Published in final edited form as:

Obes Med. 2018 March ; 9: 21–31. doi:10.1016/j.obmed.2017.12.001.

Understanding antagonism and synergism: A qualitative assessment of weight management in youth with Type 1 diabetes mellitus

Anna R. Kahkoska^{a,*}, Madison E. Watts^a, Kimberly A. Driscoll^b, Franziska K. Bishop^b, Paul Mihos^c, Joan Thomas^a, Jennifer R. Law^d, Nina Jain^d, and Elizabeth J. Mayer-Davis^{a,e}

^aDepartment of Nutrition, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

^bBarbara Davis Center for Childhood Diabetes, University of Colorado, Aurora, CO, USA

^cOdum Institute, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

^dDepartment of Pediatrics, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

^eDepartment of Medicine, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Abstract

Aims—No current clinical guidelines focus on weight management in youth with type 1 diabetes mellitus (T1DM). Our aim was to characterize the patient-perceived experience and barriers to weight management in youth with T1DM.

Methods—Participants were recruited from the University of North Carolina (n = 16, 56% female, 60% White, 50% insulin pump users, mean age 14.8 years, mean HbA1c 8.5% (69 mmol/mol)) and the University of Colorado (n = 18, 50% female, 80% white, 53% pump users, mean age 15.3 years, mean HbA1c 9.3% (78 mmol/mol)). Focus groups were stratified by sex and weight status (BMI cutoff = 25). Discussions were guided by a standardized set of questions, audio-taped, transcribed, and analyzed thematically using inductive qualitative methods.

Results—Youth with T1DM expressed four interrelated themes of antagonism between type 1 diabetes and weight management: dysregulated appetite, disruption of blood glucose levels associated with changing diet/exercise, hypoglycemia as a barrier to weight loss, and the overwhelming nature of dual management of weight and glycemic control, and two interrelated themes of synergism: improvement in shared, underlying health behaviors and exercise as a tool for weight and glycemic control. Variation in emphasis of specific thematic elements was greatest across sex. Youth identified five major components of a weight management program for T1DM: intensified glucose management, healthy diet with known carbohydrate content, exercise, individualization and flexibility, and psychosocial and peer support.

*Corresponding author. 245 Rosenau, 135 Dauer Drive, Campus Box # 7461, Chapel Hill, NC 27599, USA.

Conflict of interest statement

The authors have no conflict to disclose.

Conclusions—There is critical need for personalized, T1DM-specific weight recommendations to overcome disease-specific barriers to weight management in the context of T1DM.

Keywords

Type 1 diabetes; Pediatric obesity; Weight management; Qualitative research

1. Introduction

Type 1 diabetes mellitus (T1DM) results from cell-mediated auto-immune destruction of the β -cells of the pancreas and is one of the most common chronic diseases in childhood (Demirel et al., 2013). Since the landmark Diabetes Control and Complications Trial established the benefits of strict glycemic control through intensive insulin therapy to reduce risk for microvascular and macrovascular complications associated with T1DM (The effect of intensive t, 1993; Price et al., 2014a), contemporary management of T1DM includes a daily care regimen centered around maintaining glucose levels as close to normal as possible (Daneman, 2006; Pihoker et al., 2013). Unfortunately, unintended weight gain is a common and well-documented adverse consequence of intensive insulin therapy (The effect of intensive t, 1993; Pihoker et al., 2013; Liu et al., 2010), and the prevalence of obesity in US youth with T1DM now parallels that of the general population while the prevalence of overweight is slightly higher (Liu et al., 2010). Excess weight has been directly linked to an increased risk of macrovascular complications, such as cardiovascular disease (Maahs et al., 2014; Purnell et al., 1998, 2017), and microvascular complications, such as retinopathy and neuropathy (Price et al., 2014b; Polsky and Ellis, 2015).

In this population, weight-oriented strategies must be integrated into the complex, existing T1DM self-regulation to prevent adverse effects on short- and long-term glycemia (Liu et al., 2010). The challenge arises from a lack of weight management guidelines specific for T1DM, which may need to differ than guidelines for the general population due to potential differences in underlying metabolic processes, appetite regulation, and behavioral challenges that play into the ‘dual management’ of glycemic control and weight (Driscoll et al., 2017). In addition, therapeutic challenges with insulin dosing can result in increased hypo- and hyperglycemia which then influence weight status (Siminerio et al., 2014). There is a high co-prevalence of disordered eating behaviors and T1DM (Baechle et al., 2014), specifically diabulimia, or the purging calories through insulin omission and sustained hyperglycemia (Hasken et al., 2010). To productively address weight management in the context of T1DM, it is critical to understand how individuals with T1DM perceive and experience weight-related decisions and behaviors. However, little is known about the perception of weight management among youth with T1DM. The purpose of this study is to fill a fundamental gap in the extant weight management and T1DM literature by describing the following: 1) *perceptions and experiences of the dual management of glycemia and weight among youth with T1DM*; 2) *barriers that youth with T1DM face with regards to weight management*. Given the multifactorial nature of both T1DM and weight management, we engaged youth with T1DM in a qualitative approach to capture attitudes, experiences, and challenges of weight management in their own words, from which future hypotheses, research, and guidelines may be generated.

2. Subjects

Eligibility criteria included: age 12–17, T1DM duration > 1 year, and most recent clinic HbA1c < 13% (119 mmol/mol). Focus groups were stratified by weight status (normal weight (BMI < 25) versus overweight (BMI ≥ 25)) and gender to alleviate sensitivities surrounding the discussion of weight. Eligibility was assessed by BMI and HbA1c from most recent clinic visit. Eligible youth were recruited by phone using a uniform script for initial contact and commitment.

Supplementary Fig. S1 depicts the recruitment process and outcomes. At UNC, 93 youth (56.7% of eligible youth) were contacted by telephone, 22 youth (23.7% of contacted youth) committed to the study, and 16 youth (72.7% of confirmed youth) completed the study. At CU, 79 youth (34.2% of eligible youth) were contacted by telephone, 21 youth (26.6% of contacted youth) committed to the study, and 18 youth (85.7% of confirmed youth) completed the study. Main reasons for declined participation included disinterest and lack of transportation or availability during study dates. In general, recruitment was challenged by low interest levels among normal weight youth. Upon confirming participation, participants received a secure link to an electronic questionnaire. Paper questionnaires were provided prior to the focus group for youth who were unable to complete the electronic version. Participants were compensated \$50.

Using data saturation as the desired criterion, focus group transcripts were analyzed to determine the need for additional focus groups. Based on the depth of data provided from the eight focus groups across gender and weight status and lack of new information emerging by the end of the study, sampling was completed with 34 youth across eight focus groups.

3. Materials and methods

3.1. Study overview

We conducted eight focus groups comprised of 3–6 youth with T1DM between October and December of 2016 at the University of North Carolina at Chapel Hill (UNC) and the Barbara Davis Center for Childhood Diabetes (BDC) at the University of Colorado (CU). Focus groups were stratified by sex and weight status and addressed the perceptions and experiences of weight management in T1DM. The study was approved by the Institutional Review Board at UNC and CU. Youth were accompanied to the focus group visit by a parent who provided informed consent, while youth provided assent. Parents were not present for the focus group discussions.

3.2. Measures

Clinical Data—Most-recent body mass index (BMI) and hemoglobin A1c (HbA1c) were collected from electronic health records. BMI was calculated with height and weight measurements using standard formulas (Turconi et al., 2006).

Demographic Information—Self-reported race/ethnicity was classified as Hispanic (regardless of race), non-Hispanic white, non-Hispanic black, American Indian, Asian/

Pacific Islander, and multiracial (regardless of individual races within) (Mayer-Davis et al., 2009).

Disordered Eating—Disordered eating behavior was assessed using the 16-item Diabetes Eating Problem Survey (DEPS-R) (Markowitz et al., 2010). The survey assesses behaviors such as skipping insulin or keeping blood sugars high to lose weight as well as feelings towards the relative priorities of losing weight and taking care of one's diabetes. Higher scores are more suggestive of disordered eating behavior.

Impulsivity—The 15-item version of the Barratt Impulsivity Scale (BIS-15) measures 3 s-order facets of impulsivity to capture the overall construct of impulsivity. These include attentional, motor, and non-planning impulsivity (Patton et al., 1995). Higher scores are suggestive of more impulsive behavior.

Emotional, External, and Restrained Eating—The 33-item Dutch Eating Behavior Questionnaire (DEBQ) was developed to measure three eating styles as subscales that may contribute to or attenuate the development of obesity: *Emotional Eating* or eating in response to emotional arousal states such as fear, anger or anxiety (13 items), *External Eating* or eating in response to external food cues such as sight and smell of food (10 items), and *Restrained Eating* or conscious efforts to limit and control dietary intake (10 items) (van Strien and Oosterveld, 2008). Higher scores are more suggestive of respective eating behaviors.

3.3. Focus groups

Focus groups discussions were facilitated using a semi-structured guide developed by the research team. Questions were open-ended and addressed six major topic areas: 1) Appetite; 2) Blood Glucose; 3) Cravings; 4) Overall Knowledge of Weight Loss; 5) Diabetes Health versus Overall Health and Weight Loss; 6) Main Barriers; and 7) Ways Weight Loss Could Be Made Easier. Supplemental Table S1 depicts probing questions for each main topic. Efforts were made to elicit responses from all participants. Focus groups lasted between 60 and 90 min.

3.4. Data analysis

Focus groups were audio recorded using two digital recorders, and then transcribed verbatim. Each transcript was transcribed and rechecked in duplicate to prevent errors. Transcription was carried out by the authors (AK and MW) as a way to become familiar with the data (Braun and Clarke, 2006; Riessman, 1993).

Given the lack of published data on the perception of weight management among youth with T1DM, we used an inductive analysis process for identifying, analyzing, and reporting patterns or themes within the data (Braun and Clarke, 2006). All transcripts were read by at least two investigators, from which an initial list of codes was developed using an inductive thematic analysis approach (Braun and Clarke, 2006; Virginia and Victoria, 2006), where the content of the transcripts were used to generate codes encompassing similar topics or sentiments. Codes were defined in the codebook, and all data were then coded in relation to

the perceptions of each of the six major topic areas using the codebook, which was modified as codes emerged (King et al., 1994).

Following coding, data from each code were examined for the key qualifications, reservations, nuances, and ideological stances which study participants used when describing various aspects of weight management and T1DM. Code co-occurrence was visualized using co-occurrence tables and further explored with network maps (Braun and Clarke, 2006). Codes that co-occurred frequently and were found to be related or conceptually similar in nature were grouped together as themes (Braun and Clarke, 2006). Certain codes were selected as important subthemes and agreed upon by the study team.

Individual themes and subthemes were re-checked against the raw data and tested for saturation within and across groups to ensure thematic fidelity and informational redundancy, and that no additional codes were needed. The most relevant themes were integrated to form a theoretical framework or thematic map (Supplementary Fig. S2) (Braun and Clarke, 2006). The thematic map was then reviewed and revised in relation to the entire dataset to ensure that it reflected the meanings evident in the data as a whole (Braun and Clarke, 2006). A selection of the relevant data was reviewed by other co-authors to provide checks on the interpretation of the data. The most representative verbatim quotes for each theme and subtheme were selected for inclusion in the results (Tables 2–3).

Qualitative analyses used ATLAS.ti software version 7.5.18 (GmbH, Berlin, Germany). Statistical analyses were performed using SAS version 9.4 (Cary, NC, USA) and considered a two-sided *p*-value of 0.05 as statistically significant.

4. Results

Table 1 shows participant demographic and clinical characteristics. The sample included boys and girls at a mean age of 14.4 years, the majority of whom were non-Hispanic white and pump users. No significant differences in demographic or clinical characteristics were found between across sex or weight status ($p > .05$ for all variables).

No major differences were found between youth recruited from UNC ($n = 16$, 56% female, 60% White, 50% insulin pump users, mean age 14.8 years, mean HbA1c 8.5% (69 mmol/mol)) and CU ($n = 18$, 50% female, 80% white, 53% pump users, mean age 15.3 years, mean HbA1c 9.3% (78 mmol/mol)). Supplemental Table S2 depicts participant characteristics by focus group.

Table 1 also shows eating behavior-related characteristics of participants. Females reported higher DEPS-R scores (mean DEPS-R score of 17.8 in females versus 8.9 in males, $p = .001$) and higher emotional eating scores (mean DEBQ Emotional Eating Score of 27.1 in females versus 16.8 in males, $p = .007$). There were no significant differences in eating behavior measures between normal weight and overweight youth ($p > .05$ for all variables).

4.1. Thematic analyses

4.1.1. General appetite and cravings—Youth described their appetite as “normal,” reported cyclical variations in appetite, and described specific appetite fluctuations related to

exercise, boring activities, and after school. Youth articulated a range of cravings including seafood, cake, and popcorn. While all youth articulated that cravings included a psychological component that operated to override physiological satiety, females uniquely emphasized cravings that related to ‘forbidden’ foods or foods restricted for their high carbohydrate content in T1DM. Normal weight females discussed restrained eating and guilt associated with indulging cravings of forbidden foods.

4.1.2. Weight attitudes and behaviors—Primary health concerns of participants included complications from hyperglycemia and hypoglycemia, contagious illness, and overall health. Weight management was articulated as a primary health concern among overweight youth only. Body image concerns were discussed exclusively among females who reported wanting to be fit into certain clothes and to appear more attractive to others, although males emphasized ‘looking better’ as a benefit of exercise. Body image concerns were centered around weight and not T1DM.

Disordered eating behaviors were emphasized among females regardless of weight status, centering around anxiety of eating in front of other people and eating in response to emotions such as anger, depression, and fear. T1DM-specific disordered eating, including fear or insulin or insulin-related weight gain, was mentioned only once among normal weight females: “*Taking a lot of insulin I heard adds on to weight. ... I’m always scared taking a lot of insulin will make me gain weight and I can’t keep my weight the way I want it to be.*” Normal weight and overweight males mentioned insulin purging as a ‘dangerous’ way to lose weight. No youth endorsed current or historical insulin purging.

4.1.3. Major themes: antagonism and synergism between T1DM and weight management—The participants’ perceptions and experiences with weight management included distinct situations in which optimal weight-related behaviors were directly challenged by the demands of blood glucose management. They also included broad ways in which weight control strategies may be helpful and productive with regards to glycemic control. These ideas provided the basis for the overarching framework of the dual management of glycemia and weight. Fig. 1A presents a thematic map of two major and opposing concepts—antagonism and synergism between T1DM and weight management—and the associated subthemes.

Antagonism between T1DM and Weight Management (See Table 2 for illustrative quotes and their respective sources for each of the four subthemes.).

Appetite is Dysregulated with Short-Term Changes in Glycemia: Weight management is challenged by appetite dysregulation that occurs with short-term periods of hypo- and hyperglycemia (**2. A**). Regardless of sex or weight status, youth described increased hunger and an ‘uncontrollable urge to eat’ during episodes of non-severe hypoglycemia (i.e. episodes in which no external aid was required) that lasted until resuming euglycemia (i.e., in target range glycemia; **2.A.1**). Increased hunger was associated with overeating and overcorrecting low blood glucose levels. Youth also described the greatest increase in appetite when non-severe hypoglycemia occurred during the night (**2.A.1. A**). The majority of participants described decreased appetite, increased thirst, and feeling unwell during

hyperglycemia (2.A.2). However, several participants also described an ‘all-or-nothing’ appetite or increased appetite during hyperglycemia (2.A.3). Extreme hyperglycemia was more strongly associated with feeling sick than increased hunger. A final subtheme associated with hyperglycemia was a specific ‘taste’ that youth reported in their mouths/throats that was associated with a decreased desire to eat.

Changing Diet and Exercise Inherently Disrupts Blood Glucose Levels: Hypo- and hyperglycemia were regarded as necessary consequences of introducing new weight management habits among all youth (2. B). Participants expressed concern and fear over glycemic excursions that inhibited spontaneous, drastic changes to diet and exercise (2.B.1). Low blood glucose was regarded as an immediate threat to well-being. Related to the hesitancy to make dietary or activity changes for fear of disrupting blood glucose, youth also reported eating or drinking in the absence of hunger to avoid having to modify insulin doses; ingesting extra carbohydrates was regarded as ‘easier’ (2.B.2). Overall, disruption of blood glucose levels was posited to happen regardless of the frequency of blood glucose monitoring or efforts to mitigate glycemic excursions.

Hypoglycemia is a Specific Barrier to Weight Loss: Episodes of non-severe hypoglycemia were articulated as a barrier to weight management by all youth (2. C), but females emphasized frustration with having to consume extra calories as part of treating hypoglycemic episodes (2.C.1), while males emphasized the lower quality of food consumed when hypoglycemic (2.C.2). All youth described how hypoglycemia prevented or stopped physical activity and the ‘counterproductive’ feeling of consuming extra calories during exercise, the duration of recovery time, and general sentiments of psychological discouragement and frustration (2.C.3). Finally, youth described how fear of hypoglycemia leads to overeating and exercise aversion (2.C.4). Overweight females emphasized fear of hypoglycemia as a specific barrier to engaging in physical activity.

Managing Blood Glucose and Weight is ‘Too Much to do at Once’: Participants described feeling overwhelmed by regulating weight and blood glucose simultaneously (2. D), referencing the diligence and attention required for both tasks, a sense of worry associated with both outcomes individually, as well as frustration with the ongoing potential for strategies to be counterproductive. Females described being overwhelmed by managing diet for both outcomes, as well as the contribution of ongoing life events and stressors inherent in adolescence. Youth also described a lack of simple instructions to aid in weight management, lamenting the extended time required to adjust and optimize insulin doses for weight management changes (2.D.1).

Synergism between T1DM and Weight Management. (See Table 3 for illustrative quotes and their respective sources for each of the two subthemes).

Improving Health Behaviors that Underlie Both Glucose and Weight Control May Lead to Improvements in Both: Themes of synergism focused around how engaging in improved health behaviors for weight loss may be helpful for glycemic control, including diet and T1DM self-care (3. A). Youth also described the universal benefits of a healthful diet and moderate food intake, regardless of weight (3.A.1). Healthful diet was defined by

plant-based foods, decreased junk food, and low to moderate carbohydrates. Overweight youth described experiences in which weight loss attempts improved blood glucose levels and resulted in decreased insulin doses (3.A.2). Health behaviors subthemes were interrelated as managing food intake was suggested to decrease large glucose fluctuations, thereby aiding both long-term glycemic control and weight.

Exercise is a powerful tool for weight and glycemic control: Exercise was articulated as a positive influence on blood glucose, body weight, and overall well-being, regardless of sex or weight status (3.B.). Exercise was specifically emphasized as a preferable weight control strategy compared to dieting (3.B.1). The majority of youth described adjusting their T1DM regimen when exercising to prevent hypoglycemia which was regarded as ‘easier’ than diet-related adjustments. Overweight males further emphasized benefits of exercise over diet including having fun, feeling better, and gaining strength, value was placed on the fun or social nature of group activities (3.B.2). Both males and females described exercise in the context of team sports, but more females described exercising on their own or with family. Finally, youth articulated a benefit of mindful exercise and emphasized psychological benefits setting and executing intentions of exercise as part of a weight and T1DM management (3.B.3).

4.1.4. Suggested components of effective weight management in T1DM—In the discussion of suggested program aspects, no new themes were generated. Each key component was related to previous subthemes and positioned to either correct the antagonism or support the synergism between T1DM and weight management that was previously articulated. Youth suggested five major components of a successful weight management program in T1DM: intensified T1DM management, healthy diet with known carbohydrate content, exercise, innate individualization and flexibility, and psychosocial and peer support. Fig. 1B depicts a modified framework that integrates key components with related themes and subthemes. Table 4 provides illustrating quotes for each component.

Intensified T1DM Management: Youth described a need for more frequent blood glucose monitoring or use of a continuous glucose monitor, record-keeping and use of a log-book to document food, activity, and blood glucose, and special considerations to avoid hypoglycemia (4. A). Youth expressed the sentiment that a weight program would be most effective for someone ‘taking good care’ of their T1DM and suggested that improved self-regulation may be helpful for both outcomes. The value of a schedule or routine emerged as a sub-theme where youth expressed frustration with day-to-day variability and that it was impossible to ‘live the same day twice.’ Regular eating and exercise times were proposed to facilitate predictable insulin adjustments.

Healthful Diet with Known Carbohydrate Counts: A healthful diet of plant-based foods, with known carbohydrate counts for accurate dosing, was emphasized across groups (4. B). Several participants suggested low carbohydrate foods as ideal for both glycemic control and weight management, although this theme was not saturated across sex or weight status.

Exercise: Youth expressed enthusiasm for exercise as a central part of weight management (4. C). Youth described a related aversion to dieting and emphasized that different types of exercise may work better for different people, although social exercise conferred the greatest benefit across all groups. Overweight females suggested including exercise that may be more predictable or have a subtle effect on blood glucose. Finally, youth expressed a need for effective preventive and treatment strategies for hypoglycemia that occurs during exercise.

Individualization/Flexibility: Participants described a need for individualized plans that may be tailored to daily activities and appetite. They also described a need for flexibility within a plan to allow for unanticipated short-term changes in glycemia, such as hypoglycemia (4. D). Youth articulated an aversion to rigid diet plans, emphasizing their futility.

Psychosocial and Peer Support: All youth described the value of peer and professional support with regards to psychosocial well-being (4. E). Males referenced positive experiences at summer camps for youth with T1DM and suggested that a camp-like experience may be ideal for weight loss due to increased physical activity and social interactions. All youth described the value of peer support, specifically from other individuals with T1DM with personal experience, and males articulated competition as a helpful variant of peer support for self-improvement. Regardless of sex or weight status, youth acknowledged that weight management in T1DM was complicated, resulting in a need for specific support with day-to-day challenges and discouragements.

5. Discussion

Youth with T1DM face unique barriers regarding weight management that center around the interdependency of short-term glycemia, dietary intake and activity level, and their impact on long-term weight status. Youth in our study simultaneously perceived distinct elements of antagonism and synergism between T1DM and weight management, and they expressed a need for weight management that anticipates and reconciles the potential pitfalls and benefits.

Youth did not endorse T1DM-specific disordered eating behaviors such as insulin manipulation or purging

Youth in the present study did not endorse adaptive weight loss strategies such as insulin manipulation, instead referencing T1DM management as a clear priority, expressing the grave consequences of both acute hypoglycemia and sustained hyperglycemia. Although females also had a higher mean score on the Diabetes Eating Problem Survey than males, reflecting a higher degree of self-reported disordered eating behaviors, the mean score was below the clinical threshold for further evaluation. Instead, themes of general disordered eating behaviors co-occurred heavily with hypoglycemia, corroborating previous reports of unique behavioral barriers to weight loss in T1DM, including hypoglycemia and dietary restraint (Driscoll et al., 2017).

Variation in emphasis of specific thematic elements was greatest across sex

Across focus groups, the thematic content and emphasis varied significantly across sex, evidencing the existence of differences in the psychosocial aspects of both weight management (Kaminsky and Dewey, 2014; Minges et al., 2016) and T1DM (Huxley et al., 2015; Powers et al., 2017). The largest sex difference emerged with regard to several weight attitudes and behaviors reported uniquely by females. Males perceived that their food intake was usually matched to hunger levels, whereas nearly all females endorsed situations of overeating related to palatable food, emotions or stress, and hypoglycemia. Moreover, females used stronger language surrounding foods that were ‘forbidden’ and also reported cravings for such ‘forbidden’ foods, while males referenced cravings more generally as a strong desire for a food without qualifying the nature of the food or physiological hunger. In addition, females described specific challenges around family and social eating, highlighting instances in which they ate more with others as well as situations in which they felt uncomfortable eating when others were not.

Taken together, female narratives of increased food preoccupation and disinhibited eating triggered by emotion and dietary disruptions suggest higher cognitive restraint among girls and young women with T1DM (Knight and Boland, 1989; Polivy et al., 2005). Cognitive restraint is associated with unusual eating patterns that result from the stress inherent in chronic self-control (Clark, 2004; Herman and Mack, 1975; Herman and Polivy, 1975) and has been highlighted recently as a unique barrier to healthful or intuitive eating in T1DM (Driscoll et al., 2017; Peterson et al., 2015; Pinhas-Hamiel and Levy-Shraga, 2013; Verrotti et al., 1999; Kahkoska et al., 2017). The thematic co-occurrence of cravings and carbohydrates may reflect the clinical emphasis on carbohydrate counting and related food preoccupation (Peterson et al., 2015; Kahkoska et al., 2017).

Questionnaire data reinforced sex differences in eating behavior, as females reported higher disordered eating and emotional eating scores. Interestingly, females did not report higher measures of cognitive restraint. It may be that the instrument did not assess diabetes-specific aspects of dietary restraint or the eating attitudes surrounding forbidden and carbohydrate-rich foods.

There were comparatively slight differences in thematic content or saturation between normal weight and overweight youth and no significant differences in self-reported eating behaviors, which may be due to use of a threshold BMI cut-off resulting in high within-group BMI variation and lower between-group BMI variation. Use of percentile cut-offs may have resulted in slightly different weight-status groupings (Must and Anderson, 2006).

Hypoglycemia emerged as a major barrier to weight management in T1DM

All youth, regardless of sex or weight status, identified the occurrence of non-severe hypoglycemia as a barrier to best weight practices. Youth endorsed dysregulated appetite, an uncontrollable urge to eat, and disinhibited eating, consistent with recent thinking about hypoglycemia as a problem point in a cycle of disordered eating that resembles binge-eating (Dewan et al., 2004). It is known that hypoglycemia is associated with intense hunger (Westerberg, 2013) and a drive to consume particularly high-sugar and high-fat foods (Page

et al., 2011), likely due to the release of counter-regulatory hormones released during hypoglycemia, including cortisol, growth-hormone, epinephrine, and ghrelin (Westerberg, 2013; Blundell et al., 2010; Prodam et al., 2014). Previous studies on eating patterns in non-severe hypoglycemia have reported that disinhibited eating is common; one study reported 98% of individuals with T1DM reported engaging in disinhibited eating during episodes of hypoglycemia (Peterson et al., 2015).

Youth also described over treating hypoglycemia, referencing a failure to ‘fight the urge’ to eat or allow for blood glucose levels to normalize before consuming more recovery carbohydrates. Repeated, excess consumption can lead to a net surplus of calories and over treatment of low blood glucose followed by hyperglycemia. This in turn leads to the need for additional insulin, and potential weight gain and worsened glycemic control in a cyclical fashion (Verrotti et al., 1999; Page et al., 2011; Pinhas-Hamiel et al., 2015). In fact, studies of youth with T1DM have shown that higher BMIz is associated with more frequent episodes of hypoglycemia, implicating specific behavioral patterns that may drive weight and glycemic control farther from target among youth with T1DM (DuBose et al., 2015).

Nighttime binges associated with hypoglycemia during the night emerged in all focus groups. Data on the prevalence of this behavior is limited; one study reported that approximately 10% of youth with T1DM have night-eating syndrome: excessive eating in the evening and nocturnal awakening with ingestion of food, which is associated with obesity and triggered by psychosocial and emotional stress (Morse et al., 2006). However, it is unclear whether excessive nighttime eating specifically in response to hypoglycemia is attributable to circadian shifts in appetitive hormones such as ghrelin (Broussard et al., 2017), whether it is driven by fear of hypoglycemia (Martyn-Nemeth et al., 2017), and whether it merits consideration as a formal clinical diagnosis.

Hypoglycemia was also identified as a barrier to regular engagement in exercise, particularly among youth who engaged in team sports. Youth described frustration with the duration of time required for glucose levels to normalize. Unfortunately, hypoglycemia was also described as a necessary consequence of weight management, implicating a need for specific weight management guidelines that both preempt and integrate hypoglycemia. Our findings suggest that youth may benefit from a protocol to help identify healthy food choices for hypoglycemia recovery, tools to avoid hypoglycemia-related bingeing, personalized preventive strategies and increased monitoring when exercising, and programming to emphasize that exercise is worthwhile for health benefits outside of weight, thereby encouraging youth to finish workouts even when hypoglycemia occurs and excess calories are consumed.

Themes of synergism and overall health were grounded in discussions surrounding exercise

The positive experience and effect of exercise emerged as a major theme across all groups of youth with T1DM, where youth described benefits including improved energy, skill acquisition, increased strength, and higher self-esteem. With regards to weight management, exercise was seen as preferable to dieting, which may be attributable to the younger age range (Snethen et al., 2006). Interestingly, youth in the study indicated that they were

already adjusting T1DM management when exercising, particularly males who engaged in team sports. Future weight management guidelines could capitalize on the T1DM adjustment strategies that youth are already using to avoid hypoglycemia in exercise to facilitate similar approaches for diet-related management.

Youth acknowledged that improved diabetes self-care with respect to glycemic control was necessary for weight loss to be effective

Regardless of sex or weight status, youth in the study perceived a relationship between T1DM care and the efficacy of weight management practices, stating that is important for an individual trying to lose weight to have good control of their diabetes. Youth described 'highs and lows' as a direct challenge to weight management and referenced state of glycemic 'stability' that could and should ideally be achieved with healthy eating.

Youth seamlessly reconciled antagonistic and synergistic aspects of diabetes and weight management into five concise and saturated components of a proposed weight management program

The focus group discussion contained two distinct components: a discussion of subjective experiences and perceptions as well as a discussion of a hypothetical weight management plan, in which youth were asked to propose key aspects to include and not include. Components that participants suggested were heavily saturated across all groups and did not vary by sex or weight. Critically, no new themes emerged around this transition. Instead, each program component suggested served to anticipate and correct aspects of antagonism while promoting aspects of synergism. Interestingly, males especially emphasized concepts of patience, positivity, and flexibility as it relates to challenges with hypoglycemia, weight loss progress, and discouraging days. This theme was linked to positive experiences at diabetes camp, peer support, and competition as a specific form of peer support for self-improvement. Interestingly, youth did not express a need for privacy and instead described need for interaction with others who were facing similar challenges.

Limitations of the present study include potential selection bias, where youth who expressed interest in the focus group study were more engaged or open to weight-related discussions than youth who declined. Youth who were unable to arrange transportation to the clinic or who did not speak English were not included in the study, limiting the range of socioeconomic status and cultural diversity included in the final sample. While the overall sample size was sufficient for qualitative data collection, the small size of weight- and sex-related subgroups may result in underemphasized codes or themes and prohibits statistical comparisons across groups. The study design and process was designed to limit these weaknesses by ensuring the data collected was of high quality and the conclusions inferred were valid. Strengths of the study include the qualitative approach which allowed youth to express views and experiences in their own words to richly characterize a largely unexplored clinical area (King et al., 1994). To our knowledge, this is the first study to explore the patient-perceived experiences and barriers to weight management among youth with T1DM, where such insights are critical for the development of future research and pragmatic guidelines.

In conclusion, youth with T1DM face disease-specific barriers to weight control. Future weight management recommendations specific to T1DM should anticipate and correction for aspects of antagonism, such as hypoglycemia, and emphasize aspects of synergism, such as exercise, to promote co-optimization of weight and glycemic control.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors are indebted to the youth and their families who made the study possible. The study was supported by the UNC Scott Neil Schwirck Fellowship for Medical Student Research.

ARK is supported by funding from the University of North Carolina Renal Epidemiology Training Grant (NIH/NIDDK 5T32DK007750-16) and Medical Scientist Training Program (NIH T32 GM008719).

References

- Baechele C, Castillo K, Straßburger K, Stahl-Pehe A, Meissner T, Holl RW, Giani G, Rosenbauer J. Is disordered eating behavior more prevalent in adolescents with early-onset type 1 diabetes than in their representative peers? *Int J Eat Disord*. 2014; 47:342–352. [PubMed: 24375553]
- Blundell J, de Graaf C, Hulshof T, Jebb S, Livingstone B, Lluch A, Mela D, Salah S, Schuring E, van der Knaap H, Westerterp M. Appetite control: methodological aspects of the evaluation of foods. *Obes Rev*. 2010; 11:251–270. [PubMed: 20122136]
- Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006; 3:77–101.
- Broussard, JL., Reynolds, AC., Depner, CM., Ferguson, SA., Dawson, D., Wright, KP, Jr. Biological Timekeeping: Clocks, Rhythms and Behaviour. Springer; 2017. Circadian Rhythms versus Daily Patterns in Human Physiology and Behavior; p. 279-295.
- Clark M. Is weight loss a realistic goal of treatment in type 2 diabetes? The implications of restraint theory. *Patient Educ Counsel*. 2004; 53:277–283.
- Daneman D. Type 1 diabetes. *Lancet*. 2006; 367:847–858. [PubMed: 16530579]
- Demirel F, Tepe D, Kara O, Esen I. Microvascular complications in adolescents with type 1 diabetes mellitus. *J Clin Res Pediatr Endocrinol*. 2013; 5:145–149. [PubMed: 24072081]
- Dewan S, Gillett A, Mugarza JA, Dovey TM, Halford JC, Wilding JP. Effects of insulin-induced hypoglycaemia on energy intake and food choice at a subsequent test meal. *Diabetes Metab Res Rev*. 2004; 20:405–410. [PubMed: 15343587]
- Driscoll KA, Corbin KD, Maahs DM, Pratley R, Bishop FK, Kahkoska A, Hood KK, Mayer-Davis E. Biopsychosocial aspects of weight management in type 1 diabetes: a review and next steps. *Curr Diabetes Rep*. 2017; 17:58.
- DuBose SN, Hermann JM, Tamborlane WV, Beck RW, Dost A, DiMeglio LA, Schwab KO, Holl RW, Hofer SE, Maahs DM. N. Type 1 diabetes exchange clinic, R. Diabetes prospective follow-up, obesity in youth with type 1 diabetes in Germany, Austria, and the United States. *J Pediatr*. 2015; 167:627–632. e621–624. [PubMed: 26164381]
- Hasken J, Kresl L, Nydegger T, Temme M. Diabulimia and the role of school health personnel. *J Sch Health*. 2010; 80:466–514. 465–469. quiz.
- Herman CP, Mack D. Restrained and unrestrained eating. *J Pers*. 1975; 43:647–660. [PubMed: 1206453]
- Herman CP, Polivy J. Anxiety, restraint, and eating behavior. *J Abnorm Psychol*. 1975; 84:66–72.
- Huxley RR, Peters SA, Mishra GD, Woodward M. Risk of all-cause mortality and vascular events in women versus men with type 1 diabetes: a systematic review and meta-analysis. *Lancet Diabetes Endocrinol*. 2015; 3:198–206. [PubMed: 25660575]

- Kahkoska A, Mayer-Davis E, Hood K, Maahs D, Burger K. Behavioural implications of traditional treatment and closed-loop automated insulin delivery systems in Type 1 diabetes: applying a cognitive restraint theory framework. *Diabet Med*. 2017
- Kaminsky LA, Dewey D. The association between body mass index and physical activity, and body image, self esteem and social support in adolescents with type 1 diabetes. *Can J Diabetes*. 2014; 38:244–249. [PubMed: 25092644]
- King N, Cassell C, Symon G. Qualitative methods in organizational research: a practical guide. *The Qualitative Research Interview*. 1994:17.
- Knight LJ, Boland FJ. Restrained eating: an experimental disentanglement of the disinhibiting variables of perceived calories and food type. *J Abnorm Psychol*. 1989; 98:412–420. [PubMed: 2592675]
- Liu LL, Lawrence JM, Davis C, Liese AD, Pettitt DJ, Pihoker C, Dabelea D, Hamman R, Waitzfelder B, Kahn HS. S.f.D.i.Y.S. Group. Prevalence of overweight and obesity in youth with diabetes in USA: the SEARCH for Diabetes in Youth study. *Pediatr Diabetes*. 2010; 11:4–11. [PubMed: 19473302]
- Maahs DM, Daniels SR, de Ferranti SD, Dichek HL, Flynn J, Goldstein BI, Kelly AS, Nadeau KJ, Martyn-Nemeth P, Osganian SK, Quinn L, Shah AS, Urbina E. Cardiovascular disease risk factors in youth with diabetes mellitus: a scientific statement from the American Heart Association. *Circulation*. 2014; 130:1532–1558. [PubMed: 25170098]
- Markowitz JT, Butler DA, Volkeneing LK, Antisdell JE, Anderson BJ, Laffel LM. Brief screening tool for disordered eating in diabetes: internal consistency and external validity in a contemporary sample of pediatric patients with type 1 diabetes. *Diabetes Care*. 2010; 33:495–500. [PubMed: 20032278]
- Martyn-Nemeth P, Quinn L, Penckofer S, Park C, Hofer V, Burke L. Fear of hypoglycemia: influence on glycemic variability and self-management behavior in young adults with type 1 diabetes. *J Diabetes Complicat*. 2017; 31:735–741. [PubMed: 28143733]
- Mayer-Davis EJ, Bell RA, Dabelea D, D'agostino R, Imperatore G, Lawrence JM, Liu L, Marcovina S. The many faces of diabetes in American youth: type 1 and type 2 diabetes in five race and ethnic populations: the SEARCH for Diabetes in Youth Study. *Am Diabetes Assoc*. 2009
- Minges KE, Whittemore R, Chao AM, Jefferson V, Murphy KM, Grey M. Clinical, psychosocial, and demographic factors are associated with overweight and obesity in early adolescent girls with type 1 diabetes. *Diabetes Educat*. 2016; 42:538–548.
- Morse SA, Ciechanowski PS, Katon WJ, Hirsch IB. Isn't this just bedtime snacking? The potential adverse effects of night-eating symptoms on treatment adherence and outcomes in patients with diabetes. *Diabetes Care*. 2006; 29:1800–1804. [PubMed: 16873783]
- Must A, Anderson S. Body mass index in children and adolescents: considerations for population-based applications. *Int J Obes*. 2006; 30:590.
- Page KA, Seo D, Belfort-DeAguiar R, Lacadie C, Dzuira J, Naik S, Amarnath S, Constable RT, Sherwin RS, Sinha R. Circulating glucose levels modulate neural control of desire for high-calorie foods in humans. *J Clin Invest*. 2011; 121:4161–4169. [PubMed: 21926468]
- Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt impulsiveness scale. *J Clin Psychol*. 1995; 51:768–774. [PubMed: 8778124]
- Peterson CM, Fischer S, Young-Hyman D. Topical review: a comprehensive risk model for disordered eating in youth with type 1 diabetes. *J Pediatr Psychol*. 2015; 40:385–390. [PubMed: 25502449]
- Pihoker C, Badaru A, Anderson A, Morgan T, Dolan L, Dabelea D, Imperatore G, Linder B, Marcovina S, Mayer-Davis E, Reynolds K, Klingensmith GJ. S.f.D.i.Y.S. Group. Insulin regimens and clinical outcomes in a type 1 diabetes cohort: the SEARCH for Diabetes in Youth study. *Diabetes Care*. 2013; 36:27–33. [PubMed: 22961571]
- Pinhas-Hamiel O, Levy-Shraga Y. Eating disorders in adolescents with type 2 and type 1 diabetes. *Curr Diab Rep*. 2013; 13:289–297. [PubMed: 23266564]
- Pinhas-Hamiel O, Hamiel U, Levy-Shraga Y. Eating disorders in adolescents with type 1 diabetes: challenges in diagnosis and treatment. *World J Diabetes*. 2015; 6:517–526. [PubMed: 25897361]
- Polivy J, Coleman J, Herman CP. The effect of deprivation on food cravings and eating behavior in restrained and unrestrained eaters. *Int J Eat Disord*. 2005; 38:301–309. [PubMed: 16261600]

- Polsky S, Ellis SL. Obesity, insulin resistance, and type 1 diabetes mellitus, *Current Opinion in Endocrinology. Diabetes and Obesity*. 2015; 22:277–282.
- Powers MA, Richter SA, Ackard DM, Craft C. Diabetes distress among persons with type 1 diabetes: associations with disordered eating, depression, and other psychological health concerns. *Diabetes Educat*. 2017; 43:105–113.
- Price SA, Gorelik A, Furlanos S, Colman PG, Wentworth JM. Obesity is associated with retinopathy and macrovascular disease in type 1 diabetes. *Obes Res Clin Pract*. 2014; 8:e178–e182. [PubMed: 24743014]
- Prodan F, Cadario F, Bellone S, Trovato L, Moia S, Pozzi E, Savastio S, Bona G. Obestatin levels are associated with C-peptide and antiinsulin antibodies at the onset, whereas unacylated and acylated ghrelin levels are not predictive of long-term metabolic control in children with type 1 diabetes. *J Clin Endocrinol Metabol*. 2014; 99:E599–E607.
- Purnell JQ, Hokanson JE, Marcovina SM, Steffes MW, Cleary PA, Brunzell JD. Effect of excessive weight gain with intensive therapy of type 1 diabetes on lipid levels and blood pressure: results from the DCCT. *Diabetes Control Complicat Trial JAMA*. 1998; 280:140–146.
- Purnell JQ, Braffett BH, Zinman B, Gubitosi-Klug RA, Sivitz W, Bantle JP, Ziegler G, Cleary PA, Brunzell JD. DCCT/EDIC research group Impact of excessive weight gain on cardiovascular outcomes in type 1 diabetes: results from the diabetes control and complications trial/epidemiology of diabetes interventions and complications (DCCT/EDIC) study. *Diabetes Care*. 2017 Dec 1; 40(12):1756–1762. [PubMed: 29138273]
- Riessman, CK. *Narrative Analysis*. Sage; 1993.
- Siminerio LM, Albanese-O'Neill A, Chiang JL, Hathaway K, Jackson CC, Weissberg-Benchell J, Wright JL, Yatvin AL, Deeb LC. American Diabetes A. Care of young children with diabetes in the child care setting: a position statement of the American Diabetes Association. *Diabetes Care*. 2014; 37:2834–2842. [PubMed: 25249671]
- Snethen JA, Broome ME, Cashin SE. Effective weight loss for overweight children: a meta-analysis of intervention studies. *J Pediatr Nurs*. 2006; 21:45–56. [PubMed: 16428013]
- Diabetes Control Complicat. Trial Res. 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*. 329:977–986.
- Turconi G, Guarcello M, Maccarini L, Bazzano R, Zaccardo A, Roggi C. BMI values and other anthropometric and functional measurements as predictors of obesity in a selected group of adolescents. *Eur J Nutr*. 2006; 45:136–143. [PubMed: 16010452]
- van Strien T, Oosterveld P. The children's DEBQ for assessment of restrained, emotional, and external eating in 7- to 12-year-old children. *Int J Eat Disord*. 2008; 41:72–81. [PubMed: 17634965]
- Verrotti A, Catino M, De Luca FA, Morgese G, Chiarelli F. Eating disorders in adolescents with type 1 diabetes mellitus. *Acta Diabetol*. 1999; 36:21–25. [PubMed: 10436248]
- Virginia B, Victoria C. Using thematic analysis in psychology. *Qual Res Psychol*. 2006; 3:77–101.
- Westerberg DP. Diabetic ketoacidosis: evaluation and treatment. *Am Fam Physician*. 2013; 87:337–346. [PubMed: 23547550]

Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.obmed.2017.12.001>.

Fig. 1.

Theoretical Framework of Weight Management in T1DM Diabetes. **Panel A:** A thematic map of two major and opposing concepts—antagonism and synergism between type 1 diabetes and weight management—and the associated subthemes. Four interrelated themes of antagonism between type 1 diabetes and weight management were expressed in all groups, including dysregulated appetite, disruption of blood glucose levels associated with changing diet/exercise, hypoglycemia as a barrier to weight loss, and the overwhelming nature of dual management. Two interrelated themes of synergism between type 1 diabetes and weight management were expressed— improved health behaviors underlying both outcomes an exercise as a tool for weight and glycemic control. **Panel B:** Key components of weight management in type 1 diabetes and related themes and subthemes. Red lines denote a corrective relationship between key components and subthemes of antagonism. Green arrows denote a supportive relationship between key components and subthemes of synergism. Intensified T1DM management was proposed to prevent appetite dysregulation and overeating associated with hyper- and hypoglycemia, to mitigate the expected glycemic excursions associated with changing diet and exercise, and to decrease the frequency of non-severe hypoglycemia that may be associated with increased exercise. Incorporation of a healthful diet and a heavy emphasis on exercise in the proposed weight management plan

supported the idea of healthy behaviors underlying both the outcomes of glycemia and weight. The heavy emphasis of exercise as a tool for weight, and glycemic control was reflected by the central role of exercise in the weight management program proposed by participants. An individualized and flexible program allows for the day-to-day shifts due to episodes of non-severe hypoglycemia and was offered as a way to mitigate the overwhelming nature of dual management. The proposed element of psychosocial and peer support addresses the overwhelming nature of dual management and was closely related to positive effects of group-based exercise.

Table 1
 Characteristics of Study Participants. Focus groups were stratified by gender and weight status.

Characteristic	All Youth ^a (n=34)	Females (n=18)	Males (n=16)	p-value ^c	Normal Weight ^b (n=8)	Overweight ^b (n=26)	p-value ^d
Demographic Characteristics							
Age, years; mean (SD)	14.1 (3.0)	14.7 (1.8)	13.4 (3.9)	.22	14.1 (2.0)	14.0 (3.3)	.64
Diabetes duration, years; mean (SD)	6.6 (3.3)	6.5 (3.3)	6.7 (3.4)	.81	4.6 (3.4)	7.2 (3.0)	.22
Female sex; n (%)	18 (52.9)	–	–	–	5 (62.5)	13 (50.0)	.69
Race/Ethnicity; n (%)							
Non-Hispanic White	20 (58.8)	11 (61.1)	14 (87.5)	.08	6 (75.0)	19 (73.1)	1.00
Non-Hispanic African American	6 (17.6)	6 (33.3)	2 (12.5)	.15	2 (25.0)	6 (23.1)	1.00
Hispanic	8 (23.5)	3 (16.7)	3 (18.8)	.87	0 (0.0)	6 (23.1)	.30
Clinical Characteristics							
HbA1c ^e , %; mean (SD)	8.9 (1.8)	9.2 (1.8)	8.6 (1.8)	.34	8.1 (2.1)	9.2 (1.7)	.37
Body mass index (BMI) ^e ; mean (SD)	26.1 (4.7)	26.7 (5.0)	25.4 (4.2)	.42	20.8 (3.0)	27.7 (3.8)	.005
Pump Users; n (%)	19 (55.9)	11 (61.1)	8 (50.0)	.51	5 (62.5)	14 (53.9)	1.00
Eating Behaviors							
Disordered Eating Behavior ^f	13.6 (8.6)	17.8 (8.5)	8.9 (5.9)	.001	9.8 (9.0)	14.8 (8.2)	.31
General Impulsivity ^g	35.5 (3.6)	24.9 (2.9)	36.2 (4.2)	.30	35.8 (3.0)	35.4 (3.8)	.81
Emotional Eating ^h	22.3 (11.4)	27.1 (12.5)	16.8 (7.2)	.007	23.9 (13.3)	21.8 (11.0)	.64
External Eating ^h	23.6 (6.7)	25.6 (7.2)	21.4 (5.5)	.07	24.6 (6.1)	23.3 (6.9)	.61
Restrained Eating ^h	17.0 (6.5)	17.7 (7.0)	16.2 (6.1)	.50	14.8 (6.0)	17.7 (6.6)	.37

^a18 youth were at CU (53%) and 16 youth were at UNC (47%).

^bNormal weight defined as a body mass index < 25. Overweight was defined as a body mass index ≥ 25.

^cFor continuous measures presenting means (standard deviation), the p-values are from t-tests. For categorical variables, the p-values are from chi-squared tests.

^dFor continuous measures presenting means (standard deviation), the p-values are from Wilcoxon rank sum tests. For categorical variables, the p-values are from Fischer's Exact tests.

^eHbA1c and BMI obtained from most recent clinic visit.

^fDisordered eating behavior was measured with the diabetes-specific Diabetes Eating Problem Survey-Revised (DEPS-R); scores of 20 or greater indicate need for further evaluation for DEB.

^gGeneral impulsivity was measured by the 15-item version of the Barratt Impulsivity Scale (BIS-15).

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Emotional eating (eating in response to emotional arousal states such as fear, anger or anxiety), externality (eating in response to external food cues such as sight and smell of food), and restrained eating behavior/dietary restraint (conscious efforts to limit and control dietary intake) were measured by the Dutch Eating Behavior Questionnaire (DEBQ).

Table 2

Participants describe antagonism between type 1 diabetes and weight management.

Subtheme	Illustrative Quote	Source ^a
2.A. Appetite Dysregulation		
2.A.1. Increased appetite in hypoglycemia	Yeah when I'm low I tend to get really hungry when I'm high I just tend you know I don't really feel like I need anything at all.	OW M
	Like, I can't get full until I'm back up in range.	OW M
	I have problems with like, I know that it's low, so I'm like okay I can eat this. And then I eat a little bit more than I'm supposed to eat so then it shoots it back up again.	NW F
	When my blood sugar gets low, I eat too much. Like you don't, it doesn't hit you then. But later you feel like you ate too much. Like you overate.	OW M
2.A.1.A. Nighttime binges	S1: When I wake up in the middle of the night, I usually go downstairs, and I eat a lot of food. Like, a lot of food.	NW M
	S2: I treat it like normal ... And I mean, it's hard to fight the urge, but I know I have to because it's going to screw up my blood sugar if I don't.	
	I remember one time my grandparents had come. It was my grandpa's birthday or something and we had cake and they left some of the cake for us. And apparently during the middle of the night on a low, I went to the kitchen and had a big slice of cake and a juice and I forgot to treat it and I woke up with like a 500.	OW M
	The middle of the night is like the worst for me ... I'll just go downstairs and like all I want to do is sleep so I'll just eat everything and then go to sleep and then I won't pay attention to my blood sugar cause I'll be asleep so then I'll wake up at 300 or 250 or something like that and I'll be like, aw darn.	OW F
2.A.2 Decreased appetite in hyperglycemia	S1: I think I'm less hungry maybe, more thirsty and like I don't really want to eat. It's like I feel sick or I don't want to make it worse.	OW F
	S2: You get nauseous and really thirsty.	
	I mean when I'm high there's just two extremes and there's no in between. I'm either really, really hungry or I'm not hungry at all.	OW M
2.A.3 Increased appetite in hyperglycemia	For me it's a bit weird I do get hungry when I'm low but I also seem to get hungry when I'm high as well.	OW M
	When mine is high, I want to keep going. Like just keep eating. Like I know that it's high, but i still feel like I'm hungry.	NW F
2.B.1. Fear of glucose highs/lows prevents changes	<i>F: What would you say to someone with T1DM diabetes just starting a weight loss plan for the first time?</i>	NW M
	S1: Be careful.	
	<i>F: Of?</i>	
	S2: highs and lows, just make sure you're managing it all the time.	
2.B. Changing Diet/Exercise Disrupts Blood Glucose		
2.B.2. Eating/drinking without hunger	I [try to eat when I am not hungry because] first of all I might get hungrier later in the day, and it's easier like that. I wouldn't have to take less insulin. I wouldn't have to get low later in the day or anything like that. I try to eat whenever I can.	NW M
2.C. Hypoglycemia as a Barrier to Weight Loss		
2.C.1. Forced to eat more calories	When you're trying to lose weight it's like your diabetes is telling you 'no, you have to keep on eating.' ... Like say you're trying to eat less, and when you eat less you go low. It's like your diabetes telling you 'no I want you to eat.'	OW F
	<i>F: What, if anything, gets in the way of losing weight?</i>	NW M
	S1: Well, if you are trying to lose weight you might have a lot more lows and you would have to eat more than usual.	
	S2: I mean if you are running around a lot trying to exercise then you're gonna go low, yeah.	
2.C.2. Ingest lower quality food	<i>F: If you are low all the time how does it affect weight loss?</i>	NW M
	S1: If you are low all the time you would eat more.	

Subtheme	Illustrative Quote	Source ^a
2.C.3. Prevents or stops exercise	S2: Or eat more things with sugar and carbs.	
	S1: more sugar less substance.	
	I think my biggest like issue or barrier is when I'm exercising and I have to like stop cause my blood sugar is low but then I get so defeated cause I'm like well I was exercising but now I can't but now I'm eating so it's like cancelling that out and I'm like what's the point of even exercising.	OW F
	<i>F: Why do you think it is hard for kids and teenagers with type 1 diabetes to lose weight?</i>	OW M
	S1: Um just because of low blood sugars....Um just because they get in the way of doing things. You can't just drink and juice ...	
	S2: And go	
	S1: ... and just keep doing what you're doing because then you're just going to keep going low.	
	S2: 'Cause you have to like wait 15 min and check again. And then wait a little bit more and make sure it doesn't drop back down. So it could be kinda discouraging.	
	S1: Mmhhh. You wait 15 min and while you're waiting you're thinking about working out. And you're like 'uh do I really want to do this?'	
	S1: ... And you're like 'I'll just go home, I already wasted 15 min. It's low.'	
2.C.4 Fear of Hypoglycemia	It's getting in the way of me trying to do certain things that I want like trying to lose weight....I make sure that I don't take too much insulin or anything, and yet ... Diabetes is saying, 'screw you we're gonna do it our way.'	OW F
	For me it's like I always want to lose weight but it's just so hard like for me like I play sports and when I am playing then a lot of times like I have to stop cause I'm low and then I'm like oh well one I'm not exercising and now I'm eating so it kind of like cancels out my work.	OW F
	I tend to just clear a large swath of food in a cabinet I really overreact I mean it feels a lot worse than it actually is usually so I'll tend to think that the more carbs that I have the better... Well I don't know it's just when I get low I tend to like I don't know it's generally the way it's psychological I mean it's just my thoughts get really scattered and it feels like I'm actually building towards something or really crashing it feels very drastic in my mind compared to what's happening and so I feel like I associate getting out of that state or that fall with you know consuming carbs and so logically I consume as much as I can in order to avoid that.	OW M
	For as long as I've had diabetes I knew going into losing weight that I was gonna go low a lot because that's just what happens when you work out or have physical activity. That's just how it works. And if you haven't had diabetes that long, you might not know that. And you go into working out and you might start freaking out because you go low.	OW M
	I think with losing weight, there's so much that goes into it. And then with diabetes, there's so much going into it. So then like trying to stay on top of both things at the same time is difficult.	NW F
	Compared to other people, we just need to pay attention to what we eat a lot more. And I feel like that kind of makes it difficult too.	OW F
	S2: Just like what she said, teenagers themselves trying to lose weight is hard and diabetes you have to eat at certain times, eat certain stuff ... It's like whenever you're not hungry, you eat anyway. You have to eat or your sugars mess up - you go high, you go low. That's tough.	OW F
	S3: Constantly worrying about your diabetes is stressful enough, so trying to worry about making sure you're not dropping or going high, and making sure you're exercising and eating the right amount every day is just a lot to think about	
	2.D. Overwhelming Nature of Dual Management	
	S1: Like the three factors that go into it, if you're trying to lose weight and you exercise a lot, then you have to decrease your insulin, but then it's not enough, you have to eat more or ... It's just more complicated than someone without diabetes.	OW F
2.D.1. No simple instructions	S2: You don't know just off the bat what you need to adjust your amounts and dosages to. So it takes a long period of time of figuring out... You don't end up wanting to wait the entire time to figure out.	

Abbreviations F = facilitator. P1, P2, P3, etc. designate distinct speakers.

^aNW = normal weight (BMI < 25). OW = overweight (BMI ≥ 25). F = females. M = males.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3

Participants describe synergism between type 1 diabetes and weight management.

Subtheme	Illustrative Quote	Source ^a
3.A. Improved Health Behaviors		
3.A.1. Healthful diet	Honestly, I would tell them to eat better... The food that you eat ... It all depends on what you put in your body. You wanna put good things into your body. Put good things in, get good things out.	OW F
3.A.2. Improved blood glucose levels	Just like persistence. Persistence is key. You can't just do it for a week and expect to drop like 20 pounds. I would say if you keep on a certain diet, your blood sugars are eventually going to kind of stay with you. If you're just kind of all over the place with your eating and with what you eat, I think that it's just going to be a lot harder. Well it is for me anyways. If I have a really carb-heavy day, then of course my blood sugars are going to keep going up, and it's just like I have to maintain the kind of foods that I eat.	OW F
	Like you can't really cut out certain things. Like for me, I'm vegetarian and I'm going vegan. I think it's contributed to me and my health like substantially. Whenever I cut out meat, I cut out meat two and a half years ago, I was able to get my pump because my A1c was going down and I was balancing out my blood sugars a lot more. And as I just started cutting out more unhealthy food, my blood sugars were just staying really level.	OW F
	I remember I started trying to keep my weight under control a few years ago but I've really gotten more into it recently. When I first started working out, I remember for the first couple of months I had really good sugars because I had started working out.	OW M
3.B. Exercise for Weight and Glycemic Control		
3.B.1. Exercise preferable to dieting	<i>F: What about the difference between exercise and diet in terms of managing your blood sugar? Is one harder or easier?</i> S1: Exercise is probably easier I would say. Because with the dieting it's bound to either spike from not taking your medicine because you're not having anything to eat, or drop so low you have to go to the hospital or something. I don't like I try and eat, like you said earlier, I try and eat healthier but I'm not going to cut down on how much I eat. I'd rather just workout more than eat less. You don't notice it when you're exercising. It's just kinda like something fun, but helping you. Dieting is not really fun ...	OW M
3.B.2. Fun or social activities	<i>F: Have you found any ways to make managing weight easier?</i> S1: Having fun activities to do. Like the dancing we said is like a fun thing to do and you're also losing weight. So finding activities like that you really enjoy. S4: Mine is playing softball. Cause my coach she stays on me, I tell her she stays on me. If I don't check it before a game, I can't play that game. If I don't take my insulin before the game, I can't play that game. Softball pretty much for me.	NW F
3.B.3. Mindfulness	And I feel like when you exercise it makes you feel better because you can sort of see it. You see the sweat. You hear your breaths. You can tell that you are working your body hard. And that just sort of helps your mind get to a state where it's like this is why I'm doing this. I'm doing this so that I can lose weight and keep my diabetes under control. That's important with both I think. Weight loss, weight gain and diabetes. I think it kinda tells your body what you're gonna do and you can adapt to that kind of lifestyle.	OW M

Abbreviations: F = facilitator. P1, P2, P3, etc. designate distinct speakers.

^aNW = normal weight (BMI < 25). OW = overweight (BMI ≥ 25). F = females. M = males.

Table 4

Participants describe key components of weight management in type 1 diabetes.

Subtheme	Illustrative Quote	Source ^d
4.A. Intensified Diabetes Management	<i>F: Have you found any ways to make managing your weight easier, or what do you think would make it easier?</i>	NW M
	S1: What I have found, if you are trying to lose or gain weight, you just have to watch it more closely, that's about it. If you have good control, then you are all good.	
	S2: I would say something like a sensor would be super important in a case like that, like a CGM.	
	<i>F: If you were to design a program for people with type 1 diabetes, and the goal was for them to lose weight, what would you recommend? What would you recommend?</i>	OW M
	S1: Log what you eat. Log the exercise you do.	
	<i>F: If you could design a program for a weight management plan for people with T1DM diabetes, what would it include? Why?</i>	NW M
4.B. Healthy Diet with Known Carbohydrate Content	S1: it would include regular checks of blood sugar, like, 12 times a day, or a sensor, something like that.	
	S2: Probably a calculator, for your stuff, they have them on pumps.	
	I: I would include like their doctor that like sets their like settings on their pump just because like if you're changing your diet then you have to change your stuff so yeah	OW F
	Trying to keep your sugars in range just cause when you're low you'll eat a lot more.	OW M
	S1: I would have plates for everybody. Like I know you're supposed to have a handful of whatever and like two handfuls of whatever. Like I don't like my food touching anyways so I always have it like sectioned out. But that does help.	NW F
	<i>F: So, would that be specifically helpful for like measuring food or carb counting?</i>	
4.C. Exercise	S1: Um carb counting, and just yeah ... carb counting.	
	S2: I think it would be important to have a schedule for when you are checking you sugar.	
	Maybe changes in not necessarily the amount of food, but the quality of food, like he was saying earlier. Like, proteins, fats, calories, shifts in those.	NW M
	<i>F: If you could design a program for a weight management plan for people with T1DM diabetes, what would it include?</i>	NW F
	S1: Probably some workout videos, you know. That like diabetics and other people can use to. Like not just for certain people. It can be like cycling videos I guess.	
	S2: Mine would be like more sports. Cause you can lower your blood sugar down with sports.	
4.D. Individualization and Flexibility	I: Get in to sports.	
	<i>F: Why are sports key?</i>	
	I: For you to exercise and manage your diabetes and all that.	
	I think [a plan] depending on how much weight they're trying to lose, and how much they're exercising, how much they're eating. It could be like a formula that will help that decrease with all those factors included.	
	S1: I think like a lot of the programs we were talking about earlier like Weight Watchers or I don't remember the title of what you said but like they're just unreasonable like especially for someone with diabetes because	OW F
	S2: Because you can't be starving yourself.	
	S3: Yeah cause if you if you're starving yourself you'll probably go low and then it's just like that would just like mess up the whole reason why you're doing it.	
	S1: And it doesn't seem like it takes into account like being high and being low like the point system like oh my god I'm low and it won't go up so now I've used all my points for today but now I know I'm going to be hungry for dinner or something like that so I think it has the program has to take into account something that's going to be reasonable and like account for like...the different parts of diabetes.	
	S2: I think no day is doubled like you don't have the same day twice...I think like what you said was really important like no day is the same and I think a program would need to this is kind of	

Subtheme	Illustrative Quote	Source ^a
4.E. Psychosocial and Peer Support	just reiterating that but a program would need to include something that would like take into account that.	
	S1: Yeah I think they should have like we should make like a plan and then like on certain times of the week and like a certain time in the day when you're okay to exercise like you can't exercise right after school cause you're gonna be low but like cause like if you do it like right after a meal that would be cool but like but yeah just like make a plan.	OW F
	S2: Yeah custom.	
	<i>F: If you could design a program for a weight management plan for people with T1DM diabetes, what would it include?</i>	OW M
	S1: I mean I think it'd just be like a fun camp. It wouldn't be like people on treadmills or anything, it'd just be like normal, like we you do outdoor activities, you hike ...	
	S2: Just being active.	
	<i>F: If you guys were going to advise someone or give someone ideas on how to make losing weight easy, what would you say?</i>	OW M
	S1: don't be pessimistic	
	S2: Have fun at least. Do Zumba, I don't know!	
	[Pay attention to] how you're feeling emotionally. Because that's one of the things I have noticed with myself. Like when I was younger and I was sad, my sugar would be like all the way up in the air.	OW M
	S1: buddy system. Motivation.	OW M
	S2: Competition...It makes you push a little harder	

Abbreviations: F = facilitator. P1, P2, P3, etc. designate distinct speakers.

^aNW = normal weight (BMI < 25). OW = overweight (BMI ≥ 25). F = females. M = males.