REVIEW

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Current Management of Type 1 Diabetes in Children: Guideline-based Expert Opinions and Recommendations

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Abstract

Successful management of type 1 diabetes (T1D) requires not only optimal glycemic outcomes, but also a holistic approach that encompasses all aspects of life and recommendations to address needs. Current goals include optimal glycemic values, quality of life and life expectancy similar to peers, prevention of long-term complications, prevention of severe hypoglycemia as far as possible and facilitation of glucose management. The International Society for Pediatric and Adolescent Diabetes (ISPAD) has been updating its guidelines for diabetes care every four years since 1995, covering more and more topics. For optimal metabolic outcomes, diabetes teams need to follow these current recommendations, adapt them to their clinical practice and provide guidance to people with T1D and their families. In this review, in the light of ISPAD 2018-2022 guidelines and clinical experiences, "10 Key Recommendations", emphasizing the importance of teamwork and the use of technology, current T1D treatment is described for practical applications.

Keywords: Carbohydrate counting, diabetes camp, glucose target, HbA1c, insulin carbohydrate ratio, insulin sensitivity, glycemic outcome

Introduction

Today, the management of type 1 diabetes (T1D) in children continues to pose significant challenges, particularly among preschoolers and adolescents. In many countries, mean/median hemoglobin A1c (HbA1c) levels are consistently 7.5% and above, contrary to recommendations (1). However, effective diabetes management extends beyond glucose control. Achieving successful treatment requires a holistic approach that encompasses optimal glycemic outcomes, as well as addressing lifelong needs and aspirations. To achieve this, knowledge about treatment needs to be made practical and explicit, based on evidence-based recommendations. Otherwise, routine practice may rely on concepts that are challenging to translate into daily practice, such as complex mathematical calculations or individual diabetes team member opinions with resultant lack in achieving target HbA1c levels. When diabetes teams lack current practice recommendations or have insufficient guidance, and individuals with T1D struggle to undertake a complex clinical management plan, the motivation toward long-term goals is disrupted. This can lead to inertia, characterized by inactivity, dormancy, and passivity. Treatment-related "inertia" is a condition that diabetes teams, as well as people with diabetes themselves fall into, and leads to a gradual move away from the goal of optimal metabolic control (2).

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However, important practices, such as carbohydrate counting, should be taught from diagnosis, and people with T1D and their families should be encouraged to be take an active role in insulin dose adjustments and nutritional management from the very beginning. Hanas (3), who has worked for many years as a pediatric diabetologist combining clinical practice with science, describes this approach as "*becoming an expert on your own diabetes*".

Guidelines, Exemplary Country Practices, and Advancements

The International Society for Pediatric and Adolescent Diabetes (ISPAD) has been publishing guidelines on various aspects of diabetes in childhood every four years since 1995, and has increased the number and scope of these texts over the years. Most recently, in late 2022, 25 guideline texts covering all aspects of diabetes in children were published. Compared to previous texts, in the last four years, the concepts of continuous glucose monitoring (CGM) (sensors), automated insulin delivery (AID) systems, technology, groups/regions with limited resources, inequalities, social determinants of health, cultural awareness, and person-centered care/personalized care are prominent (4).

However, centers in countries like Australia and Sweden have achieved a notable decrease in HbA1c levels to an average range of 6.7-6.8% over a decade, attributed to target settings (HbA1c target 6.5% since 2017), the nationwide practices, quality control programs, team goal setting and also benchmarking (5,6). Reportedly, in Sweden, the percentages of individuals with T1D whose HbA1c levels were below 6.5% (48 mmol/mol), below 7.3%, and above 8.6% nationally in 2022 were 43.3%, 76.7%, and 4.5%, respectively (7). Table 1 outlines the key features and leading practices observed in both the Sweden and Australia programs.

For the last eight years, the authors of this review have been implementing a program similar to the Sweden and Australia recommendations, the main components of which are the "10 Key Recommendations", teamwork and the use of technology, which we will detail in this article. The authors have seen 1,870 children with T1D and their families since 2016 through a clinical implementation program, including a 1-hour pediatric endocrinology visit, a 2-hour basic principles diabetes training by a diabetes educator, and 3-session nutritional training by a nutritionist. The 1-hour pediatric endocrinology visits address topics such as individual treatment recommendations, glucose targets, insulin dose calculations [insulin-to-carbohydrate ratio (ICR) and insulin correction/sensitivity factor], rules to be followed at bedtime, dawn/reverse dawn phenomena and their management, hypoglycemia management, correction dose timing, optimal carbohydrate amount, and the role of families, especially fathers. All these recommendations are given to the caregivers as a printed "Individual Treatment Plan", which is prepared for each child, tailored to the age and characteristics of the child.

To date, 60.4% of the children admitted to our department use CGM and 20% use insulin pump therapy (continuous subcutaneous insulin infusion) and 44.7% of these are using the Minimed 780G. In an evaluation of 543 children with regular follow-up in our center between 2018-2022, the median HbA1c was 7.1%, 45% of the children had

Table 1. The Characteristics of the Sweden and Australia Child Diabetes Programs*

Sweden	Australia
- Improvement of local and national guidelines. - Lowering of HbA1c target to NICE target 6.5% (48 mmol/mol) - Aiming for >50% of CGM values to be within 4-8 mmol/L (70-140 mg/dL) and <4% below 70 mg/dL (3.9 mmol/l). - Aiming for average glucose level <7.8 mmol/L (140 mg/dL) - Teamwork with weekly or bi-weekly meetings. - CGM for all patients within 1 week of onset. - Carbohydrate counting education for all patients from the onset of T1D. - Use of injection aids (i-Port) for young children from the onset of diabetes. - CSII for preschool children and encouraging CSII use in all age groups. - Downloading pump and CGM at each visit and promoting active use of the digital glucose logbook at home. - Improved technology training. - Encouragement of exercise.	- Team approach instead of individual (clinician-based) practices, reviewing team recommendations at least once a year, providing them as a written document to patients. - While insulin pump is recommended for all children <5 years of age, multiple daily injection doses at the time of diagnosis, transition to insulin pump according to family and clinician's recommendations. - Glycemic targets, correction boluses, and structuring meals are recommended. - NICE Guidance targets (<6.5%) instead of ISPAD targets. - NORMAL glucose is targeted as much as possible across all age groups. - Blood glucose measurement at least 5 times a day. - While constant snacking and snacking habits used to be assumed normal in young children until 2004, now regular main meals, minimum snacks as much as possible, and no need for snacks before bedtime have been adopted. - Postprandial insulin was administered for children who refused to eat until 2004, now always pre-meal insulin is recommended. - Previously, determination and adjustment of insulin doses were done by medical and nursing staff and insulin adjustment education was given after diagnosis when parents were "ready". Now, insulin sensitivity factor and insulin/carbohydrate ratio are taught at the time of diagnosis, families are given easy dosing schemes/cards. - Mini-dose glucagon is taught.

*Adapted from the references 3 and 5.
CSII: continuous subcutaneous insulin infusion, T1D: type 1 diabetes, ISPAD: The International Society for Pediatric and Adolescent Diabetes, HbA1c: hemoglobin A1c, CGM: continuous glucose monitoring

HbA1c <7%, and only 7% had HbA1c above 9%. Although these children might have had a better social and economic status, these encouraging findings may also have been due to the comprehensive training, teamwork, "10 Basic Recommendations" that set the basic goals, and the use of technology in our clinic.

Given the absence of a national diabetes registry in our country, the availability of metabolic control data remains limited. A 2013 study encompassing 1,032 cases across various national centers reported a mean HbA1c level of 8.5%. Similarly, a 2016 study involving 498 cases at the national level reported an average of 8.6% (8,9). In these studies, the percentage of children with an HbA1c level >9% was 36.9% and 35.7%, respectively. A more recent cohort study, spanning 2018 to 2023 and comprising 2,730 children from 42 centers, reported a median HbA1c of 8.4% (10). These statistics underscore that the average HbA1c in our country surpasses recommended targets, demonstrating a lack of improvement over the past decade. Particularly concerning is the persistently high proportion of children with an HbA1c above 9%, a threshold associated with increased risk of complications. Notably, these numbers reflect the status of approximately 30,000 children with T1D in Turkey, providing evidence for the necessity for new national initiatives.

This review article will focus on the main recommendations based on the ISPAD 2018-2022 guidelines (4), Hanas' (3) book and the authors' clinical experiences. Our aim is to bring to the attention of pediatric diabetes teams these apparently beneficial practices and to be the basis for a new countrywide program.

Current Goals in the Care of Children with T1D

Current goals in the management of T1D include not only better glycemic values and closer glycemic values to those without diabetes but also the quality of life and life expectancy similar to their peers, prevention of long-term complications, no severe hypoglycemia, mild hypoglycemia not being a burden, alleviating the fear of hypoglycemia, facilitating glucose management during/after meals, comfortable/fearless sleep for families and children, implementing CGM monitoring, ensuring adequate diabetes management at school supporting academic performance, participating in enjoyable activities, preventing diabetic ketoacidosis, weight control and prevention of eating disorders, reduction of diabetes treatment routines/burdens, reduction of glucose fluctuations and related problems (restlessness, sudden anger, etc.), facilitating the management of conditions such as sports, menstruation, pregnancy, lactation, surgical intervention, and fasting. The current targets for glucose regulation include an HbA1c target below 7% (below 6.5% for individuals with stage 3 diabetes, during the remission period, and for individuals with access to advanced technology, under the care of clinics offering advanced education and services) (11). Additionally, maintaining a coefficient of variation of less than 36% and achieving Time In Range (TIR) of 70-180 mg/dL at over 70%, with preprandial glucose levels between 70-144 mg/dL (11). Notably, recent emphasis has been placed on achieving a Time In Tight Range of 70-140 mg/dL at least 50% (12).

There exists a close relationship between set targets and corresponding actions. For instance, administering correction doses above 145 mg/dL aids in achieving the target HbA1c of <6.5%. Furthermore, effective communication within diabetes teams is important, ensuring clear articulation of proposed glycemic targets with a unified voice. Aligning the goals of the child and family with those of the diabetes team is also imperative, fostering overlapping objectives for optimal management.

Several Topics Concerning the Management of T1D and the '10 Key Recommendations'

In this section, certain themes related to the management of T1D will be addressed, providing practical recommendations. Unreferenced practices in this section are derived from Hanas's (3) book and the authors' clinical experiences. The '10 Key Recommendations,' which the authors apply in their clinical practices and are detailed below, are provided in Table 2.

Administering Meal Bolus Insulin 15-20 Minutes Before the Meal for the Best Post-prandial Glucose Profile

Mastery of matching the effect of exogenous insulin with the effect of nutrients is one of the cornerstones of T1D management. Except for fatty meals and instances of slow eating, it is recommended to administer rapid-acting insulins 15-20 minutes before meals, aiming for a physiologically appropriate bolus delivery. This practice is particularly beneficial, especially during breakfast, considering the lower insulin sensitivity until 10 am (13). In addition, this practice helps to suppress glucagon secretion at the onset of the meal. It remains applicable even in preschool-aged children, although the timing might need adjustment and implementation could be more challenging. This is also recommended for individuals using an AID system, like the Minimed 780G.

The Selection, Dose, and Timing of Basal Insulin

Basal insulin requirement is higher between 10 pm and 10 am (14). The daily basal insulin rate is not more than 50%

Table 2. '10 Key Recommendations' for children with T1D

1. Administering meal bolus insulin 15-20 minutes before the meals (by deleting the last digit of the pre-meal glucose value- e.g. 162 mg/dL 16 minutes before a meal). Using abdomen and arms as injection sites for the fast-acting insulins and buttocks and thighs for slow-acting insulins.
2. Going to bed with a normal glucose level (>120 mg/dL for pre-schoolers, >90 mg/dL for older children), avoiding unnecessary carbs with the fear of hypoglycemia.
3. Avoiding snacks unless necessary, to consume carbohydrates in a moderate amount during main meals. Preschoolers may need a small snack without insulin at midmorning to avoid pre-lunch hypoglycemia.
4. Calculating the bolus dose carefully according to the carbohydrate ratio and the glucose value at the time, increasing doses if necessary to take into account the effect of fats and proteins.
5. Avoiding milk intake at night before bedtime, taking into account the glucose spike between 9 pm and 12 am after falling asleep ("reverse dawn phenomenon") in the young children; shifting milk intake to daytime active hours.
6. Using a sensor as soon as possible and an insulin pump (better yet, automated insulin delivery systems) as soon as possible after diagnosis if finances permit.
7. Administering correction boluses promptly, if the insulin sensitivity factor permits when the blood glucose is over 145 mg/dL.
8. Limiting problematic foods that may pose challenges, such as pizza and hamburgers.
9. Incorporating exercise into daily routine and taking it as a therapeutic tool, akin to a 'third type of insulin'.
10. To continue diabetes treatment according to the principle of doing our best, without turning it into a stress, and to live with diabetes in a peaceful (friendly) way.

T1D: type 1 diabetes

with exceptions including adolescence (honeymoon period, low carbohydrate diet, vigorous exercise) (13,15). When the basal insulin rate is higher than 50% of TDD (total daily dose) when using injection therapy, it causes an increased frequency of hypoglycemia during the fasting period - a kind of slope effect, which can be defined as the direction of the glucose curve pointing downwards.

It should be taken into consideration that the basal insulin requirement in young children is 25-30% of the total daily insulin dose (TDI) (12). If an insulin pump is not used, it is a good option to administer insulin glargine (Lantus) at 7 or 10 pm to benefit from its relatively strong effect in the first 12 hours. It should be kept in mind that the effect of insulin glargine begins three hours after administration. Some clinicians suggest that for doses of 15 U or less, splitting into two doses given in the morning and evening provides better coverage and less risk of fasting hypoglycaemia, and that two doses also facilitates titration for the desired glycemic effect (3).

In pre-adolescents and young children, administering insulin glargine at 7 pm before dinner can help reduce hyperglycemia occurring between 9 pm and 12 am due to the 'reverse dawn phenomenon' after falling asleep. For adolescents, administering insulin glargine at 10 pm can prevent hyperglycemia after 5:00 am. However, it can be given in the morning in very young children having hypoglycemia late at night (between 3 and 6 am). Since insulin detemir (Levemir) has 18% less receptor affinity (16) and therefore lower potency, it is usually not possible to obtain sufficient basal insulin effect with one dose/day. Insulin glargine 300 U/mL (Toujeo) or Tresiba may be preferred in children with nocturnal and/or general hypoglycemia problems. It should be noted that its effect in the first 12 hours is weaker than Lantus and the duration longer. The dose may be increased by 10-18% in transition.

The Prevention of Lipohypertrophy and Recommended Insulin Injection Sites Regarding Insulin Types

Lipoatrophy is rare, while lipohypertrophy remains a prevalent issue. To prevent lipohypertrophy, it's essential to rotate injection sites for insulin pump set/pod placement or injections, ensuring a minimum distance of 1 cm between each injection point. In Turkey, the common practice of injecting around the lower abdomen and both sides of the navel originates from the era of longer needle tips. However, using the entire abdomen is more accurate, as there is at least approximately 4 mm of fat tissue almost everywhere over the abdomen. Therefore, using both the upper and lower parts of the abdomen as injection sites is advisable. Lipohypertrophy tends to develop more easily in the arms of young children. Administering fast-acting insulins to the abdomen and arms while opting for slow-acting insulins in the hips and thighs is recommended (13). In Sweden, arms are not normally recommended for injections, except for Omnipod (3).

Early Corrections with Small Doses of Insulin

Improving time spent within the target range enhances insulin sensitivity. It's advisable to initiate corrections early and with smaller doses. This approach not only increases TIR but also mitigates the risk of hypoglycemia associated

with larger corrective doses. When the glucose level exceeds >145 mg/dL (equivalent to 6.5% in terms of HbA1c) two hours after the last bolus dose, and if the sensor glucose trend shows no decline while the insulin sensitivity factor (ISF) allows for correction, an additional insulin dose should be administered promptly. It is not advisable to wait for values exceeding >250 mg/dL before considering an additional insulin dose. Conversely, if glucose levels range between >220-270 mg/dL, it may be appropriate to administer a corrective dose according to the individual correction factor (ISF). However, a correction dose should normally not exceed 0.1 U/kg but can be repeated after 2 hours, if needed. The target glucose range for this correction should be between 100-120 mg/dL (17). For corrections made after 10:00 pm, particularly in children aged 10 years and older, it is recommended to administer half of the daytime calculated insulin dose to minimize the risk of nighttime hypoglycemia. When a correction dose is given before bedtime, glucose monitoring should be conducted around 2-3 am. In preschool-aged children, there is a heighted glucose concern between 9 pm to 12 am due to the 'reverse dawn phenomenon.' Therefore, correctional dosing should align with daytime practices until midnight. Some centers recommend correcting the night in the same way as the day for all age groups and thus expect less variability during the night (5). Another approach is to start with a half dose correction at night and then adjust individually.

The Recommended Total Daily Carbohydrate Intake and Optimal Amount of Carbohydrate in Meals

In the last 15 years, recommendations regarding the percentage of daily energy derived from carbohydrates have evolved. While the previous recommendation was to obtain 55% of energy from carbohydrates, recent guidelines from ISPAD advocate for carbohydrates to constitute approximately 40-50% of daily energy intake. Furthermore, the updated recommendations propose fats to account for <35% of energy (<10% from saturated fats) and proteins to make up 15-25% of daily energy (18). Explaining this change through calculation, consider a 6-year-old boy. If 40% of his energy intake is derived from carbohydrates, this would amount to 147 grams of carbohydrates per day. In contrast, adhering to the former recommendation of 55% from carbohydrates would necessitate an intake of 202 grams - a significant difference. Consistent with this current recommendation, carbohydrate intake should be tailored based on the child's specific circumstances, such as whether they are an athlete or not, while ensuring that daily energy intake from carbohydrates does not fall below the 40% threshold. In general, consuming more than 60 grams of carbohydrate in a single meal (different amounts may be recommended for different age groups) may lead to difficulties in achieving optimal insulin-carbohydrate matching (19). When more carbohydrate is consumed at a meal, increasing insulin doses to prevent postprandial blood glucose spikes may lead to a risk of hypoglycaemia before the next meal. A recently published study investigating varied carbohydrate amounts (20, 50, 100, and 150 grams) at breakfast showed that the glucose curve most closely resembling the effect of fast-acting insulins was observed with 50 grams of carbs. Participants given 20 or 150 grams experienced prolonged glucose elevation lasting up to three hours, suggesting the need to adjust the ICR in such cases (20). This concept parallels the 'green wave' system employed by traffic authorities on certain roads; the concept that if you drive at 50-60 km/h on those roads, you will almost never come across a red light. Thus, aiming for a total carbohydrate intake of around 60 grams per meal can lead to a more favorable postprandial glucose curve.

Low Carbohydrate Diets

If carbohydrate intake is to be reduced, this should be discussed with the dietitian and endocrinologist in the diabetes team. However, it is generally not recommended that a child with T1D should get less than 40% of their energy from carbohydrates (3) as this may make it difficult to meet nutrient requirements and may affect growth. The definition of high, moderate, low, and very low carbohydrate intake is given in Table 3 (21). Ketones will occur when carbohydrate and therefore energy intake is significantly reduced, inducing a state resembling starvation in the body. For a growing child, it's recommended that blood ketone

Table 3. High, moderate, low, and very low carbohydrate intake in childhood*

	Carbohydrate (g/day) 1-6 years	Carbohydrate (g/day) 6-10 years	Carbohydrate (g/day) 11-16 years
High carbohydrate diets (>55% energy from carbohydrates)	>170 g	>230 g	>320 g
Moderate carbohydrate diets (45% energy from carbohydrates)	140 g	200 g	280 g
Low carbohydrate diets (<26% energy from carbohydrates)	<80 g	<100 g	<150 g
Very low carbohydrate diets (<10% energy from carbohydrate)	<30 g	<40 g	<60 g

*Adapted from reference 22

levels remain below 0.5 mmol/L - the same upper limit seen in healthy children - to avoid any negative impact on growth. In young adults who have reached their final height, a blood ketone level of up to 1.0 mmol/L may be acceptable if the reduction in carbohydrate intake is overseen by an endocrinologist and dietitian. Strict low-carbohydrate high-fat diets (LCHF) are not recommended for people with T1D as no studies indicate their benefit over more moderate carbohydrate intakes. Typically, blood ketone levels exceed 3 mmol/L during ketoacidosis, and individuals strictly following a LCHF diet may experience ketone levels ranging from 3-5 mmol/L. For individuals with diabetes, this narrow margin increases the likelihood of ketoacidosis, a potentially life-threatening condition, which is particularly concerning in children. The most important potentially negative effect of low carbohydrate nutrition is on growth (22). Given that insulin has an important effect on growth, once children with T1D are compelled to follow a low-carbohydrate diet paired with inadequate insulin, it leads to a marked slowdown in growth in a short period of time.

Diets with low to very low carbohydrate intake can disturb the natural relationship that children and adolescents have with food. Over time, these diets can gradually impact the child's relationship with food, for example food restricton can cause disordered eating which can lead to binge eating, potentially leading to the development of disordered eating (23). This scenario can be likened to an overstretched spring, losing its tension and functionality. Some adolescents, after an extended period on a low-carbohydrate diet, encounter difficulties reverting to their previous diet and may face challenging issues like depression.

Calculating Empirical ICR and Addressing Low Morning ICR

The conventional method for calculating the ICR has been dividing the number 500-450 by the TDI as an empirical practice. However, recent reports highlight that this formula often results in insufficient bolus dose calculation, particularly in children. Instead, it has been found more effective to utilize the average number 315 for this calculation (24). Recently, the ISPAD guidelines for insulin treatment have emphasized a revised approach to this calculation. Specifically, it is recommended to divide by 330 or 250 for young children. In the case of preschool children, a division by 150 is advised during breakfast (12,13). Typically, insulin sensitivity decreases due to the influence of anti-insulin hormones until 10 am. This underscores the need to divide the total insulin dose into a smaller number for morning ICR calculation in all age groups. In the 2022 edition of his book, Hanas (3)recommends using the formulas 200/TDI at breakfast and 400/TDI at other meals in preschool children and 300/TDI at breakfast and 500/TDI at other meals in older children and adolescents for empirical ICR calculation (3). Ideally, these empirical calculations should be individualized and reviewed in line with carbohydrate intake. Breakfast typically involves a high carbohydrate intake, posing a challenge to administer sufficient insulin before lunch without the risk of hypoglycemia. Hence, it might be prudent to recommend a lower carbohydrate intake during mornings compared to other meals. Additionally, a concern arises regarding the ICR to apply when waking up later than usual. The dawn phenomenon consistently occurs at a specific time daily, yet if one stays up late, the cortisol response upon waking will happen later. Consequently, even with a very delayed breakfast, it's recommended to use the breakfast ICR (3).

Time to Start Carbohydrate Counting and Use of "Carbohydrate-Bolus Calculator Application"

Presently, precise carbohydrate counting is crucial for calculating the bolus doses. However, the primary challenge families encounter in diabetes management is often determining the appropriate food portions. Carbohydrate counting allows for more flexible carbohydrate intake as well as understanding that there is a mathematical basis for insulin dose calculation. It is inaccurate to claim, as often suggested, that learning carbohydrate counting is premature or overly challenging at the time of diagnosis. Carbohydrate counting ought to be introduced right at the time of diagnosis and ideally during hospitalization. Many mothers, closely linked to food management, find valuable assistance through the Carbohydrate-Bolus Calculator Application to navigate this process (25). The "sliding scale method" for determining the insulin doses according to glucose value ranges based on fixed carbohydrate administration prevents families from participating in and mastering insulin dose calculations from the onset. The sliding scale method falsely implies that the insulin dose is determined solely based on the glucose level. Determining the pre-meal insulin dose primarily depends on the carbohydrate amount. The sliding scale method may be likened to fastening the first button incorrectly, so all the following buttons are also incorrect. This method may hinder the proper understanding and adjustment of insulin doses.

Going to Bed with a Normal Glucose Level and Fear of Hypoglycemia

Several factors contribute to the challenge of achieving optimal control, such as the lack of residual beta cell function, non-physiological insulin treatments, burnout, increased strain on families, outdated methodologies, limited access to technology, and other disparities (26). In addition, fear of

nocturnal hypoglycaemia may lead families to ignore their goals, given that more than 50% of severe hypoglycemic episodes in children and adolescents occur during sleep (27). The fear of hypoglycemia often leads people with T1D to consume unnecessary carbohydrates and go to bed with high glucose levels (sometimes exceeding 250 mg/dL). However, it is a more accurate approach to enter the night with normal glucose (>120 mg/dL is safe for the preschool period, and >90 mg/dL is safe for older children) (11). If glucose levels exceed 160-180 mg/dL, it is advisable to administer an additional dose, provided that there is no downward trend in the glucose level. The previous suggestion to avoid administering an extra dose of insulin at bedtime was due to the possibility that the extra dose might coincide with the the glucose lowering effect of NPH and result in low blood glucose levels 4-5 hours later. However, this issue is not anticipated in individuals using insulin glargine or an insulin pump. Between the hours of 3 and 6 am, the amount of insulin requirement decreases (12), which can lead to a risk of hypoglycemia. To avoid this, it is important to allow certain hormones like glucocorticoids, adrenaline, and glucagon to be activated when they are needed during this period. This helps to maintain a normal balance in the body. It is not advisable to rely on unnecessary carbohydrates before bedtime to protect against hypoglycemia during the night. This approach can lead to high glucose levels in the first half of the night. This is especially true for young children, who may experience the "reverse dawn phenomenon" between 9 pm and midnight. When a person sleeps with high glucose levels at night, insulin sensitivity decreases due to hyperglycemia, which can lead to high glucose levels both during the night and in the morning. This same problem may also occur after 4 pm, or during afternoon nap-time, which is called the "dusk" phenomenon.

Routine/Obligatory Snacks and Milk Before Bedtime

In the past, using NPH and regular insulins together increased the risk of hypoglycemia. As a result, it became routine to have snacks between the main meals, three times a day. Using multiple injections of rapid-acting insulin or an insulin pump reduces the need for snacks between meals. These types of insulins have a similar effect to the way blood glucose increases after a meal, resulting in lower insulin levels between meals. Therefore, it is suggested to minimize snacking throughout the day and only consume snacks if necessary (18). Unregulated snacking habits often lead to the consumption of high-glycemic index carbohydrates without insulin, causing elevated glucose levels during the day (5,28). In preschoolers, frequent or irregular snacking can cause early fullness, making it difficult to predict the required amount of carbohydrates in their main meals. Similar concerns arise with night-time snacks, particularly the "milk feed" before bedtime. The carbohydrates in milk, slowed by fats and proteins, cause a glucose curve that insulin doesn't effectively match. This may also be related to insufficient bolus or any food/liquid consumed after dinner with multiple daily injections (MDI). This impact is noticeable at all times but more pronounced in young children experiencing elevated glucose levels between 9 pm and midnight due to the "reverse dawn phenomenon" (29). Consequently, it's advantageous to consider shifting milk consumption to earlier in the day, preferably before daytime physical activities rather than right before bedtime, whenever feasible.

The Impact of Fats on Insulin Sensitivity and the Issue of Problematic Foods

High-fat meals are one of the major causes of post-prandial glucose elevation and even AID systems are not successful in this regard. Fats delay the post-prandial rise time of glucose by delaying the gastric emptying time, decreasing insulin sensitivity, and increasing hepatic glucose production, preventing the matching of insulin and carbohydrates, and causing glucose elevation within 3-5 hours after the meal (30,31). This leads to the problem of inability to manage "problematic foods" such as pizza, pasta and hamburgers and results in out of target glucose levels (32). High glucose levels due to fats leads to decreased insulin sensitivity caused by high glucose and a "vicious cycle".

T1D guidelines recommend consideration of fat and protein in the meal-time insulin strategy, but optimal adjustments are still unknown. Data support an insulin dose increase of up to 30% for carbohydrate meals containing more than 30 g fat or 15 g fat + 25 g protein (33).

Combined boluses in pump therapy favorably influence the glycemic course and at least 60% of the calculated bolus should be given 15 minutes before a meal. With MDI, the efficacy of a split insulin strategy in improving postprandial glucose control is uncertain. Consequently, navigating the impact of fats is challenging, requiring dietary guidelines that prioritize reducing fats by avoiding "problematic foods" (34).

Diabetes Care at School

Children typically spend over 30 hours per week at school. Optimal diabetes management at school including help with carbohydrate counting and insulin dosing at lunch is closely related to successful academic performance and preventing complications. Diabetes care should be

maintained at the same high standard at home and school, with consistent daily blood glucose targets, regardless of the setting (35). Besides national programs, pediatric diabetes teams should provide an "Individual Treatment Plan for School" for each child and make diabetes care at school a part of their routine practice. Recently, the aim has been to ensure that the glucose levels are kept within the target range for a full 24 hours, not just at home but also when at school. To achieve this, pediatric diabetes teams need to be complemented by "diabetes teams at home (the family or caregivers of a child with diabetes)" and teachers need to be part of pediatric diabetes teams. (https://okuldadiyabet.meb.gov.tr/anasayfa).

Diabetes Technologies

Insulin pump therapy should be presented as an option, not a necessity, and sensors should always be prioritized (36). The authors do not start insulin pump therapy before the end of the honeymoon period, with exceptions for preschool children with small doses but they do encourage the use of sensors from the time of diagnosis. Striving for equitable access to diabetes technologies is recognized as important and education programs should be as short and structured as possible. The teams should strive for the training programs to be outpatient and individualized.

Continuous communication and support should be provided to technology users, and the establishment of groups on online platforms should be encouraged for learning and experience sharing among users.

Diabetes Camps for Children and Families

The "My friend diabetes camps" have been organized in İznik (Turkey) since 1997 to improve the education and health of children with diabetes (37). Numerous families who send their children to these camps express that they would like the camps to be organized for themselves as well. They would like to receive the same comprehensive education as their children receive and also want to share their experiences and interact with other families who have children with diabetes. The "My Friend Diabetes Family Camp" has been organized since 2018 to respond to this request, which has been voiced over the years, to help families provide better diabetes care. In addition to children with diabetes, their parents and non-diabetic siblings can participate in this camp.

The camps aim to enable children and families to find a new "normal", to be hopeful and to be friends with diabetes, and to create versatile opportunities for this. Being friends with diabetes is the first step of living with diabetes; it is not helpful to magnify the difficulties that come with diabetes, not to exhaust themselves with worries. Once diabetes is encountered, it is best to leave the past behind, look to the future, and live a life at peace with diabetes. The objectives of diabetes camps for children and families are given in Table 4.

Table 4. The objectives of diabetes camps

- To make children with diabetes and their families competent in diabetes care and treatment and to enable them to cope with problems in diabetes care.
- To gain awareness of diabetes care.
- Providing training on new treatments and technologies.
- To enable participants to share their experiences with each other and feel less alone.
- Helping them to look at their future life more positively and confidently.
- Providing an environment in which democratic parenting attitudes are valued over neglectful, authoritarian or permissive parenting attitudes.
- To enable families of children with diabetes to better understand and manage the changes/problems their children experience during adolescence.
- To strengthen the training of pediatric diabetes teams and other camp participants, to provide an environment where they can receive feedback from families and evaluate their own work/attitudes, and to train health teams to better understand children with diabetes.

"10 Behaviors to Avoid" for Better Diabetes Care and Health in Children with T1D

Improving the management of T1D in children requires education that emphasizes not only what to do but also the behaviors to avoid. In the long term, technology and behaviors will largely determine the treatment of T1D. Therefore, the "10 Behaviors to Avoid" that complement the "10 Key Recommendations" are also important.

1. Assuming that one can gauge their glucose level solely based on how they feel, without glucose testing: This behavior is more common in adolescence and leads to a gradual neglect of diabetes management, avoidance of confronting glucose values and doing what is necessary, ignoring the facts, self-deception and eventually a "vicious circle" develops. Children who exhibit such behavior usually have high HbA1c values and are at a greater risk of being hospitalized with severe hypoglycemia or ketoacidosis. Managing diabetes without glucose data, including fasting and postprandial glucose values, is like walking blindfolded or driving a car with the speedometer, fuel gauge, and warning alerts turned off. It is important to have access to 24-hour sensor data to get a complete picture of glucose levels and manage diabetes effectively.

2. "Skipping or forgetting to take pre-meal rapid-acting insulin doses and administering it after the meals": Understandably, diabetes treatment can lead to fatigue

and disruption of routines over time. However, if diabetes is neglected, it will not simply disappear. It is important to remember that missing or forgetting to take fast-acting insulin doses (also known as bolus doses) before a meal or taking them after a meal can lead to poor glucose management during the meal, insulin resistance caused by elevated glucose levels, and eventually, a prolonged period of high glucose levels throughout the day. Diabetes management relies on successfully managing fasting and post-prandial periods separately; getting enough basal insulin cannot compensate for problems caused by skipping bolus doses, as is sometimes assumed.

3. Irregular sleeping habits, going to bed late and waking up late: The dawn phenomenon, which causes high blood glucose levels in the morning, can be prevented to some extent by maintaining a regular sleep schedule. On the other hand, lack of sleep can lead to reduced insulin sensitivity, making diabetes management more challenging. It is also essential to avoid lying in bed until late morning, as this can result in skipping the morning bolus doses that help overcome the dawn phenomenon. This may cause elevated glucose levels and a difficult start to the day, even when fasting.

4. Irregular eating: Although meals can be managed with accurate carbohydrate counting and appropriate insulin doses, eating at short intervals complicates diabetes control. The high-dose insulin/excess carbohydrate intake behavior leads to weight gain. Insulin is the cornerstone of diabetes treatment, but diet is the key to successful glucose control. It is of most importance not to skip meals and to eat meals most of the time at similar times every day. In addition, gluten-free diets should be avoided, in the absence of celiac disease, and practices promoted as "alternative medicine", such as very low-carbohydrate or ketogenic diets, should be avoided too. Furthermore, adolescents should avoid behavior, such as not eating and not taking insulin to lose weight or using unhealthy dietary supplements with unclear ingredients, such as unlabelled protein powders for body-building.

5. Living a life without exercise: Inactivity and prolonged screen time reduce insulin sensitivity, negatively affect fat metabolism, cause weight gain, and decrease vitality and happiness. It is healthy for everyone, particularly children, to spend time in nature, walking, playing games, spending time with friends, reading books, and helping others. It is crucial to keep in mind that life is a gift, and we should welcome every sunny day and every beautiful cloud with joy.

6. Hiding diabetes: If you have diabetes, it is better to be open about it and explain it to others. Answering people's questions briefly by saying "I have type 1 diabetes and I use insulin" will help you lead a more comfortable life. Trying to hide your condition can be exhausting and make you feel sad. In the long run, it can lead to behaviors such as denial and avoidance of your diabetes and its requirements, which can negatively impact your glycemic control.

7. Ignoring diabetes: When diabetes is ignored, it reminds itself with hypoglycemia or hyperglycemia, reduces the quality of life, makes the person feel bad, and these negative emotions can push the person further away from their diabetes. To break this cycle, it is important to accept the condition, take necessary measures, and move forward. This process can be described as befriending diabetes. Neglecting and forgetting diabetes supplies can lead to difficult situations in life. It is crucial for individuals with diabetes to always have access to the necessary materials for measuring blood glucose, insulin, and hypoglycemia treatment.

8. Not collaborating for diabetes management: Managing diabetes is a continuous and challenging process, and having the support and shared responsibility with loved ones can help the person with T1D feel more comfortable and achieve successful diabetes management. On the other hand, blocking the efforts of parents and siblings by saying "stay out of my way", refusing the people who offer to help, hiding information from relatives, and pushing them out of diabetes management can make life difficult and lead to negative outcomes. In addition, such behaviors can upset, disempower and depress parents whose hearts are always beating for their children. Life is bigger than diabetes, and the way to make more time for oneself and one's life is to reduce the burden of one's diabetes through cooperation. Making diabetes management as easy and enjoyable as possible depends on this shared behavior. Adolescents (and their parents), who are gradually achieving self-control in many areas of life, need to understand that their parents are needed as "diabetes coaches" during the teenage years. Try to distinguish between diabetes parenting and diabetes coaching.

9. Refusing to embrace certain technologies by stating "I prefer not to incorporate anything into my body": Today, sensors and AID systems are of great importance in reducing the burden and improving the quality of life for people dealing with T1D. Sensors provide a wealth of information to understand the course of glucose and master diabetes management. Taking the right steps towards a diabetes management goal, such as maintaining normal glucose levels, creates a "positive feedback loop" and diabetes management becomes easier. Diabetes technologies, especially sensors are of value for creating a positive cycle and turning point for individuals living with diabetes. Instead of dismissing these technologies outright,

it is important to give them a chance and try them out for a while. Eliminating the question marks and concerns about the sensors (showering, swimming, sports activities, social concerns) will accelerate the acceptance process. Starting a sensor at diabetes onset will facilitate the use of the device.

10. Scaring children with complications, blaming them for blood glucose levels that are not in the targeted range: Parents should avoid using scare tactics such as threatening their children with kidney damage or blindness, no matter how concerned they might be. Such threats are not productive and can create a sense of hopelessness in children. Instead, parents should try to motivate their children to think carefully about their actions and decisions. Constantly blaming children for high or low glucose levels can lead to feelings of inadequacy and failure. It is not recommended to use the words "good glucose" and "bad glucose" as it can be emotionally distressing. Instead, it is better to use words such as "glucose on target", "high glucose", and "low glucose". It is essential to remember that almost every day, despite all the efforts, unexpected blood glucose levels can occur, and it may not be possible to prevent this completely. It is the long-term average glucose, TIR and HbA1c that count in the long run.

Conclusion

The primary focus should be on achieving good glycemic control from the diagnosis of diabetes, and maintaining HbA1c levels at or below 6.5% in all age groups. Providing written, clear, and up-to-date recommendations and targets can provide a basis for good metabolic control, and each center can tailor recommendations such as the "10 Essential Recommendations" used by the authors. In the long run, maintaining a normal glucose target range between 70-140 mg/dL should be stressed more, in our opinion. It should be noted that the use of appropriate technology significantly contributes to achieving this goal. More effort should be made to provide support and adherence to goals at school, keeping in mind that teamwork and mentoring/guidance programs make a difference. Emphasizing and creating opportunities to learn from each other, other diabetes teams, other children/young people living with T1D, and their families are important and beneficial. We suggest that an open national registry should be set up with clear visibility of data from all centers. Finally, efforts should be made to ensure that fathers are involved from the beginning.

Ethics

Authorship Contributions

Surgical and Medical Practices: Şükrü Hatun, Concept: Şükrü Hatun, Tuğba Gökçe, Ecem Can, Elif Eviz, Kağan Ege Karakuş, Carmel Smart, Ragnar Hanas, Gül Yeşiltepe Mutlu, Design: Şükrü Hatun, Tuğba Gökçe, Ecem Can, Elif Eviz, Kağan Ege Karakuş, Carmel Smart, Ragnar Hanas, Gül Yeşiltepe Mutlu, Data Collection or Processing: Şükrü Hatun, Tuğba Gökçe, Ecem Can, Elif Eviz, Kağan Ege Karakuş, Gül Yeşiltepe Mutlu, Analysis or Interpretation: Şükrü Hatun, Gül Yeşiltepe Mutlu, Literature Search: Şükrü Hatun, Gül Yeşiltepe Mutlu, Writing: Şükrü Hatun, Tuğba Gökçe, Ecem Can, Elif Eviz, Kağan Ege Karakuş, Carmel Smart, Ragnar Hanas, Gül Yeşiltepe Mutlu.

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