

SYSTEMATIC REVIEW

ADHERENCE TO DIET IN CHILDREN AND YOUTH WITH TYPE 1 DIABETES MELLITUS

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Abstract

Background: This article reviewed current findings on dietary adherence in children and youth with type 1 diabetes mellitus (T1DM). Purpose: The main objective of this study was to implement a systematic review methodology in order to contribute to the literature on the dietary adherence to the patients with T1DM. **Methods:** We performed a systematic literature review among articles published between January 2006 and June 2022 using electronic databases (PubMed and Google Scholar) for all available publications in English. **Results:** The included studies involved children and youth with T1DM, presented dietary adherence data specifically, and described usual dietary patterns in youth. Articles are focus exclusively on dietary adherence. The final sample was 27 articles of last 16 years. 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. The available literature identified many children and youth with T1DM have poor adherence and not meeting dietary guidelines for their disease. **Discussion:** Regarding the diet of children with T1DM, it seemed that it is usually no different from that of their healthy peers. A review of the literature also shows the great interest that exists regarding the factors that can act as inhibitors of compliance. Many youths with T1DM did not adhere to daily recommendations for the intake of fruits, vegetables, and whole grain foods. Last but not least it is found that nutrition education targeting children with T1DM should continue to reinforce healthful dietary patterns while ensuring success with carbohydrate estimation to optimize metabolic control. **Conclusion:** Future research should examine diet in youth exclusively on intensive insulin regimens, community-based predictors of diet, and the influence of mood on dietary adherence.

Keywords: adherence to diet; children; diabetes type 1

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BACKGROUND

Type 1 Diabetes Mellitus (T1DM) is a chronic illness, with increased morbidity and mortality, due to a higher rate of cardiovascular disease among other factors. It is an endocrine disorder which is characterized by autoimmune destruction of pancreatic β -cells resulting in a total lack or minimal secretion of insulin [1,2]. The target hemoglobin A1c (HbA1c) for all children with type 1 diabetes, including preschool children, is recommended to be $<7.5\%$ (<58 mmol/mol) [1]. This target is chosen with the aim of minimizing hyperglycemia, severe hypoglycemia, hypoglycemic unawareness, and reducing the likelihood of development of long-term complications[1]. This results in hyperglycemia and ketosis; thus, insulin replacement is vital to management. In some patients, especially children and adolescents, ketoacidosis is the first clinical manifestation of T1DM 2. Type 1 Diabetes Mellitus affects 5% -10% of cases 490,000 children worldwide [3]. Overall, type 1 diabetes (T1DM) accounts for approximately 5% of diabetes and affects about 20 million individuals worldwide [1,3]. Treatment of T1DM involves replacement of insulin in an effort to achieve blood glucose levels that approximate the normal range. One of the key dimensions of health care quality and improved disease management is adherence to recommended medication therapy and medical nutrition therapy(MNT) [4]. The World Health Organization defines adherence as "the extent to which a patient's behavior—taking medication, following a prescribed diet, and executing lifestyle changes—corresponds with agreed recommendations from the health care provider" [5]. Hence, the poor adherence to the dietary recommendation, is associated with both a high risk of obesity in T1D, which were the same as the general pediatric population and the occurrence of diabetes-related complications [6]. Supporting the family is necessary for promoting health in the pre-school chil-

dren with T1D. Early childhood is important for establishing the health promoting needed for a long life with type 1 diabetes [1].

DIETARY MANAGEMENT IN T1DM

Establishing positive food behaviors and meal-time routines are important for children with type 1 diabetes, as these behaviors impact glycemic control and encourage life-long nutrition practices. Normal early childhood development, including seeking independence, transient food preferences, variable appetite, food refusal, and behavioral resistance often make meal times challenging for parents. Parents of children with type 1 diabetes report more disruptive meal behaviors, including longer meal duration and more frequent food refusal compared with controls, even for children using insulin pump therapy [1]. As well as insulin treatment, a vital part of T1DM therapy is the medical nutritional therapy (MNT) [4]. Medical nutrition therapy is a most important part of diabetes management and diabetes self-management education, moreover it describes a process of individual counseling to educate patients and families about healthful eating practices to maintain near normal blood glucose levels [7]. The 2018 International Society for Pediatric and Adolescent Diabetes (ISPAD) Guidelines recommend as proper nutrition habits for diabetes in children, a diet that allows for normal growth, ideal weight maintenance and the prevention of acute and chronic complications of diabetes mellitus. The approximate energy intake and the essential nutrients should be distributed as follows: carbohydrates 45–55%, fats 30–35% and proteins 15–20% [1]. Dietary recommendation for children and adolescents with diabetes mellitus are the same as those for all healthy children and adolescents. Individualized meal plans should emphasize a wide variety of healthy food choices to meet the recommended nutrient intakes for essential vitamins and minerals, energy, and fiber and to provide for normal growth and development [4]. Nutritional guidelines

are established on the principles of healthy eating based on Mediterranean Diet (MD). Increased nutritional awareness of patients and their families is associated with better glucose control and the high quality of the diet in young people [8]. The traditional MD can be characterized as a plant-based diet containing high amounts of monosaturated fats, omega-3 fatty acids, polyphenols, vitamins and antioxidants, and low amounts of saturated fats and ethanol. The MD provides approximately 35%–45% fats (of which about 20% derives from monounsaturated fatty acids (MUFAs), 5% from polyunsaturated fatty acids (PUFAs) and 9% from saturated fatty acids (SFAs), 15% protein and 45% carbohydrates [9,10]. Moreover, in the MD is included a variety of food components, including unrefined cereals, legumes, fish, vegetables, fruit, nuts, most importantly, olive oil, which is considered the traditional symbol of MD [11].

Eating behaviors, dietary control, and physical activity are perceived as an essential parts diabetes management. Avoidance of deviation in the recommended nutrition is an integral part of the treatment and self-management of T1DM. An important role in the improvement of the diet quality and optimizing glycemic control have the mealtime routine and restriction of snacking [9]. Central to dietary management in T1DM is monitoring carbohydrate intake and balancing carbohydrate intake and insulin levels [12]. Diet and physical activity are critically important in the management of the ABCs (A1C, Blood pressure, and Cholesterol) of type 1 diabetes. To effectively manage glycated hemoglobin (A1C) and achieve stable blood sugar control, it is important to understand how to balance food intake, physical activity, and insulin [7]. Making healthy food choices every day has both immediate and long-term effects. With education and practice it is possible to eat well and control diabetes. Compared to the general population, patients with diabetes have better nutritional education [13,14].

The main objective of this study was to implement a systematic review methodology in order to contribute to the literature on the dietary adherence to the patients with T1DM.

METHODOLOGY

1. The present study

We focused our research in childhood and adolescence and we set particular criteria;

1. We searched only for research which investigate the dietary adherence.
2. We rejected the records that participate young people up to 22 years old,
3. We don't include in our study reviews and meta-analysis.

2. Data Search Process

The guidelines of the Preferred Reporting for Systematic Reviews were followed PRISMA recommendation [14]. A literature search among articles, published between January 2006 and June 2022 was conducted, which is a 16-year period the most recent, that encompasses enough articles to see the relevant trend in nutrition, using electronic databases (PubMed and Google Scholar) for all available publications in English. Keywords included "adherence to diet; children; diabetes type 1". Synonyms were used to increase search sensitivity. References in key papers were also explored. The process of study selection, identification, screening, eligibility and inclusion followed the PRISMA recommendations for a flowchart (Figure 1). Based on the keywords search, 190 titles were retrieved, of which 92 were selected based on title and abstract. All papers were crosschecked and 20 of them removed due to duplication. 72 papers reviewed for selection. As a result, 27 records were eligible, and met criteria for be full reviewed and be included in the study.

Purpose

RESULTS

In the present review, 27 articles were found after the exclusion based on the criteria mentioned above. Below is the Table 1 showing the articles that were finally included in the review as well as the sample number, the methodology followed and the results. The articles were published in the last sixteen years, 2006-2022. Both surveys have been conducted in Greece [15,16], and the rest of them in USA, Europe, UK, Taiwan and Uganda. Regarding the diet of children with T1DM, it seemed that it is usually no different from that of their healthy peers [17,18]. In three studies are showed [18,19,20] the compliance of participants in both the dietary patterns and the mealtime routine. More particular, Lode-falk & Aman [20] proved that patients used to eat more regularly, and more often ate fruit and fruit juice, potatoes and root vegetables, meat, fish, egg, offal and sugar-free sweets than control subjects. On the other hand, control subjects more often ate ordinary sweets and snacks. Moreover 95% of participants ate breakfast as the recommendations [21]. Also, Overby et al [18] reached in this result. In fact, in this search is showed that fewer children and adolescents with type 1 diabetes skip meals compared with healthy peers. Those who skip meals and have more snacking events have poorer glycemic control and less healthy dietary and leisure habits [18]. The same author in an earlier study suggested that the Children with higher fiber and fruit and vegetable intake and lower sugar intake and the recommended number of meals were able to maintain better glycemic control. Moreover, in this study the results showed that a regular meal pattern and high fiber intake are factors that improve HbA 1c in young diabetic patients. Among adolescents, moreover, lower intake of added sugar and sugar-sweetened soft drinks, as well as higher fruits and vegetables intake were observed among patients with optimal compared with suboptimal blood glucose control. The authors supported the policy that dietary guidance should be intensified during adolescence to improve dietary intake, meal pattern and

blood glucose control [19]. It seems that the poor compliance is not associated with the age, sex, duration of diabetes, or insulin regimen but it seems that it is significantly associated with overweighty and obesity [22]. In the other hand in boys, social anxiety is associated with worse diet and insulin injection adherence and this association is not found in girls [23]. In only two studies are included participants with both T1DM and T2DM [24,25]. The family has also been studied in some studies, since the literature shows that it is an integral part of compliance [26,27,28,29]. Regarding the diet of children with T1DM, it seemed that all of included studies agreed with the same diet to their peers without diabetes. The majority of studies are about older children, only 4 studies investigate little children 0 to 8 years old [26,27,28,29]. In these studies, it is showed the vital role of family in the children's dietary compliance. More particularly Patton et al [27] noticed that Children's dietary deviations revealed better-than-predicted adherence to the number and timing of feedings per day and number of carbohydrate units consumed per meal. In contrast, children's daily carbohydrate intake was approximately 80% of the recommended levels based on their weight and age. In addition, children's energy intake was only 78% of the recommended levels based on age. Moreover, young children with type 1 diabetes are likely to have adequate dietary intake of most micronutrients. However, their adherence to specific carbohydrate and energy intake recommendations may be lower [27]. Also, in other study Patton et al [28] demonstrated significant negative associations between children's dietary adherence and two dimensions of family functioning. Affect Management correlated negatively with the percent of blood glucose levels below the normal range. In this study 31% of young children with type 1 diabetes demonstrated mealtime family functioning in the unhealthy range [28]. In fact, parents who perceive more problematic child mealtime behaviors have children with poorer dietary quality, and that achieving better dietary adherence may be associated

with more perceived mealtime behavior problems [30,31]. Due to the fact that the higher parent education is associated with lower A1C [32] it is supporting the importance of educating children with T1DM and families to maintain healthy eating habits [21]. In this study, it is suggested that consuming a healthy diet may also be an important determinant of better health outcomes in young children with type 1 diabetes [31]. Seckold et al [26] emphasized the importance of specific strategies to encourage healthy eating in this age group (>7 years old) as food preferences likely impact future eating habits. The aim of these specific strategies and interventions is to promote dietary quality and particularly vegetable intake in children. In this retrospective, cross-sectional study, the findings regarding poor dietary quality in young children with T1DM. Also, it is suggesting that children are eating diets similar to their peers without diabetes [26]. The variety of food choice is associated with poor compliance both young children 24 and adolescence and youth [22,33]. Moreover, as far as the nutrient intake is concerned it seems that children usually do not comply with the recommendations and their eating habits do not meet their needs [27,32,34,35].

Adolescents with diabetes took in less total energy than recommended. The percentage of calories from carbohydrates and protein were within recommendations for adolescents with and without diabetes, but adolescents with diabetes exceeded the recommended fat intake. Male subjects with diabetes had an especially high intake of saturated fat. Adolescents with type 1 diabetes consume fewer calories from carbohydrates but more calories from fat than adolescents without diabetes and exceed the recommended levels of fat intake. These findings are of concern given the risk that type 1 diabetes poses for cardiovascular disease [36]. Moreover, dietary intake in a large cohort of youth with diabetes substantially failed to meet current recommendations. The poorer diet quality, poorer attitudes related to healthful eating, and lower dietary satisfaction all

support the existence of a maladaptive relationship with food among these youth [36]. There is a critical need for improvement in dietary intake in youth with diabetes [24]. The same result found in other study that were participated patients with approximately the same age and had poor adherence behaviors in each aspect of diabetes mellitus management and diabetes control total glycosylated hemoglobin was very poor [34]. It seemed that Dietary guidance should be intensified during adolescence to improve dietary intake and blood glucose control [19]. Findings suggest that youth with diabetes have a general understanding of healthy eating and face similar barriers and facilitators to healthy eating as nondiabetic children do [37]. The need to increase complex carbohydrates and reduce the consumption of total and saturated fat, in order to approach the traditional dietary pattern of Crete for this population, should be addressed via appropriate nutrition education programs [15]. In one study was evaluated adherence to the Mediterranean diet (MedDiet) among children and adolescents with type 1 diabetes mellitus (T1DM) in relation to metabolic control and the results showed that the adherence Dietary risk factors, typical of low adherence to the MedDiet, were associated with a high risk of obesity in T1DM, which were the same as the general pediatric and adult population [38]. The group with optimal adherence to the MD recommendations scored more points that are associated with eating fruit and vegetable, as well as more frequently consuming fish, whole cereals/grains, and dairy products [39]. On the contrary, the suboptimal adherence to MD group lost points by going more frequently to fast-food restaurants or more frequently consuming commercially baked goods or pastries for breakfast, as well as more frequent skipping of breakfast, or eating sweets and candies more than once a day [6,40]. The associations of fat and fiber intake with glycemic control are consistent with previous research. Associations between increased dietary fat and higher A1c in type 1 diabetes have been previously demonstrated [20]. Nutrition education targeting

children with T1DM should continue to reinforce health-ful dietary patterns while ensuring success with carbo-hydrate estimation to optimize metabolic control. Chil-dren and adolescents whose caretakers are married and

those whose caretakers are divorced/separated were more adherent to type 1 diabetes recommendations in this study [41].

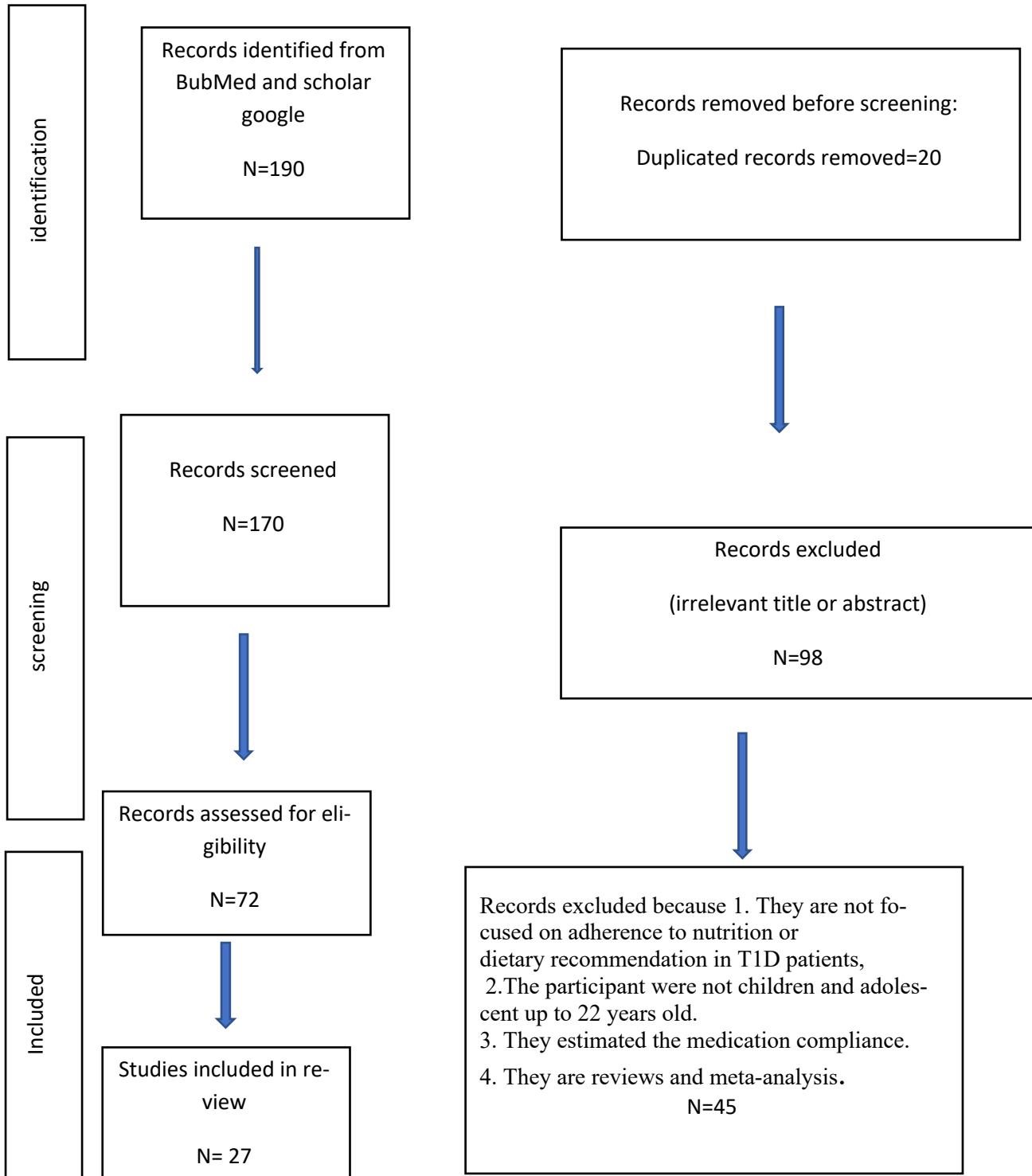


FIGURE 1 | Flow chart of the included studies regarding dietary adherence in patients with T1DM

DISCUSSION

The main aim of this study is to investigate in literature the dietary adherence in children and adolescent with T1DM. Regarding the diet of children with T1DM, it seemed that it is usually no different from that of their healthy peers [18,21]. The fact is that children with T1DM are not meeting dietary guidelines, and in some areas their diets are less healthful than children without diabetes [42,43]. As these dietary behaviors may affect the risk of long-term complications, the incorporation of behavioral approaches promoting healthy eating into routine clinical practice is warranted [44]. Type 1 diabetes patients need to adhere to several treatment parameters such as diet, insulin regimens, and blood glucose monitoring among others specifically because they all contribute to better disease outcomes. Although adherence to type 1 diabetes recommendations has been widely assessed in various studies, most of them assessed adherence incorporating one treatment parameter. For instance, it is seemed that assessed adherence to blood glucose monitoring alone [45], while others assessed diet adherence discretely [46]. Given that improved disease management among type 1 diabetes subjects requires combined adherence to several treatment components [47], it is equally important to understand the extent to which type 1 diabetes patients adhere to all treatment parameters. Moreover, adhering to good dietary practices, keeping insulin injection schedules, and regularly monitoring blood glucose have been found very beneficial in improving treatment outcomes in people with diabetes. Examining percent of calories from carbohydrates, some studies found that youth consumed approximately 50% of calories from carbohydrates, which was within age recommendations [15,20,24,27,36].

Two 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 [24,48]. In other study founded that youth with T1DM consumed fewer carbohydrates than matched controls [36]. In this study, the authors attributed the difference to soda intake, which was relatively uncommon in youth with T1DM [36]. Poor dietary quality in young children with T1DM is supported [31]. Many studies examining dietary intakes in this age group with T1D have found children with T1D consume more dietary fat, including saturated fat than recommended and do not consume sufficient fruit and vegetables [19,31,39]. In terms of nutrient intake, it seems that children usually do not comply with the recommendations and their eating habits do not meet their needs [22,24,49]. Acknowledgement that time of day affects glycemic response to food in T1D is reflected in common use of higher insulin to carbohydrate ratios in the morning as compared to the afternoon [35]. Both overall diet quality and macronutrient distribution were associated with more optimal glycemic control. These findings suggest that glycemic control may be improved by increasing intake of high-fiber, low glycemic-index, carbohydrate-containing foods [50]. A review of the literature also shows the great interest that exists regarding the factors that can act as inhibitors of compliance [16,27,33]. For example, the child's fear of adopting new diets and the fear of impending hypoglycemia are subversive factors. In a study that examined neophobia (ie children's phobia of adopting other eating habits) and the diversity of their dietary choices, it was found that this case is positively related to poor compliance of children with type T1DM [33]. The study involved 252 children with a mean age of 13.2 years and a mean disease duration of 6.3 years. Participants and their parents in the study answered a questionnaire about neophobia, dietary diversity, and diabetes management. The dietary diversity questionnaire had 20 suggested dietary groups and was based

on the Health Eating Index 2005 (HEI 2005). The results showed that the average child prefers to eat 8 of the 20 food groups. Most children preferred non-citrus fruits (74%), whole grains (94%) and low-fat dairy products (87%) [33]. Adherence to healthy diet recommendations for daily energy intake and range of intake of macronutrients are essential in the management of diabetes and prevention of diabetes-related complications. Compared to the general population, patients with diabetes have better nutritional education [13]. International guidelines for nutrition in type 1 diabetes (T1D) provide guidance regarding macronutrient composition and are based on healthy eating recommendations suitable for the whole family [26]. Nutritional education for patients with T1D has largely focused on carbohydrate counting [51]. The importance of education is obvious in the record that Only 30.5% (61 of 200) of the adolescents (or children caretakers) had good knowledge about diabetes in this study, which may explain why this study similarly found poor adherence to recommendations in this population. This finding therefore makes it necessary for health care professionals to stage appropriate interventions in a view to increase knowledge about diabetes to caretakers [41]. In the same study, the authors also believe that divorced caretakers may have more time to engage in diabetes management tasks such as insulin administration and monitoring of injections as they may not have a lot of family tasks to engage in compared with when they were still married [41]. 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 [7,12,26,42]. Many youths with T1DM did not adhere to daily recommendations for the intake of fruits, vegetables, and whole grain foods [26]. Similarly, studies demonstrated that youth were consuming more fat and saturated fat than was recommended

[19,20,25,27]. Study for dietary adherence suggested that poorer adherence was associated with poor parent-child mealtime behaviors and knowledge deficits specific to diabetes dietary management [50]. The dietary intake among patients with type 1 diabetes does not, for many nutrients, meet the recommendations [24,25,27]. In specific, patients with type 1 diabetes should pay more attention to sufficient intake of carbohydrates and fibre, and avoid excess intake of total fat, saturated fatty acids, and salt. The majority of children in this cohort routinely give insulin before meals, which has been shown to be an important factor in minimizing postmeal glycemic excursions [52].

CONCLUSION

Study findings suggested that many children with T1DM struggling with adherence and not meeting dietary guidelines for their disease. Specific strategies are needed to encourage healthy eating in this age group as food preferences likely impact future eating habits. The promotion of the MedDiet is vital to be included in the management of children with T1DM, and all parents should be aware of this to obtain the best results for their children in the management of the disease. Collaborative care interventions and a team approach have demonstrated efficacy in diabetes self-management, outcomes of depression, and psychosocial functioning, because it is important to emphasize that Diabetes during early childhood creates a psychosocial challenge to the families of these children. So, Successful management of infants and toddlers with diabetes depends on a well-functioning and educated family. Last but not least, Nutritional therapy should focus not only on glycemic control and pure carbohydrate counting but also on healthy eating patterns and complication prevention.

APPENDIX
TABLE 1 | Main measures and dietary adherence among T1D patients.

References	Sample Age group	Type of study	Main Results
1. Helgeson VS et al 2006 [36] USA	132 adolescences With T1DM 131 Healthy adolescence as control group Age:10,7-14,2 years	Case control study	T1DM: Consumption of fewer calories from carbohydrates and more fat. Control group: High fat intake.
2. Lodefalk M et al 2006 [20] Sweden	174 adolescences With T1DM 160 Healthy adolescence as control group Age:13-19 years	Case control study	The eating habits of children with T1DM were healthier than those in the control group.
3. Mayer et al 2006 [24]. USA.	1511 Children with T1DM 186 Children with T2DM Age: 10-22 years	Cohort study	The majority of participant in both groups did not comply with the recommendation.
4. Faulkner MS et al 2006 [25] USA	50 children with T1DM 14 Children with T2DM 53 Healthy children as control group Age:15-19 years	Case control study	Children with T1DM and T2DM consume more saturated fat than healthy children.
5. Chang CW et al 2007 [34] Tai-wan	101 Children 10-18 years	Cross-sectional study	25% of children consumed the ideal number of calories.48% consumed fewer calories than needed for their daily needs. 15% of the population consumed 60% more calories from carbohydrates and 30% from fats. >90 % ate 3 main meals and only 18% consumed the recommended number of meals per day.
6. Overby NC 2007 [19] Norway	550 children with T1DM Age: 2-19 years	Cross-sectional study	Children with higher fiber and fruit and vegetable intake and lower sugar intake and the recommended number of meals were able to maintain better glycemic control.

7. Patton SR. 2007 [27] USA	33 families Age of children: 5-6 years	One sample Cross-sectional study	The children had poor dietary compliance mainly in carbohydrate and energy intake.
8. Gellar LA. et al 2007 [37]. USA	140 Children with T1DM Age: 7-16 years	Case control study	The compliance of children with diabetes with their dietary habits depends on the family's eating habits. 76% of children reported consuming unhealthy foods due to the insulin pump.
9. Papadakis A. et al 2008 [15] Greece	41 Children with T1DM Age: 6-17 years	Case control study	Non-compliance with the diet component-high fat intake.
10. Overby NC et al 2008 [18] Norway	665 Children with T1DM Age: 9-13 years	Prospective population-based	5% of children did not eat breakfast and dinner five times a week while 95% followed the recommendations on the number of meals they should eat.
11. Mehta S. et al 2008 [32] USA	119 youth with T1DM 9-14 years	Cross-sectional study	Children whose parents were better informed were better on the diet. The intensive insulin therapy the children received helped with compliance.
12. Galli-Tsinopoulou A. et al 2009 [16] Greece	24 children with T1DM 24 healthy children Age:4-16 years	Case control study	Younger children had poorer compliance. The group of diabetic children received more vitamins compared to the control group.

13. Patton SR. et al 2009 [28] United State	35 families with children with T1DM Age: 2-8 years	Cross-sectional study	Children in poorly functioning family at the table had poorer compliance by 31%.
14. Di Battista AM. et al 2009 [23] Canada	76 children Age: 13-18 years	Cross-sectional study	Due to the Social stress that boys affected more than girls the compliance in boy is poorer.
15. Tse J. et al 2012 [22]. USA	151 Children Age:8-18 years	Cross-sectional study	Young people where the measurements showed that they receive less quality nutrition comply.
16. Patton SR. et al 2013 [31]. USA	39 families with children with T1DM Age of children: 1-7 years	Cross-sectional study	Children's compliance depends directly on the family's eating habits.
17. Quick et al 2014 [33]. USA	252 children with T1DM Age :8-18 years	Cross-sectional study	Lack of variety in children's diet contributes negatively to their poor dietary compliance.
18. Katz et al 2014 [17] USA	252 children with T1DM Age: 8-18 years	Cross-sectional study	11.5% of participants consumed the recommended amount of carbohydrates, fats and proteins. 2/3 of young people received insufficient fiber 4.4% of children complied with the recommendations on the avoidance of trans fats

<p>19. Mehta et al 2014 [39] USA</p>	<p>67 children with T1DM Age: 2-12 years</p>	<p>Cross-sectional study</p>	<p>Greater proportions of children with T1D meet daily recommendations for vegetables vs. 13% for the controls, Fiber intake is very low in both groups. Both groups reported similar age-appropriate levels of total energy intake. Children with T1D consumed more daily servings of vegetables fewer children with T1D met daily total grain requirements. Average z-BMI scores for young children with T1D were significantly greater than age- and sex-matched children without T1D.</p>
<p>20. Mackey ER et al 2018 [40]. USA</p>	<p>257 Children with T1DM Age: 11-14 years</p>	<p>Cross-sectional study</p>	<p>Lower intake of carbohydrates. Higher intake of protein. Higher intake of fats. 47.6% meet the minimum recommendation for dietary fiber.</p>
<p>21. Kyokunzire C et al 2018 [41]. Uganda</p>	<p>200 children with T1DM Age:0-19 years</p>	<p>Cross-sectional study</p>	<p>The overall prevalence of adherence to diabetes care recommendations was at 37%. The evaluating adherence to specific treatment parameters showed that 52%, 76.5%, and 29.5% of the children and adolescents adhered to insulin, blood glucose monitoring, and dietary recommendations, respectively. Children and adolescents whose caretakers are married and those whose caretakers are divorced/separated were more adherent to type 1 diabetes recommendations</p>
<p>22. Baechle C,2018 [42] Germany</p>	<p>712 children with T1DM Age:11–19 years</p>	<p>Cross-sectional study</p>	<p>A total daily carbohydrate intake of is lower in T1D compared to controls. Carbohydrate intake is consistently lower at all eating occasions compared to control group.</p>

			Participants with T1D consumed breakfast, lunch, dinner, and snacks more frequently.
23. Seckold R 2019 [26]. Australia	22 Children with T1DM Age: >7 years	Cross-sectional study	Young children with T1D eat diets similar to their peers, Macronutrient distribution was carbohydrate (48%±4%), protein (16%±2%) and fat (33%±5%) with saturated fat (15%±3%). The majority of children did not meet vegetable and lean meat/protein intake recommendations. HbA1c was not correlated with daily total carbohydrate, protein or fat intake (p>0.05). HbA1c was significantly higher in children offered food in a the non-recommended pattern compared with those offered regular meals.
24. Dłużniak-Gołaska 2019 [43] Poland	194 children with T1DM Age: 8-18 years	Case control study	unsatisfactory dietary habits in children and adolescents with type 1 diabetes was associated with longer duration of the disease, higher doses of insulin and overweighty or under weighty.
25. Maffei et al 2020 [21]. Italy	229 children with T1DM Age: 6-16 years	Case control group	Energy intake is not significantly different in the two groups. Carbohydrate intake is significantly lower in group B. Protein intake is significantly higher in group B.
26. Antoniotti et al 2022 [38]. Italy	65 Children and youth with T1DM Age: 9 - 18 years	Cross-sectional study	The adherence to the MedDiet was poor in 12.3%, average in 58.6%, and high in 29.1% of the subjects. The promotion of the MedDiet, mainly having a healthy breakfast, is a good strategy to include in the management of

			T1D to improve glucose and metabolic control.
27. Dominguez-Riscart et al 2022 [6]. Spain	97 children with T1DM with Age 4-16 years	Cross-sectional study	49,7 % of children had optimal adherence to the dietary recommendations. That is associated with eating fruit and vegetable, as well as more frequently consuming fish, whole cereals/grains, and dairy products. The group with the suboptimal adherence (50,53%) used to consume more frequently fast-food or more frequently consuming commercially baked goods or pastries for breakfast, as well as more frequent skipping of breakfast, or eating sweets and candies more than once a day

REFERENCES

1. Sundberg F, Barnard K, Cato A, Beaufort de C, Dimeglio L, Dooley G, Hershey T, Hitchcock J, Jain V, Weissberg-Benchell J, Rami-Merchar B, Smart C, Hanas R. ISPAD guidelines. Managing diabetes in preschool children. *Pediatr Diabetes*. 2017;18(7): 499–517.
2. Syed FZ. Type 1 Diabetes Mellitus. *Ann Intern Med*. 2022; 175(3):33-48.
3. Desai S, Deshmukh A. Mapping of Type 1 Diabetes Mellitus. *Current Diabetes Reviews*. 2020; 16(5): 438 – 441.
4. American Diabetes Association. Standards of medical care in diabetes, 2021. *Diabetes Care*. 2021; 44(1):15-33.
5. WHO. Adherence to long term therapies: evidence for action; 2003. Available from <http://apps.who.int/iris/bitstream/handle/10665/42682/9241545992.pdf;jsessionid=A353FF1DCC29CEBDB27330D2480541A4?sequence=1> Accessed June 16, 2022.
6. Dominguez-Riscart J, Buero-Fernandez N, Garcia-Zarzuela A, Morales-Perez C, Garcia-Ojanguren A, Lechuga-Sancho AM. Adherence to Mediterranean Diet Is Associated with Better Glycemic Control in Children with Type 1 Diabetes: A Cross-Sectional Study. *Front Nutr*. 2022; 4(9): 813989.
7. Marincic PZ, Salazar MV, Hardin A, Scott S, Fan SX, Gaillard PR, Wyatt C, Watson L, Green P, Glover P, Hand M. Diabetes Self-Management Education and Medical Nutrition Therapy: A Multisite Study Documenting the Efficacy of Registered Dietitian Nutritionist Interventions in the Management of Glycemic Control and Diabetic Dyslipidemia through Retrospective Chart Review. *J Acad Nutr Diet*. 2019 Mar;119(3):449-463.

8. Rovner AJ, Nansel TR, Mehta SN, Higgins LA, Haynie LD, Laffel LM. Development and Validation of the Type 1 Diabetes Nutrition Knowledge Survey. *Diabetes Care*. 2012; 35(8):1643–1647.
9. Silverstein J, Klingensmith G, Copeland K, Plotnick L, Kaufman F, Laffel L, Deeb L, Grey M, Anderson B, Holzmeister LA, Clark N. Care of children and adolescents with type 1 diabetes: a statement of the American Diabetes Association. *Diabetes Care*. 2005; 28(1):186–212.
10. Davis CR, Bryan J, Hodgson JM, Murphy KJ. Definition of the Mediterranean Diet—A Literature Review. *Nutrients*. 2015;7(11): 9139-9153
11. Trichopoulou A, Lagiou P. Healthy Traditional Mediterranean Diet: An Expression of Culture, History, and Lifestyle. *Nutr. Rev.* 1997;55(11): 383–389.
12. Bantle JP, Wylie-Rosett J, Albright AL, Apovian CM, Clark NG, Franz MJ, Hoogwerf BJ, Lichtenstein AH, Mayer-Davis E, Mooradian AD, Wheeler ML. Nutrition recommendations and interventions for diabetes: a position statement of the American Diabetes Association. *Diabetes Care*. 2008;31(1): 61–78.
13. Ewers B, Trolle E, Jacobsen SS, Vistisen D, Almdal TP, Vilsboll T. Dietary habits and adherence to dietary recommendations in patients with type 1 and type 2 diabetes compared with the general population in Denmark. *Nutrition*. 2019, 61,49-55.
14. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Aki EA, Brennan SE. The PRISMA 2020 Statement: An updated guideline for reporting systematic reviews. *PLoS Med*. 2020, 18:e1003583.
15. Papadakis A, Linardakis M, Codrington C, Kafatos A. Nutritional intake of children and adolescents with insulin-dependent diabetes mellitus in Crete. A case control study. *Ann Nutr Metab*. 2008;52(4):308-314.
16. Galli-Tsinopoulou A, Georgiou M, Grammatikopoulou M, Stylianou C, Kokka P, Emmanouilidou E. A preliminary case–control study on nutritional status, body composition, and glycemic control of Greek children and adolescents with type 1 diabetes. *J Diabetes*.2009;1(1):36-42.
17. Katz M, Mehta S, Nansel T, Quinn H, Lipsky LM, Laffel L. Associations of Nutrient Intake with Glycemic Control in Youth with Type 1 Diabetes: Differences by Insulin Regimen. *Diabetes technology & therapeutics*. 2014;16(8): 512-518.
18. Overby NC, Margeisdottir HD, Brunborg C, Dahl-Jorgensen K, Andersen LF. Sweets, snacking habits, and skipping meals in children and adolescents on intensive insulin treatment. *Pediatr Diabetes*.2008;9(4):393-400.
19. Overby NC, Margeisdottir HD, Brunborg C, Andersen LF, Dahi-Jorgensen K. The influence of dietary intake and meal pattern on blood glucose control in children and adolescents using intensive insulin treatment. *Diabetologia* 2007;50(10):2044-51.
20. Lodefalk M, Aman J. Food habits, energy and nutrient intake in adolescents with Type 1 diabetes mellitus. *Diabet Med*. 2006; 23(11):1225-32.
21. Maffei C, Tomasselli F, Tommasi M, Bresadola I., Trandev T, Fornari E, Marigliano M, Morandi A, Oliviera F, Piona C. Nutrition habits of children and adolescents with type 1 diabetes changed in a 10 years span. *Pediatr Diabetes*. 2020;21(6):960–968.
22. Tse J, Nansel T, Haynie TR, Haynie DL, Mehta SN, Laffel LMB. Disordered Eating Behaviors are Associated with Poorer Diet Quality in Adolescents with Type 1 Diabetes *Acad Nutr Diet*. 2012; 112(11): 1810–1814.
23. Di Battista AM, Hart TA, Greco L,Gloizer J. Type 1 diabetes among adolescents: reduced diabetes self-care caused by social fear and fear of hypoglycemia. *Diabetes Educ*.2009;35(3):465-75.
24. Mayer-Davis EJ, Nichols M, Liese AD, Bell RA, Dabelea DM, Johansen JM, Pihoker C, Rodriguez BL, Thomas J, Williams D. Dietary intake among

- youth with diabetes: the SEARCH for Diabetes in Youth Study. *J Am Diet Assoc.* 2006;106(5):689-97.
25. Faulkner MS, Chao WH, Kamath SK, Quinn L, Fritschi C, Maggiore JA, Williams RH, Reynolds RD. Total homocysteine, diet, and lipid profiles in type 1 and type 2 diabetic and nondiabetic adolescents *J Cardiovasc Nurs.* 2006 ;21(1):47-55.
 26. Seckold R, Howley P, King BR, Bell K, Smith A, Smart CE. Dietary intake and eating patterns of young children with type 1 diabetes achieving glycemic targets. *BMJ Open Diabetes Res Care.* 2019; 7(1): e000663.
 27. Patton SR, Dolan LM, Powers SW. Dietary adherence and associated glycemic control in families of young children with type 1 diabetes. *J Am Diet Assoc.* 2007;107(1):46-52.
 28. Patton SR, Piazza-Waggoner C, Modi AC, Dolan LC, Powers SW. Family Functioning at Meals Relates to Adherence in Young Children with Type 1 Diabetes *J Paediatr Child Health.* 2009; 45(12): 736–741.
 29. Patton SR, Dolan LM, Smith LB, Brown MB, Powers SW. Examining mealtime behaviors in families of young children with type 1 diabetes on intensive insulin therapy. *Eat Behav.* 2013 Dec;14(4):464-7..
 30. Blaine, R.E., Kachurak, A., Davison, K.K. et al. Food parenting and child snacking: a systematic review. *Int J Behav Nutr Phys Act* 14, 146 (2017). <https://doi.org/10.1186/s12966-017-0593-9>
 31. Patton SR, Dolan L, Chen M, Powers SW Dietary Adherence and Mealtime Behaviors in Young Children with Type 1 Diabetes on Intensive Insulin Therapy. *J Acad Nutr Diet.* 2013;113(2): 258–262.
 32. Mehta S, Volkening L, Anderson B, Nansel T, Weissberg-Benchell J, Wysocki T, PHD,5 Laffel L. Dietary Behaviors Predict Glycemic Control in Youth With Type 1 Diabetes. *Diabetes Care.* 2008; 31(7): 1318–1320.
 33. Quick V, Lipsky LM, Laffel LMB, Mehta SN, Quinn H, Nansel, TR. Relationships of neophobia and pickiness with dietary variety, dietary quality and diabetes management adherence in youth with type 1 diabetes. *Eur J Clin Nutr.* 2014;68(1):131–136.
 34. Chang CW, Yeh CH, Lo FS, Shih YL. Adherence behaviours in Taiwanese children and adolescents with type 1 diabetes mellitus. *J Clin Nurs.* 2007;16(7B):207-14.
 35. Service FJ, Rizza RA, Hall LD, Westland RE, O'Brien PC, Clemens AH, Haymond MW, Gerich J.E. Prandial insulin requirements in insulin-dependent diabetics: Effects of size, time of day, and sequence of meals. *J. Clin. Endocrinol. Metab.* 1983;57(5):931–936.
 36. Helgeson VS, Viccaro L, Becker D, Escobar O, Siminerio L. Diet of adolescents with and without diabetes: Trading candy for potato chips? *Diabetes Care.* 2006;29(5):982-987.
 37. Gellar LA., Schrader K, Nansel TR, Perceptions, Facilitators, and Barriers Among Youth with Diabetes. *Diabetes Educ.* 2007; 33(4): 671–679.
 38. Antoniotti V, Spadaccini D, Ricotti R, Carrera D, Savastio S, Goncalves Correia FP, Caputo M, Pozzi E, Bellone S, Rabbone I, Prodham F. Adherence to the Mediterranean Diet Is Associated with Better Metabolic Features in Youths with Type 1 Diabetes. *Nutrients.* 2022; 14(3): 596.
 39. Mehta SN, Volkening LK, Quinn N, Laffel LMB. Intensively managed young children with type 1 diabetes consume high-fat, low-fiber diets similar to age-matched controls. *Nutr Res.* 2014; 34(5):428–35.
 40. Mackey ER, O'Brecht L, Holmes CS, Jacobs M, Streisand R. Teens with type 1 diabetes: how does their nutrition measure up? *J Diabetes Res.* 2018, 5094569.
 41. Kyokunzire C, Matovu N, Mayega RW. Factors associated with adherence to diabetes care recommendations among children and adolescents with type 1 diabetes: a facility-based study in two urban

- diabetes clinics in Uganda. *Diabetes Metab Syndr Obes.* 2018; 29(11):93-104.
42. Baechle C, Hoyer A, Castillo-Reinado K, Stahl-Pehe A, Kuss O, Holl RW. In cooperation with the German Pediatric Surveillance Unit (ESPED) and the DPV Science initiative, supported by the German Center for Diabetes Research (DZD). Eating Frequency and Carbohydrate Intake in Adolescents with Type 1 Diabetes Differ from Those in Their Peers and are Associated with Glycemic Control. *Exp Clin Endocrinol Diabetes.* 2018;126 (5): 277–286.
 43. Dłużniak-Gołaska K, Panczyk M, Szostak-Wegierek D, Szybowska A, Sińska B. Analysis of the diet quality and dietary habits of children and adolescents with type 1 diabetes. *Diabetes Metab Syndr Obes.* 2019;12,161–170.
 44. Rovner AJ, Nansel T. Are children with type 1 diabetes consuming a healthful diet? a review of the current evidence and strategies for dietary change. *Diabetes Educ.* 2009;35(1):97-107.
 45. Moström P, Ahlén E, Imberg H, Hansson PO, Lind M. Adherence of self-monitoring of blood glucose in persons with type 1 diabetes in Sweden. *BMJ Open Diabetes Res Care.* 2017;5(1): e 000342.
 46. Patton SR. Adherence to diet in youth with type 1 diabetes. *J Am Diet Assoc.* 2011;111(4):550–555.
 47. Gandhi K, Vu BK, Eshtehardi SS, Wasserman RM, Hilliard ME. Adherence in adolescents with type 1 diabetes: strategies and considerations for assessment in research and practice. *Diabetes Manag (Lond).* 2015;5(6):485–498.
 48. Overby NC, Flaaten V, Veierod MB, Bergstad I, Margeisdottir HD, Dahl Jorgensen K, Andersen LF. Children and adolescents with type 1 diabetes eat a more atherosclerosis-prone diet than healthy control subjects. *Diabetologia.* 2007, 50(2):307–316.
 49. Lazzeri G, Ahluwalia N, Niclasen B et al. Trends from 2002 to 2010 in daily breakfast consumption and its socio-demographic correlates in adolescents across 31 countries participating in the HBSC Study. *PLoS ONE.* 2016;11(3): e0151052
 50. Nansel TR, Lipsy L, Liu A. Greater diet quality is associated with more optimal glycemic control in a longitudinal study of youth with type 1 diabetes. *Am J Clin Nutr.* 2016;104(1): 81-87.
 51. Evert AB, Dennison M, Gardner CD, Garvey WT, Lau KHK, MacLeod J, Mitri J, Pereira RF, Rawlings K, Robinson S, Saslow L, Uelmen S, Urbanski PB, Yancy Jr Ws. Nutrition therapy for adults with diabetes or prediabetes: a consensus report. *Diabetes Care.* 2019; 42(5): 731–54.
 52. Slattery D, Amiel SA, Choudhary P. Optimal prandial timing of bolus insulin in diabetes management: a review. *Diabet Med.* 2018;35(3): 306–16.