are increasingly challenged by being overweight or obese [14,15]. However, no study has previously investigated how overeating and binge eating are associated with emotional symptoms, QoL and clinical outcomes, using a nationwide, registry-based sample of adolescents with T1D. Therefore, we aimed primarily to investigate the point prevalence of symptoms of overeating (OE), subclinical binge eating (SBE) and clinical binge eating (CBE) in a National Danish cohort of adolescents with T1D. Secondarily, we aimed to examine the associations of these individual subcategories of symptoms of eating disorders with generic and diabetes specific quality of life, symptoms of anxiety and depression as well as HbA_{1c} levels and BMISDS.

2. Subjects, materials and methods

2.1. Study design and participants

The present cross-sectional study was part of a nationwide web survey initiated to assess the influence of psychosocial variables on adherence, HbA_{1c} and quality of life in all Danish children and adolescents with T1D (ages 2–17 years). The study was conducted in collaboration with the Danish Society for Diabetes in Childhood and Adolescence, who supervises the Danish Registry for Childhood and Adolescent Diabetes (DanDiabKids). Since 1996, DanDiabKids has collected data on all children and adolescents in Denmark with a diagnosis of T1D, including annual registration of HbA_{1c} levels, which are analyzed centrally to ensure uniformity. Participants have been described previously [16,17]. Briefly, based on information from DanDiabKids, all families in Denmark with a child or an adolescent, aged 2–17 years, with a diagnosis of T1D (n = 1739) were invited to participate. We excluded 258 families, who were registered as being unwilling to participate in scientific research, had a protected address, or were no longer residing at the address registered in the Danish Civil Registration System from which all participant addresses were collected. For the actual study, children<12 years were excluded. All children received a written invitation by post, asking them to participate in the national web survey. They were also given the option of completing a paper version of the questionnaire. Only children with 100% complete questionnaires, a blood sample for central HbA_{1c} determination, and with height and weight data in the DanDiabKids database were included in this study. In total, 506 participants with 100% complete data were included, 185 patients missed one or more variable and were excluded (Fig. 1).

2.2. Measures – Questionnaires

2.2.1. The Youth Eating Disorder Examination Questionnaire (Y-EDEQ) was originally adapted from the Eating Disorder Examination Questionnaire and has been shown to be a commonly used tool for assessment of eating pathology in adolescents [12]. For the present study, selected items from the Y-EDEQ were used to group participants into the subgroups - no symptoms of overeating (NOE), OE, SBE and CBE. Eating categories were derived from responses to the questions: “How many times over the past 28 days have you eaten what other people would think was a really big amount of food, given the situation (objective overeating)?” “On how many of these times did you feel like you had lost control while eating (binge eating)?” OE was defined as $\geq$ 1 objective overeating episodes, but zero loss of control episodes over the past 28 days. SBE was defined as $\geq$ 1 to < 4 binge eating episodes over the past 28 days. CBE was defined as $\geq$ 4 binge eating episodes over the past 28 days [13].

2.2.2. Pediatric Quality of Life 4.0 Generic Core Scales (PedsQL generic) is a 23-item youth or parent completed measure of generic health-related QoL [18]. It encompasses four subscales: physical functioning, emotional functioning, social functioning, and school functioning. It is scored by calculating mean scores for each subscale, as well as for the total score. The total score ranges between 0 and 100, and higher scores represent better generic PedsQL [19]. The reliability and validity have been established and it is commonly used in diabetes-related research as an outcome measure [18]. In the present study, the Cronbach’s alpha for the child-report was 0.88.

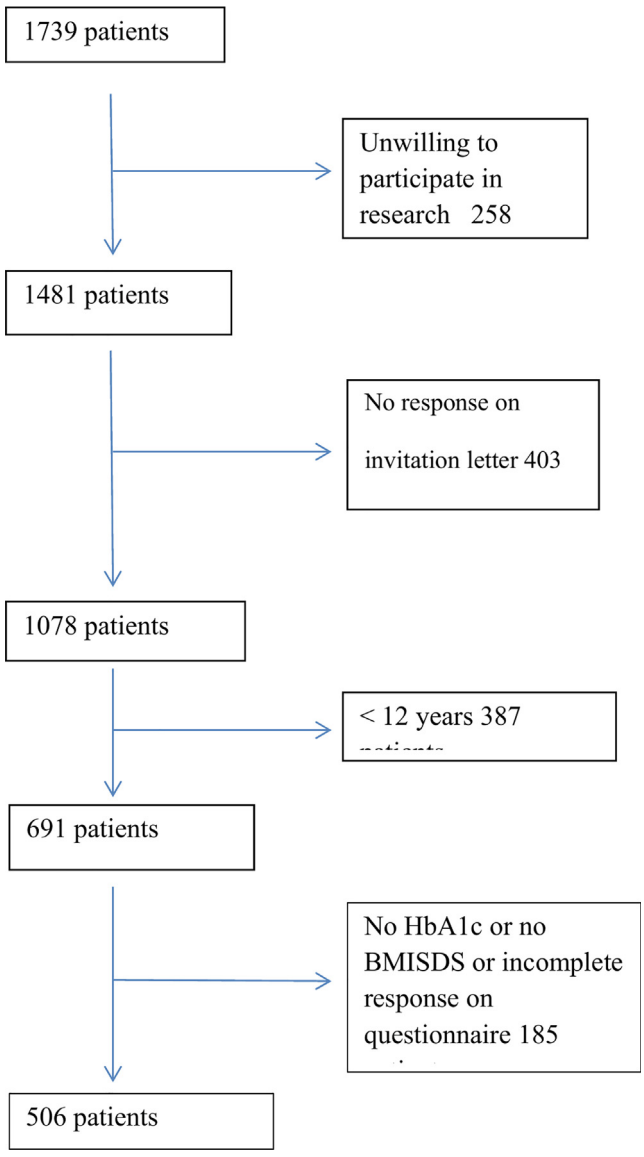

Fig. 1 – Flowchart showing included and excluded patients for each inclusion criteria.

2.2.3. Pediatric Quality of Life Inventory 3.0 Diabetes Module (PedsQL diabetes) is a 27-item youth- or parent-completed measure of diabetes related QoL [18]. It has five subscales: diabetes symptoms, treatment barriers, treatment adherence, worry, and communication. It is scored like the generic PedsQL. In the present study Cronbach's alpha for the child-report was 0.82.

2.2.4. The anxiety (BAI-Y) subscales and the depression (BDI-Y) subscales of the Beck's Youth Inventories second edition (BYI-II). Each subscale consists of 20 questions with each question scored on a Likert scale from 0 (never a problem) to 3 (almost always a problem) and a total score ranging from 0 to 60. The Danish version of the BDI-Y's internal consistency was high and its test–retest reliability adequate [20]. In the present study, the Cronbach's alpha was 0.92 for the BAI-Y subscale and 0.94 for the BDI-Y subscale.

2.3. *T1D clinical and paraclinical variables*

Age, diabetes duration and height and weight data of the children for BMISDS calculations at the time of answering the questionnaires were determined using the DanDiabKids database / registry. All children submitted a blood sample for HbA_{1c} at the time of answering the questionnaire. Blood samples were analyzed centrally at Copenhagen University Hospital at Herlev and reported in International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) units (mmol/mol) [21].

2.4. *Statistical analysis*

Patient characteristics, data on symptoms of OE, SBE and CBE, generic QoL, diabetes specific QoL, depression and anxiety symptoms, HbA_{1c} levels and BMISDS were examined using descriptive statistics. BMI was calculated as weight in kilograms divided by squared height in meters. BMISDS was calculated by use of the Danish child reference charts [22]. T-tests and chi-square test were used to compare patient characteristics across gender. One-way between-groups analysis of variance (ANOVA) with post hoc testing were conducted to compare generic QoL scores, diabetes specific QoL scores, anxiety scores, depression scores, HbA_{1c}, and BMISDS across the disordered eating subscales of OE, SBE and CBE. *P*-values equal to or below 0.05 were considered statistically significant. Magnitude of effect size was assessed using Cohen's effect size guidelines, such that eta squared ($\eta 2$) of 0.01, 0.06, and 0.14 indicated "small", "medium", and "large" effect sizes, respectively [23]. All statistical analyses were performed with Stata 16.1.

2.5. *Ethics*

Study approval was obtained from the Danish Society for Childhood and Adolescent Diabetes. The regional ethics committee was consulted and responded that questionnaire-based studies did not require permission from ethics committee. Although a blood sample for HbA_{1c} analyses was obtained from all participants for both clinical and research purposes, no biological samples were collected for a research-based biobank, and therefore, the project was not considered to be biomedical research and deemed not eligible for Committee review and approval. The project was registered with the Danish Data Protection Agency (Ref no. 2013–41-1528) [16].

3. Results

Table 1 shows the participant characteristics stratified by gender. Number of patients, age, diabetes duration and HbA1c were not different in males and females while BMISDS was higher in females. Thirty-four percent of patients had symptoms of OE, SBE or CBE, of which 18% had symptoms of SBE and 7.9% had symptoms of CBE. There were sex differences between the prevalence rates of disordered eating symptoms ($P < 0.001$) (Table 2). OE symptoms were more common in adolescent males (11.2%, versus 4.5% in females) while CBE

Table 1 – Patient characteristics. BMISDS = BMI standard deviation score, NOE = no symptoms of overeating, OE = overeating, SBE = subclinical binge eating, CBE = clinical binge eating, SD = standard deviation. *P value for sex differences in symptoms of disordered eating behavior.

	All	Male	Female	P-value
Number (%)	506	259 (51.2)	247 (48.8)	0.59
Age, mean years (SD)	14.68 (±1.59)	14.69 (±1.64)	14.66 (±1.54)	0.83
Diabetes duration in years (SD)	6.04 (±3.46)	5.93 (±3.55)	6.16 (±3.37)	0.45
HbA_{1c}, % (SD)	8.2 (±1.2)	8.2 (±1.3)	8.2 (±1.2)	0.72
(HbA_{1c}, mmol/mol (SD))	66 (±13)	66 (±14)	66 (±13)	
BMISDS (SD)	0.73 (±1.01)	0.63 (±1.05)	0.84 (±0.96)	0.02
NOE N (%)	335 (66.2)	175 (67.6)	160 (64.8)	<0.001*
OE N (%)	40 (7.9)	29 (11.2)	11 (4.5)	
SBE N (%)	91 (18.0)	48 (18.5)	43 (17.4)	
CBE N (%)	40 (7.9)	7 (2.7)	33 (13.4)	

symptoms were more common in adolescent females (13.4%, versus 2.7% in males).

There were statistically significant differences between the disordered eating categories for the variables of generic QoL as well as diabetes specific QoL (Table 2). Post hoc tests showed, that for generic QoL, youth with NOE (M = 81.4, SD = 11.4) scored significantly higher (better) than youth with SBE (M = 74.7 SD = 13.0), $P < 0.0001$, and CBE (M = 70.9, SD = 14.7), $P < 0.0001$. For diabetes specific QoL, youth with NOE (M = 66.5, SD = 13.9) scored significantly higher (better) than youth with SBE (M = 58.7, SD = 13.3), $P < 0.0001$, and CBE (M = 52.5, SD = 12.2), $P < 0.0001$) (Table 2).

There were statistically significant differences between the disordered eating subcategories for the variables BDI-Y and BDA-Y (Table 2 and Fig. 2). Post hoc tests showed, that for BDI-Y, youth with NOE (M = 6.1, SD = 7.4) scored significantly lower (better) than youth with SBE (M = 10.4, SD = 8.8), $P < 0.0001$ and CBE (M = 14.8, SD = 12.8), $P < 0.0001$. Youth with CBE scored significantly higher (worse) than youth with OE (M = 6.8, SD = 6.5), $P < 0.0001$) for BDI-Y. For BAI-Y, youth with NOE (M = 6.9, SD = 7.1) scored significantly lower (better) than youth with SBE (M = 10.4, SD = 7.5), $P = 0.001$ and CBE (M = 13.7, SD = 9.4), $P < 0.0001$. Youth with CBE scored significantly higher (worse) than youth with OE (M = 7.9, SD = 7.2), $P = 0.007$ for BAI-Y (Table 2).

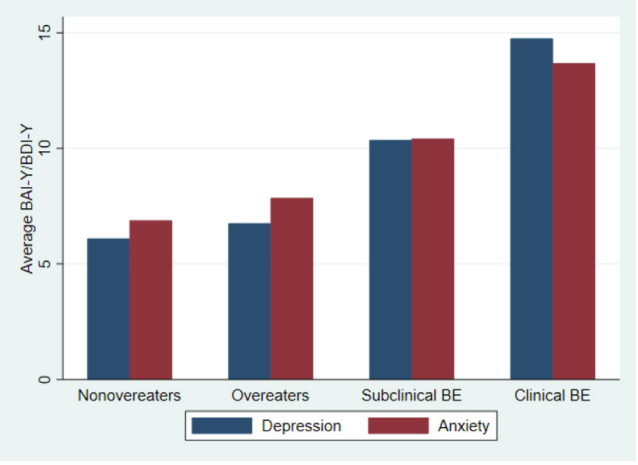

Fig. 2 – Depression (average Beck Depression Inventory-Youth / BDI-Y scores) symptoms (blue bars) and anxiety (average Beck Anxiety Inventory-Youth scores / BAI-Y) symptoms (red bars) versus disturbed eating behavior subcategories in youth with type 1 diabetes. NOE = No symptoms of overeating. OE = Overeating. SBE = Subclinical binge eating. CBE = Clinical binge eating. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2 – Means (M), standard deviations (SD), for the outcome variables 1) generic Quality of Life (QoL), 2) diabetes QoL, 3) Beck's Depression Inventory for Youth (BDI-Y) subscale score, 4) Beck's Anxiety Inventory for Youth (BAI-Y) subscale score, 5) BMI standard deviation score (BMISDS) and (6) HbA_{1c} for the disordered eating behavior groups. P value for ANOVA.

	NOE (N = 335)	OE (N = 40)	SBE (N = 91)	CBE (N = 40)	ANOVA	
	M (SD)	M (SD)	M (SD)	M (SD)	P-value	eta squared
Generic PedsQL score	81.4 (±11.4)	78.2 (±12.7)	74.7 (±13.0)	70.9 (±14.7)	< 0.0001	0.08
Diabetes PedsQL score	66.5 (±13.9)	59.1 (±14.9)	58.7 (±13.3)	52.5 (±12.2)	< 0.0001	0.10
Average BDI-Y score	6.1 (±7.4)	6.8 (±6.5)	10.4 (±8.8)	14.8 (±12.8)	< 0.0001	0.09
Average BAI-Y score	6.9 (±7.1)	7.9 (±7.2)	10.4 (±7.5)	13.7 (±9.4)	< 0.0001	0.07
BMISDS	0.69 (±1.03)	0.50 (±0.97)	0.87 (±0.94)	0.99 (±0.98)	0.078	0.01
HbA_{1c}, %	8.1 (±1.2)	8.3 (±1.4)	8.1 (±1.1)	8.9 (±1.3)		
(HbA_{1c}, mmol/mol)	65 (±13)	67 (±15)	65 (±12)	74 (±14)	= 0.001	0.03

Mean HbA_{1c} level was 8.2% (66 mmol/mol) and with no difference between males and females (Table 1). The mean HbA_{1c} was significantly lower in youth with NOE compared with youth with CBE, with a HbA_{1c} of 8.1% (65 mmol/mol) and 8.9% (74 mmol/mol), respectively, $P < 0.001$ (Table 2 and Fig. 3).

BMISDS was significantly lower among males than females (Table 1). Mean BMISDS was lowest in the OE group, and it increased, but to a borderline significant degree, over the groups; OE = 0.50 to CBE = 0.99, $P = 0.078$ (Table 2). Stratifying for gender did not change the results.

4. Discussion

The present study was conducted to investigate the prevalence of overeating (OE), subclinical binge eating (SBE) and clinical binge eating (CBE) symptoms in Danish adolescents (aged 12–17 years) with T1D, and their associations with psychosocial and somatic wellbeing. Approximately one-third of adolescents with T1D had symptoms of OE, SBE or CBE. More males than females had OE symptoms, and more females than males had CBE symptoms. Binge eating symptoms associated positively with lower QoL, higher depression scores, higher anxiety scores, and poorer clinical outcomes.

The point prevalence of CBE symptoms of 7.9% was markedly higher in this Danish national youth T1D cohort compared to binge eating disorder rates found in the general populations based on a systematic literature review of 27 studies [1]. However, in a Canadian study of females with T1D in the age interval of 12–19 years, Jones et al found a higher frequency of self-reported symptoms of binge eating behavior than in our study [2]. Remarkably, the frequencies of SBE and CBE in an American cohort of adolescents with T2D in the age interval 10 – 17 years (N = 678; 65% females) were comparable with the frequencies in our study, while the frequency of self-reported OE was much lower in our adolescent cohort with type 1 diabetes [13]. Furthermore, in the American T2D cohort, females were evenly distributed in all the groups – OE, SBE, CBE [13] - while in our type 1 diabetic cohort, females were more frequent in the CBE group and males were more frequent in the OE group. The gender difference with more symptoms of disordered eating in females with type 1 diabetes is in accordance with recent studies [8,24,25].

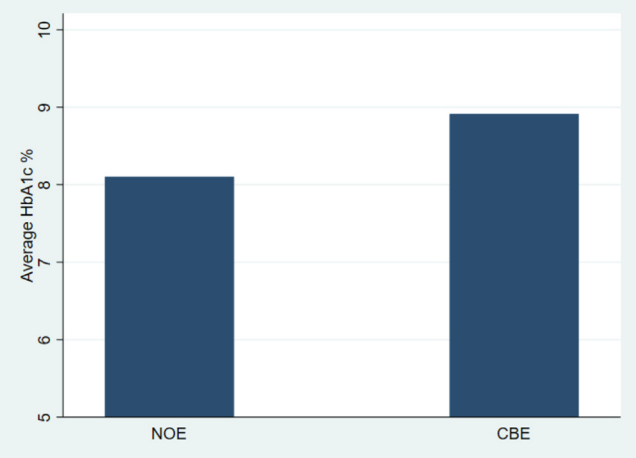

Fig. 3 – Average HbA_{1c} by no overeating symptoms (NOE) and clinical binge eating (CBE) symptoms.

Adolescents with any form of binge eating (SBE or CBE) behavior were significantly more likely to have reduced generic QoL, and adolescents with CBE behavior were more likely to have reduced diabetes specific QoL. Quite the same pattern was observed in the T2D cohort of American adolescents [13]. Likewise, in another American cohort of both T1D and T2D patients in the age group 10 to 25 years, patients scoring highest on the disordered eating behavior scale had the poorest QoL [10]. Emotional difficulties (anxiety and depression) scores incrementally increased from the NOE group to the disordered eating groups of OE, SBE and CBE. Females were overrepresented in the CBE group, and the CBE group scored the highest on depression symptoms. The same pattern over the groups of NOE, OE, SBE and CBE, and about the same mean scores of emotional difficulties were observed in the American cohort of adolescents with T2D [13]. A recent study of age comparable adolescents with T1D from Australia and another recent study of American youths with T1D and T2D diabetes [9,10] also reported a positive correlation between the severity of disordered eating behavior and emotional difficulties.

The average HbA_{1c} level was highest in patients with symptoms of CBE. Similarly, most recent studies have found the poorest glycemic control in the patients with the most symptoms of disordered eating [6,7,10,24], although Colton et al. did not find this association in adolescent females [26]. BMISDS was relatively high in the whole cohort independent of disordered eating symptoms. It is known that children and adolescents with T1D are challenged by higher BMISDS rates worldwide [14,15]. There were only borderline significant differences in BMISDS among the four eating behavior groups. However, we observed the lowest mean BMISDS in the OE group, which may be explained by overrepresentation of males in this group. We observed the highest mean BMISDS in the CBE group, with overrepresentation of females, in accordance with other studies showing the highest BMISDS in adolescents with the most symptoms of disordered eating [7,8,10], although not universal [27].

An important strength of our study includes the fact that participants consisted of a homogenous cohort of almost all Danish children with T1D in the age group 12–17 years. Another strength of the study was the central analysis of HbA_{1c} sampled at the time the children answered the questionnaires. The study also has certain limitations. First, due to the decision of only to include participants with 100% data-completeness, the cohort was reduced 27% from 691 to 506 participants. We tracked the HbA_{1c} of the non-participant group from the DanDiabKids database, and the HbA_{1c} levels of nonparticipants were significantly higher than HbA_{1c} levels of participants [28]. Study participants with high HbA_{1c} levels, scored significantly lower on QoL and significantly higher on the emotional difficulty (anxiety and depression) scales. Therefore, if the non-participant group had been included, it could have been expected that for increased severity of symptoms of disordered eating (especially CBE

symptoms), the QoL scores might have been even lower and the emotional difficulty scores might have been even higher. Second, the symptoms of disordered eating were not verified by clinical examination and a diagnostic interview to determine the severity of the symptoms, but our study performance was similar to a large study in peers with T2D, and the prevalence of SBE and CBE symptoms were quite similar [13]. Third, height and weight data for BMISDS calculations were taken from the DanDiabKids database, which means that we used the height and weight data at the date closest to the date of the participants answering the questionnaire. Therefore, the BMISDS data may not be exactly as at the time the psychosocial data was collected.

In summary, the point prevalence of the disordered eating symptoms, SBE and CBE, was relatively high and comparable with a large American study of SBE and CBE in peers with T2D, indicating that binge eating symptoms also are an important topic in adolescents with T1D as well as with T2D. Increasing severity of disordered eating behaviors associated negatively with QoL and positively with emotional difficulties. Furthermore, clinical outcomes were worst in the CBE group with overrepresentation of females. Thus, our study indicates close interconnections between increased severity of disordered eating – OE, SBE, CBE - symptoms and decreased QoL, increased emotional difficulties and poor somatic outcomes (high HbA_{1c} and high BMISDS). However, as the study is cross sectional, we can only show concurrent associations, and longitudinal studies are needed to reveal if disordered eating symptoms like OE, SBE or CBE persist and are important predictors of future somatic, mental health and wellbeing outcomes. Until we have compelling results, youth with T1D should regularly be screened for binge eating symptoms, and QoL and emotional status should be assessed in accordance with the International Society of Pediatric and Adolescent Diabetes guidelines [29].

Author contributions

All authors contributed to the design of the study and collection of data. MBJ was responsible for the statistical analysis. KPM, MT and NHB wrote the manuscript. All authors critically revised the manuscript and approved the final version.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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