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Adherence to Diet in Youth with Type 1 Diabetes

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Abstract

This paper reviewed current findings on dietary adherence in youth with type 1 diabetes mellitus (T1DM), discussed factors predicting dietary adherence, and presented directions for future research. The search terms were: type 1 diabetes mellitus; youth (0-22 years); diet; dietary adherence; nutrition; dietary intake; obesity; and complications. The studies involved youth with T1DM, presented dietary adherence data specifically, and/or described usual dietary patterns in youth. Articles that explored predictors had to focus exclusively on dietary adherence. The final sample was 23 articles. Adherence articles were organized into two categories: Eating Behaviors and Macronutrients and Dietary Recommendations. Rates of adherence to eating behaviors ranged from 21-95%. Studies examining macronutrients and dietary recommendations revealed higher than recommended intakes of fat and saturated fat and lower than recommended intakes of fruits, vegetables, and whole grains. Six studies investigated factors predicting dietary adherence. These studies revealed associations with child behavior problems and knowledge deficits. The available literature identified many youth with T1DM struggling with adherence and not meeting dietary guidelines for their disease. Future research should examine diet in youth exclusively on intensive insulin regimens, community-based predictors of diet, and the impact of mood on dietary adherence.

Keywords

type 1 diabetes; adherence; adolescents; children; nutrition

Type 1 diabetes mellitus (T1DM), the most common metabolic disorder of childhood, is characterized by a decline in and later an absence of insulin production by the pancreas which leads to chronic insulin deficiency [1,2]. Without insulin, youth with T1DM are unable to metabolize glucose which leads to a rise in glucose levels [1,2]. Treatment of T1DM involves replacement of insulin in an effort to achieve blood glucose levels that approximate the normal range [2]. This is important as near normal blood glucose levels can reduce the risk for diabetes-related micro- and macro-vascular complications [2-4]. Medical nutrition therapy (MNT) is also an important component of modern diabetes treatment. MNT describes a process of individual counseling to teach patients and families about healthful eating practices to maintain near normal blood glucose levels and to prevent or treat comorbid medical conditions such as obesity, dyslipidemia, and hypertension [2]. Thus

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MNT, with its focus on dietary management, provides an important foundation for diabetes self-care [2].

Dietary Management in T1DM

Central to dietary management in T1DM is monitoring carbohydrate intake and balancing carbohydrate intake and insulin levels [5]. Close adherence to carbohydrate intake recommendations is associated with better glycemic control [6,7]. Moreover, a mismatch between carbohydrate intake and insulin can result in immediate and long-term complications from hypo- and hyperglycemia [2]. It is also important for patients to consume a healthy diet. While there are no disease-specific nutrition guidelines for youth with T1DM, youth are at risk for dyslipidemia and cardiovascular disease (CVD) and several epidemiology studies have demonstrated that many youth with T1DM already had abnormal lipid levels and other risk factors for CVD [8-10]. Thus, it is recommended that youth with T1DM eat a healthful diet according to the 2005 Dietary Guidelines for Americans [11]. These guidelines call for a diet that incorporates fruits and vegetables, whole grain foods, and foods low in fat (Table 1). The American Diabetes Association (ADA) further recommends that all youth with T1DM should attempt to consume no more than 7% of calories from saturated fat [5]. Within the literature, several studies have examined adherence to dietary recommendations in youth with T1DM, but no review of these studies has previously been reported. In the absence of a review to synthesize and evaluate the available research, it is difficult to appreciate the scope of this literature and to identify directions for future research. Thus, the purpose of this article is to complete a **narrative** review of the current literature examining dietary adherence in youth with T1DM. As a secondary goal, this paper presents research identifying factors predicting dietary adherence for youth with T1DM.

Methods

Articles in this review were identified through an electronic database search. The inclusion criteria were: 1- studies that recruited a sample of youth with T1DM (**youth including patients 0-22 years old**), 2- studies that reported usual dietary intake and/or adherence to diet therapy, and 3- studies written in English. Both observation and intervention studies were eligible for review. Similarly, there was no restriction on studies that recruited newly diagnosed youth with T1DM. Studies were excluded if they did not report usual dietary intake, if they did not provide data specific to dietary adherence, and/or if they recruited a mixed sample of youth and adults with T1DM. The electronic search of studies was conducted using PubMed. The search terms used for this review included type 1 diabetes mellitus; youth (0-22 years); diet; dietary adherence; nutrition; dietary intake; and complications. **Based on these parameters, 70 records were initially** identified as potentially relevant for this review. An additional screening of the titles and abstracts was completed by the author leading to the exclusion of 47 records. Thus, the final sample for this review included 23 articles (Figure 1). Four articles **focused** exclusively on adherence to eating behaviors in youth with T1DM, while 13 studies **reported** on adherence to recommendations for macronutrient intake and dietary quality. Six articles examined predictors of dietary adherence in youth with T1DM (Table 2). The studies used different strategies to measure adherence including standardized food records [8,12-16], 24 hour recall [17-22], weighed diet diaries [6,21], food frequency questionnaires [23], and standardized adherence measures [7]. Eleven studies sampled youth from a wide age range (e.g. 2-19 years) [8,12,15,17,¹⁹,²¹,²³,24,26,29,30], while the remaining studies targeted youth from specific age groups (e.g., adolescents, young children) [6,7,13,14,¹⁶,¹⁸,²⁰,22,25,27,28]. For clarity, in the discussion of results, the specific age group was named, if applicable.

Results

Eating behaviors

Studies focused on adherence to eating behaviors examined on how well youth balanced their intake of carbohydrates with their blood glucose and insulin levels. In addition, **two** older studies examined how well youth followed a prescribed schedule for meals and snacks. In two studies which measured adherence using a standardized interview conducted with youth and parents, researchers found adherence rates ranging from 21-66% with higher values suggesting better adherence [7,24]. In the first study [24], youth followed a fixed carbohydrate regimen and their adherence rates ranged from 21-56% for their regimen. In contrast, Mehta et al. [7], interviewed youth who were primarily following a flexible insulin (and carbohydrate) regimen and their adherence rate was 66% for their regimen.

Overby et al. [12], measured dietary adherence according to the number of meals or snacks consumed by youth in a week. Using standardized food records, the results identified only 5% of youth skipping breakfast and dinner more than five times per week, **indicating 95%** of youth were adhering to recommendations regarding eating frequency. In contrast, an earlier study using 24 hour recalls, found youth were eating only 5 times per day when 6 times per day was recommended, suggesting youth were not adherent to this recommendation [17].

Macronutrient and Dietary Recommendations

Adherence to macronutrient recommendations was the most studied aspect of dietary adherence in youth with T1DM. Studies revealed that youth with T1DM consumed more fat and saturated fat than age-based recommendations [6,13-15,18-21,23] and more than healthy controls [8,15,18,19]. Youths' total percent of calories from fat ranged from 31-47%, which was higher than the Healthy People 2010 recommendation of <30%. Similarly, youths' mean percent of calories from saturated fat ranged from 11-15%, which was higher than the ADA recommendation of <7% [5]. However, two studies did not find greater than recommended total fat intake in youth with T1DM. In a sample of adolescents (13-17 years), Cook et al. [22] found that adolescents met the daily guideline averaging 30% of calories from fat. Likewise, Virtanen et al. [13] found that young children with T1DM (less than 6 years old) consumed only 28% of calories from fat; however, these young children also recorded a daily average of 11% of calories from saturated fat, which exceeded ADA recommendations.

Examining percent of calories from carbohydrates, 10 studies found that youth consumed approximately 50% of calories from carbohydrates, which was within age recommendations [6,8,13,14,¹⁶,18,19,21-23]. Three studies reported on the types of carbohydrates consumed by youth; results indicating that youths' carbohydrate intake consisted primarily of low fiber grains, rice, and potatoes, and limited intake of confections and sweetened beverages [8,9,23]. In contrast, four studies found youth with T1DM consumed fewer carbohydrates than matched controls [8,17,18,20]. For two of these studies, the authors attributed the difference to soda intake, which was relatively uncommon in youth with T1DM [8,18]. The remaining two studies did not speculate on which foods may have accounted for the difference in carbohydrate intake between youth with T1DM and controls [17,20].

With respect to percent of calories from protein, youth with T1DM consumed between 13 to 19% of calories from protein, which was within the guidelines [6,8,13,14,¹⁶,18,19,21,23]. In addition, three studies [8,13,18] found youth with T1DM consumed more calories from protein than controls (16% versus 14%).

Two studies examined adherence to dietary quality recommendations or the number of servings of fruits, vegetables, whole grain foods, and dairy consumed by youth with T1DM per day compared to national age-based recommendations [8,23]. The results found that youth with T1DM consumed significantly less than the recommended number of servings of fruits and vegetables per day. Moreover, one of the studies found that less than 10% of youth met their daily fiber goal [23], while in the other study, youth with T1DM consumed less than one serving of low-fat milk per day [8].

Comparing dietary quality to peers without diabetes, Virtanen et al. [13] found young children with T1DM consumed a slightly better diet with respect to fruit and vegetable intake. In this study, young children with T1DM reported a higher proportion of calories from vegetables (10% versus 6%) than controls and about the same proportion of daily calories from fruits (10% versus 12%) as controls. However, this study did not report on the number of servings of fruits and vegetables consumed by young children with T1DM, rendering it impossible to determine how closely the children's diet approximated daily intake recommendations.

Predictors of Dietary Adherence

Achieving optimal dietary adherence in T1DM is challenging. To be successful there needs to be a high level of cooperation between the parent and child to overcome barriers. The research examining predictors of dietary adherence is relatively new and limited in scope. However, this is an important area for research because it is key to identifying risk factors for poor adherence and developing interventions.

Examining behavior first, one study has identified parent-child mealtime interactions as a predictor of dietary adherence in young children with T1DM (age < 8 years) [25]. In this study, families had at least three meals videotaped in their home which were later coded using a valid behavioral coding system. Dietary adherence was assessed according to deviations from the prescribed number of carbohydrate units per meal which were determined by diet diaries. The findings demonstrated associations between young children's disruptive behavior at mealtimes and their adherence. In addition, parents' use of coercive management strategies was correlated with poorer adherence rates. This project was cross-sectional and the associations do not describe causation. However, the associations do suggest mealtime behaviors may be one factor related to dietary adherence in families of young children with T1DM [25].

Knowledge of diabetes treatment has also been examined as a predictor of dietary adherence and glycemic control. In an older study, the researchers found that youth's knowledge of their dietary regimen accounted for 54% of the variance in their adherence scores [26]. Similarly, two newer studies have found an association between better carbohydrate counting skills and better glycemic control in youth with T1DM [27,28]. Finally, there have been two studies which have explored whether knowledge deficits predict adherence to healthy eating behaviors in youth with T1DM [29,30]. These studies used focus groups to gather data on youth and parents' perceptions of healthy eating for diabetes. The results identified misperceptions of healthy eating practices in T1DM among youth and parents. Specifically, Gellar et al. [30] found youth commonly reported "free" foods (e.g., which in this study included foods high in fat, but low in carbohydrates) as good for diabetes management. Similarly, Mehta et al. [29], found youth and parents identified "healthy" versus "unhealthy" foods based on their effect on glycemic control. For example, parents and youth categorized fruits as "unhealthy" because they can lead to higher post-prandial glucose levels. Thus, study findings suggested a lack of knowledge or misunderstanding of diabetes dietary management may be a risk factor for poorer adherence for some youth.

Conclusion

Medical nutrition therapy is an essential component of modern diabetes treatment and teaches patients and families dietary management in T1DM [2,5]. Close adherence to dietary management has been found to correlate with better glycemic control in youth with T1DM [6,7] and following recommendations for healthy eating may be the best method for preventing or treating comorbid conditions [5]. This review summarized current dietary adherence findings for youth with T1DM in two general areas: Eating Behaviors and Macronutrient and Dietary Recommendations. In addition, the research examining factors predicting dietary adherence was discussed.

Results found adherence to eating behaviors in youth with T1DM varied from 21-95%, depending on the specific behaviors studied and whether youth were following a fixed or flexible carbohydrate regimen [7,12,17,24]. Many youth with T1DM did not adhere to daily recommendations for the intake of fruits, vegetables, and whole grain foods [8,13,23]. Similarly, studies demonstrated that youth were consuming more fat and saturated fat than was recommended [6,8,13-15,18-21,23]. The limited research specifically examining predictors of dietary adherence suggested that poorer adherence was associated with poor parent-child mealtime behaviors and knowledge deficits specific to diabetes dietary management [25-30].

Some limitations to the research include the near complete absence of samples primarily on an intensive insulin and flexible carbohydrate regimen, the lack of a gold-standard measure of dietary adherence for youth with T1DM, and the lack of longitudinal studies examining changes in dietary adherence over time. Addressing these limitations should be the focus of future research. In addition, there is a need for research exploring new predictors of dietary adherence including the food environment and the impact of mood and eating disorders on dietary adherence in youth with T1DM. Finally, there is a need to develop interventions specific to dietary adherence in youth with T1DM and to test these interventions via large randomized clinical trials.

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Figure 1.
Flowchart for main search

Table 1

Dietary Recommendations for Youth: Dietary Guidelines for Americans 2005 [11]

Food group/macronutrient	Recommendation
fruits/vegetables	2 cups of fruit and 2 ½ cups of vegetables per day for a reference diet of 2,000 calories (higher or lower intake required depending on calorie levels). Children should consume a variety of fruits and vegetables. Children should emphasize intake from 5 vegetable subgroups (dark green, orange, legumes, starchy vegetables, other vegetables).
dairy	Children 2-8 years old should drink 2 cups of fat-free or low-fat milk or equivalent milk products per day. Children 9 years and older should drink 3 cups per day.
whole grains	At least half of the grains eaten should be whole grains.
meat and beans	Children should eat lean or lowfat meat, chicken, turkey, and fish. Other sources of protein include nuts, seeds, beans, and peas.
carbohydrates	To eat sufficient amounts of fiber, try to eat whole fruits, vegetables, and whole grains. Try to avoid excessive amounts of calories from added sugars.
fat	Limit intake of fats and oil high in saturated and/or trans fatty acids. Try to consume fats which come from sources of polysaturated and monosaturated fatty acids. Young children (2-3 years) should strive for a diet that has 30-35% calories from fat, while older children (4-18 years) should consume 25-30% calories from fat.

Table 2
Studies addressing dietary adherence in youth with type 1 diabetes mellitus (T1DM)

Author	Location	Sample Size; Patient Age	Main outcomes studied	Method of measurement	Main Results
Mehta et al., 2008	US (5 centers: MA, TX, MD, IL, FL)	n=119; 9-11 years old	Individual adherence score/total adherence	Diabetes Self-Management Profile	Mean of 66% adherence to a flexible insulin and carbohydrate regimen.
Overby et al., 2008	Norway	n=65; 3-19 years old	Number of meals/snacks consumed	Standardized 4-day food records	5% of youth reported skipping breakfast and dinner more than 5 days per week; 20% reported eating more than 2 snacks per week.
Delamater et al., 1988	US (FL)	n=34; M age = 14 years old	Individual adherence score/total adherence	Interview; skills test with food models	Mean of 21-56% adherence to a fixed insulin and carbohydrate regimen.
Johnson et al., 1986	US (FL)	n=168; 6-19 years old	Number of meals/snacks consumed	24-hour recall interview	5 meals per day; 6 meals per day were recommended.
Overby et al., 2007	Norway	n=550; 2-19 years	% calories from fat; other macronutrients	Standardized 4-day food record	% calories from fat exceeded upper limit; Intake for fiber was below recommended levels.
Overby et al., 2007	Norway	n=177; 9-10 and 12-13 years old + Age matched control group	% calories consumed fat/saturated fat	Standardized 4-day food record	% calories fat and saturated fat exceeded upper limits; Daily intake of fruits and vegetables was below recommended levels.
Patton et al., 2007	US (OH)	n=33; ages 2-8 years old	% calories fat, carbohydrate, protein; other macronutrients	Parent reported 3-day diet diary	% calories fat exceeded upper limits; % calories from carbohydrate and protein within recommended levels. 45% of young children met the DRI for calcium.
Helgeson et al., 2006	US (PA)	n=132; 10-14 years old + Age matched control group	% calories fat, carbohydrate, protein	24-hour recall interview	% calories fat exceeded upper limit; % calories from carbohydrate and protein within normal limits.
Lodfalk & Aman, 2006	Sweden	n=174; 13-19 years old + Age matched	% calories fat and saturated fat	4-day food record	Boys with T1DM exceeded upper limit for % calories from fat, while girls did not; % calories from carbohydrate and protein within recommended levels; Boy and girls exceeded upper limit for % calories from

Author	Location	Sample Size; Patient Age	Main outcomes studied	Method of measurement	Main Results
		control group			saturated fat.
Mayer-Davis et al., 2006	US (6 centers: OH, CO, WA, SC, HI, CA)	n=1,511; 10-22 years old	% calories fat, carbohydrate, protein; daily intake of fruit, vegetable, whole grains	Food frequency questionnaire	% calories from fat exceeded upper limit; % calories from carbohydrate and protein were within recommendations; Daily intake of fruits, vegetables, and whole grain was below recommended levels.
Faulkner et al., 2006	US (IL)	n=50; 13-18 years old + Age matched control group	Total grams of fat and saturated fat	24-hour recall interview	Youth with T1DM consumed more grams of fat and saturated fat than youth without T1DM.
Virtanen et al., 2000	Finland	n=38; 0-6 years old + Age matched control group	% calories fat and saturated fat. % calories carbohydrates and protein	5-day food records for children with T1DM; 3-day food records for comparison children	% calories fat within guidelines; % calories saturated fat exceeded upper limit; % calories from carbohydrates and protein were within recommendations.
Randecker et al., 1996	US (PA)	n=66; 0-10 years old	% calories fat, carbohydrates, protein	24-hour recall interview	% calories fat and saturated fat exceeded upper limits; Fiber intake was lower than recommended levels.
Papadaki et al., 2008	Greece	n=41; 6-17 years old + Age matched control group	% calories fat and saturated fat	24-hour recall interview; 3-day diet diary	% calories fat exceeded upper limit; Intake of fruits and vegetables was below the recommended number of servings.
Wilson et al., 2003	US (IL)	n=35; 11-16 years old	% calories fat	Food record	% calories fat exceeded upper limit.
Cook et al., 2002	US (IL)	n=61; 13-17 years old	% calories fat and saturated fat	24-hour recall interview	% calories fat and saturated fat exceeded upper limits.

Predictors of dietary adherence					
Author	Location	Sample Size; Patient Age	Adherence criteria	Assessment method	Main Results
Koontz et al., 2010	US (OH)	n=75; $\bar{M}$ age= 13 years	# correct/100 (total possible)	PedCarbQuiz (PCQ)	Mean PCQ score was 87% (out of 100%). Higher PCQ scores correlated with lower HbA1c ($r = -0.29$).
Mehta et al., 2009	US (MA)	n=67; 4-12 years old	Parent estimated carbohydrate/NDIS estimated carbohydrates	Diet recalls	Parent estimates of carbohydrate intake was 120% of computer calculated estimates. Greater accuracy and consistency in carbohydrate counting correlated with lower HbA1c levels.
Mehta et al., 2009	US (MA)	n=35; 8-20 years old	> association between themes and general recommendations	Focus group	Youth and parents determined "healthy" versus "unhealthy" foods based on their effect on youths' post-prandial glycemic control.
Patton et al., 2007	US (OH)	n=34; 2-8 years old	# carbohydrate grams consumed/recommended levels	Parent-reported 3-day diet diary	Child disruptive behavior and parents' use of coercive/ineffective parenting strategies correlated with poorer dietary adherence.
Gellar et al., 2007	US (MD)	n=140; 7-16 years old	> association between themes and general recommendations	Focus group	Youth named foods low in carbohydrate and high in fat content as good choices for diabetes.
Lorenz et al., 1985	US (TN)	n=97; 9-15 years old	# carbohydrate grams consumed/recommended levels	Interview; skills test based on sample menu/ability to load a buffet plate at a buffet	On average, youth incorrectly answered 1/3 of the knowledge questions. Knowledge accounted for 54% of variance in adherence.